Chapter 7
Energy Efficiency: A Key Challenge of the Energiewende

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"A saved kilowatt hour is the most cost-effective kilowatt hour."
Agora Energiewende (2013, p. 2): Lesson 12.

7.1 Introduction

A significant improvement in energy efficiency is crucial for the success of the energiewende. Energy efficiency plays an important role in reducing primary energy demand and fuel costs, and in many cases, it constitutes the least-cost option for GHG emissions reduction. Other benefits arise from its positive impact on local air quality, human health, and productivity. By making the use of fossil fuels more

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This chapter summarizes work by the authors and their respective organizations, DIW Berlin and DIW Econ, see references, we draw particularly on a study on deep decarbonization coordinated by Claudia Kemfert et al. (2015); the usual disclaimer applies.

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energy-efficient, the external costs of energy provision can be reduced. And as fossil fuel combustion is reduced, black carbon as well as sulfur dioxide emissions are projected to decline significantly. Demand for fossil fuels is therefore expected to decrease as well, which will help to reduce exposure to volatile international prices. This will correspond directly to increased energy security and will also reduce Germany's dependence on energy imports. In addition, energy efficiency investments may trigger positive employment effects through growth in the the building sector, and in the longer term, household energy savings will boost spending in other sectors.[1] Furthermore, fossil fuels are limited resources, and their efficient use increases the potential for their non-energy use in sectors where substitution is more costly or impossible.

The important role of energy efficiency in the energiewende is clear. This chapter summarizes the German approach to energy efficiency, both in general and at the sectoral level in areas such as building, industry, and transport. It also discusses obstacles that could prevent an increase in energy efficiency from a general viewpoint and in the specific case of Germany. In the following section, we provide a survey of the energy efficiency targets identified in Germany's Energy Concept 2050 and other documents, and discuss the results of this policy, which have been mixed to date. Section 7.3 then provides a sectoral analysis, looking specifically at the building, industry, and transport sectors. Section 7.4 looks at specific energy efficiency policies going forward, in particular the National Action Plan on Energy Efficiency (NAPE) and some key future challenges. Section 7.5 concludes.

7.2 Energy Efficiency Targets and Achievements

7.2.1 Issues Related to Energy Efficiency

Energy productivity, defined as GDP per unit of domestic energy consumption, is the key indicator of progress in energy efficiency. It measures the use of energy in relation to the performance of the economy as a whole. The measure may focus on either primary or final energy productivity. For assessing improvements in energy efficiency at consumption level, final energy productivity is the more appropriate indicator, as it disregards the fuel mix and the efficiency of the energy transformation. These parameters are of more interest when analyzing the total primary consumption as needed for e.g., the analysis of international energy security and climate policy.

Energy demand is influenced by a variety of factors besides the energy efficiency improvements that are intended to decrease demand. Historically, growth of population, GDP, and the sectoral share of industry contributed to increases of energy

[1] Blazejczak, J., Edler, D., Schill, W.-P. (2014): Steigerung der Energieeffizienz: ein Muss für die Energiewende, ein Wachstumsimpuls für die Wirtschaft. DIW Wochenbericht Nr. 4/2014, pp. 47–60.

demand, while growing prices and a growing GDP-share of the service sector dampens demand growth. In addition, climatic conditions play a substantial role. Besides these factors the stock of buildings and the stock of electric appliances are shaping the energy demand of a country.

In addition to the multitude of variables affecting energy demand, there are also numerous uncertainties about the extent to which demand will decline with energy efficiency improvements as a result of what is known as "rebound effect." The rebound effect describes the response of consumers to the lower per unit cost of energy after an investment. A direct rebound effect is the increase in consumption of a good, in this case energy, resulting from the lower cost of use. An indirect rebound effect occurs when lower consumption has reduced the price of energy, and the lower cost in turn enables increased household consumption. Hence, the rebound effect describes an adjustment and optimization of household consumption following changes in prices (Borenstein 2013).

7.2.2 Efficiency Objectives for Germany

Efficiency targets have a long history in German energy policy, and they were a cornerstone of the Energy Concept 2050 announced in 2010 (BMWi and BMU 2010). Table 7.1 summarizes the initial efficiency targets of the Energiewende. These include a reduction of primary energy consumption of 20% by 2020 and of 50% by 2050 and an energy productivity increase of 2.1% annually (compared to average growth of 1.7% for the period 1990–2012). In the building sector, a nearly carbon-neutral building stock should be in place by 2020, with a thermal refurbishment rate for residential buildings of 2% annually. Gross electricity consumption should be decreased by 10% (2020) and by up to 25% (2050, base year: 2008), and final energy consumption of the transport sector should be reduced by 10% (2020) and by 40% (2050, base year: 2005).[2] Moreover, gross electricity generation by combined heat and power (CHP) plants should increase from 101 TWh in 2014 to 110 TWh in 2020 and 120 TWh in 2025.[3] Compared to 1990, primary energy consumption should decrease slightly and overall energy productivity should improve by 2020.

[2]The indicators assume a macroeconomic growth rate of 0.8% annually.

[3]§1 (1) *Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung* (Kraft-Wärme-Kopplungsgesetz - KWKG), Kraft-Wärme-Kopplungsgesetz vom 21. Dezember 2015 (BGBl. I S. 2498).

Table 7.1 Energy efficiency objectives of the energiewende

Energy efficiency					
	2014	2020	2030	2040	2050
Primary energy consumption (compared with 2008)	−6.5%	−0.2			−0.5
Energy productivity (final energy consumption)	1.2% p.a. (av. 2008–2014)	2.1% p.a.			
Gross electricity consumption (compared with 2008)	−4.6%	−0.1			−0.25
Thermal refurbishment of residential buildings	~1% p.a. (2012 value)	2% p.a.			
Final energy consumption of transport sector (compared with 2005)	+0.2%	−0.1			−0.4

Source: BMWi (2015), Löschel et al. (2015)

In addition to these initial targets, the government added three additional targets (BMWi and BMU 2012, 16):

- 20% reduction of heat demand in the existing building stock by 2020
- reduction of primary energy consumption of buildings by about 80% up to 2050[4]
- rise in the thermal refurbishment rate of the existing building stock to 2% per year

7.2.3 *Achievements to Date: Aggregate Results*

However, a closer look at the results achieved to date shows that significant challenges still lie ahead in adjusting the measures and instruments currently in place. Energy productivity in Germany is increasing steadily, although the current rate is insufficient to reach the efficiency targets set as part of the energiewende. Figure 7.1 shows developments in Germany compared to other major European economies. Interestingly, the GDP per unit of energy consumption [in kilogram of oil equivalent (KGOE)] is quite similar across Western Europe, between 8 and 10 €. Poland, by contrast, has only half of that level of energy productivity. Together with the UK, Germany has achieved relatively high energy productivity gains by European comparison, slightly higher than the EU average.[5]

[4]Both heat demand and primary energy consumption in this case do not include renewable energies (Löschel et al. 2014b, 17). The use of renewable energy will therefore help in improving both indicators, which is reasonable from the point of view of GHG emissions reductions.

[5]Eurostat (2018): Data Explorer, last accessed 05.05.2018 at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_r_e3gdp&lang=en

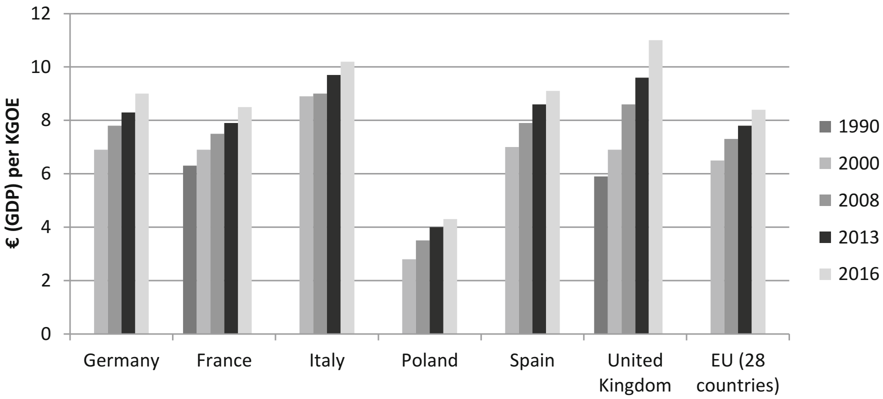

Fig. 7.1 Energy productivity 1990–2016: Germany in the European context. Source: Eurostat (2018) Data Explorer, last accessed 05.05.2018 at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_r_e3gdp&lang=en

Although Germany has achieved some success in reducing primary energy consumption and gross electricity consumption, it has still failed to reach its targets for energy productivity improvements. Up to 2013, primary energy consumption fell by just 4.0% compared to the base year 2008 (Löschel et al. 2014b, 6). Recent estimations show that depending on the assumed growth rates and primary energy productivity, a gap of between 9.9% and 12.8% (or 1.445 and 1.751 PJ)[6] will still have to be closed to achieve compliance with the 20% primary energy consumption target for 2020 (Fraunhofer ISI 2014, 10). Final energy consumption increased by 1.19% between 2008 and 2013 (see Fig. 7.2). To reach the envisaged targets, it is crucial that GDP growth be further decoupled from energy consumption and that energy productivity increases more rapidly.

Final energy productivity has varied across different time periods. While average energy productivity increased by 2% from 1990 to 2000 and by 1.3% from 2000 to 2004, the increase was even more substantial between 2004 and 2008 (as much as 2.6%). However, from 2008 to 2012, the rate of energy productivity improvement slowed to an average rate of 1.1%. To achieve the 2050 target, an annual average energy productivity increase of about 2.6% from 2012 to 2020 would be required (Löschel et al. 2014a).

Structural processes underway in the economy, including price fluctuations and the changing sectoral and sub-sectoral composition of GDP, have a significant impact on both GDP and energy consumption. These factors affect the aggregate indicator as well. This makes it difficult not only to interpret the overall indicator but

[6]The basis of calculation is temperature-adjusted primary energy consumption of 14,594 PJ in 2008. Fraunhofer ISI / Fraunhofer IFAM/ Prognos/ Ifeu (2014): Ausarbeitung von Instrumenten zur Realisierung von Endenergieeinsparungen in Deutschland auf Grundlage einer Kosten-/Nutzen-Analyse. Wissenschaftliche Unterstützung bei der Erarbeitung des Nationalen Aktionsplans Energieeffizienz (NAPE). Zusammenfassung.

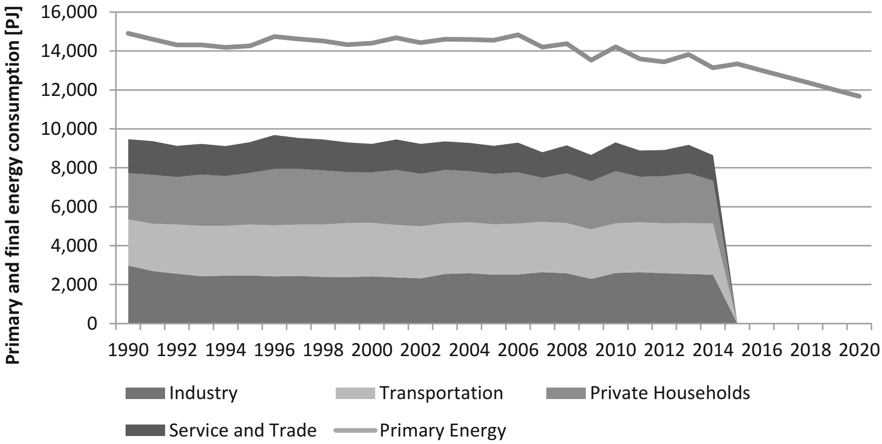

Fig. 7.2 Primary and final energy consumption development (in PJ). Source: Own depiction based on data from BMWi (2014) *Energy Data*: Complete Edition. Berlin, Germany

in particular to disentangle the success of policy measures aiming at energy efficiency increases from other factors. It is therefore necessary to monitor energy efficiency improvements at a disaggregated sectoral level.

7.2.4 Disaggregated Results

7.2.4.1 Commercial Sector, Buildings, Transport

The commercial and service sector performed best (3% energy productivity improvement annually since 1991), followed by road freight transportation (2.3%), individual road transportation (1.5%), industry (1.3%), and private households (1%) (Löschel et al. 2014a, 50). For industry, which accounts for 29% of total final energy demand in Germany, a future annual increase of 1.3% in energy productivity was agreed upon in negotiations between government and industry over CO_2 tax relief. Whereas the less energy-intensive service sector, which includes the public sector, is less affected by business cycles, the industrial sector is more sensitive to international market developments. Energy productivity in industry decreased in 2003 and 2009, years with low market demand for industrial goods and low utilization of existing capacities. Overall, energy productivity has improved since 1991. Technological processes and increasing use of CHP plants have contributed to this development. The growing importance of less energy-intensive sectors has also played a role.

Moreover, building construction is central to improving energy efficiency, and produces positive results. Although the building stock grew over the period 2000–2012 with the rise in living standards (measured in terms of living space in m^2/

person), heat consumption in residential buildings decreased by around 450 PJ or 20% (Schlomann et al. 2014, 23). Temperature-adjusted specific heat demand per m^2 declined by 10.8% from 2013 to 2008.[7] If these trends continue, achieving the 2020 targets for residential heat consumption will be possible if the refurbishment rate of buildings increases to 2% annually, as targeted (Löschel et al. 2014b, 13). However, it is important to note that further efficiency improvements in buildings will be more difficult to achieve in the years to come and will also become ever more costly as effiency levels rise. The even more challenging target for 2050 of reducing primary energy demand in the building sector by about 80% will call for a substantial increase in investment in this sector.

With regard to envisaged energy savings in the transport sector, the target appears to be quite ambitious: a 10% reduction by 2020 compared to 2005. In 2012, the achieved reduction was only 0.6% compared to the reference year. Over the same period, transport services[8] for passenger and freight traffic increased by 4 and 9%, respectively. Energy consumption in passenger and freight traffic, which decreased between 2005 and 2012 by 2.9% per year, was therefore more than compensated for by the overall increase in transport services. Energy consumption in the various subsectors of transport differed substantially:

- In road transport, energy consumption declined by almost 2% from 2005 to 2012 and in rail transport it decreased even more rapidly (4.6%).
- In shipping (2% increase) and aviation (including fuel tank contents on international flights), energy consumption increased by almost 8%.

7.2.4.2 Electricity (TT)

A remarkable development was observed in the electricity sector (see Fig. 7.3). Electricity consumption peaked at around 620 TWh between 2006 and 2008 due to the rapid economic growth in Germany during this period. However, since 2007, electricity consumption has decreased slightly, dropping to 581 TWh gross electricity consumption in 2009 during the financial crisis. This represents a reversal of the continuous increase in gross annual electricity consumption that was observed up to 2007, and a slight decrease in gross annual electricity consumption since 2008.

Although the average annual decrease from the base year 2008 to 2013 was about 0.55%, this rate needs to be doubled to 1.1% annually to reach the 2020 reduction target of 10%. This, too, is a daunting task. Private electricity consumption is currently decreasing, but at the same time, electricity consumption in sectors like transport is still increasing compared to 1999.

Assuming the kind of economic development projected in the German government's energy scenarios, growth in electricity productivity needs to increase to 1.6%

[7]BMWi (2014): Die Energie der Zukunft. Erster Fortschrittsbericht zur Energiewende. December 2014, page 32.

[8]Services are measured in passengers/km and tons/km.

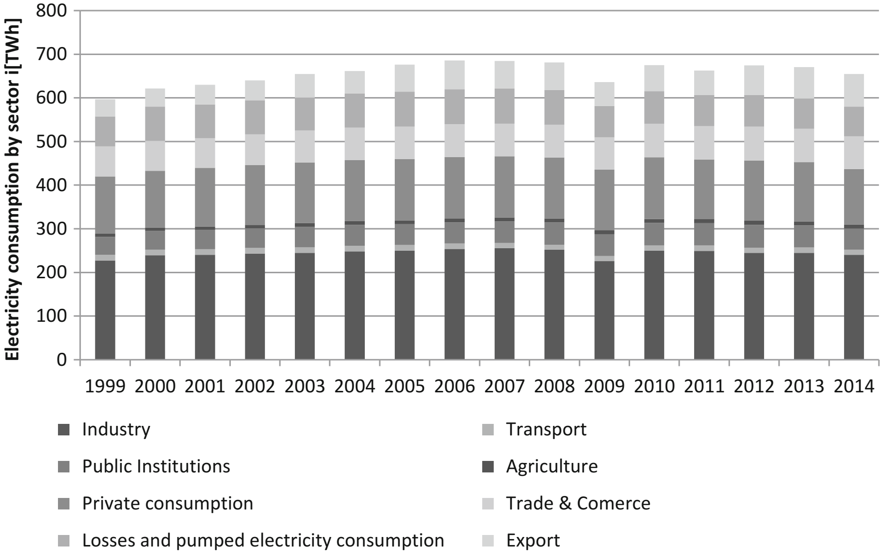

Fig. 7.3 Total gross electricity consumption from (1999 to 2014). Source: Own graph based on data from BMWi (2014) Energy Data: Complete Edition. Berlin, Germany

annually. This corresponds to an increase of 0.2 percentage points compared to the average annual productivity increase of about 1.4% in Germany from 2008 to 2013 (Löschel et al. 2014a, 46). Although considerable progress in energy efficiency has been achieved in recent years, present results indicate the need for efforts to strengthen this trend and increase energy productivity to achieve the 2020 goals.

7.3 Sectoral Policy Analyses

7.3.1 Policies for the Building Sector

Energy consumption in residential and commercial buildings represents more than 40% of total final energy use and is the main source of energy savings potential identified on the demand side (Öko-Institut and Fraunhofer ISI 2014, 14). The building sector therefore needs to contribute substantially to achieving the targets of reducing primary energy demand and of increasing final energy productivity. Buildings differ widely by type, age, owner, and user. Their final energy demand is driven mainly by heating and cooling, hot water supply, and lighting. These drivers depend heavily on heat losses through the building envelope (roof, walls, cellar, windows, and ventilation) and the energy standard of the equipment in place. Measures to reduce energy consumption therefore need to focus on all these elements.

Market failures, information problems, and human behavioral issues (bounded rationality of behavior) can threaten the success of measures to reduce energy consumption, and a variety of appropriate policies should be put in place to overcome these potential obstacles. Homeowners' and experts' assessments of the economic viability of refurbishment often differ, leading to differences between the estimated "optimal" rate of refurbishment and the actual rate of practical implementation. A viable approach for this sector would integrate different demand- and supply-side policies—for instance, raising the standards for insulation and heat production while providing financial assistance and working to raise public awareness for energy efficiency issues. For new buildings, the use of renewable energy for heat should be obligatory, and mandatory efficiency standards should be established.

Currently existing policies can be grouped into the following broad categories:

Administrative law

- policies creating minimum standards for the energy performance of new and existing buildings and their energy equipment combined with gradual tightening of these standards over time through additional ordinances and laws. This approach also includes the use of renewable heat in accordance with technical availability and economic viability.
- regular inspection of heating and air-conditioning systems.
- changes in the principal-agent relationship (building owners and tenants). In May 2012, the German government amended the tenancy law to split financial benefits and costs between landlords and tenants to facilitate refurbishment. Landlords are now allowed to increase rents up to 11% per year to cover the costs of energy renovation.
- obligatory use of renewable heat in new buildings.

Economic incentives

- public financial assistance to building owners through soft loans, investment grants, and subsidies that reduce liquidity constraints.

"Soft" instruments

- provision of information and advice on energy consumption reduction in buildings through energy consulting and building labelling (energy performance certificates) to reduce informational market barriers and to identify potential for savings based on high energy efficiency standards.
- Information and awareness-raising campaigns.

These instruments should lead, on the one hand, to 25% lower energy consumption for new buildings after 2016. On the other hand, building insulation should be improved by 20% from 2016 on. This requires a doubling of the refurbishment rate. The aim is to reach a 20% reduction of primary energy consumption between 2008 and 2020.

7.3.2 Policies for Industry

The majority of German industry is export-oriented and, thus, exposed to international competition. Not surprisingly, this sector is oriented primarily toward international regulations, and energy efficiency policies in industry are defined mainly by European legislation. Apart from the EU-ETS, which covers a large part of German industry, EU policies for industries have two main areas of focus:

Technology-driven activities Energy efficiency standards were introduced for energy-related products (ErP) through the 2009 EU directive establishing a framework for the setting of eco-design requirements for energy-related products. The directive defines minimum standards for energy-using products used in all sectors. It sets implementing regulations for various types of products. Examples include power transformers, water pumps, industrial fans, and electric motors. The regulations applying to electric motors serve as an example:

- The EU Motor Regulation (640/2009) defines requirements for the environmentally compatible design of electric motors and the use of electronic variable-speed drive control and creates four international efficiency classes for induction motors.
- The European Energy-related Product Standard EN 50598 focuses on the drive system as a whole and defines requirements for energy-related products (energy efficiency, eco balancing) for drive systems in electrically-driven machines.

Process-driven activities Energy management tools such as voluntary and obligatory energy audits are being used at regular intervals for all non-SME companies, and energy management systems are being installed in accordance with ISO 50001 standards. These systems provide a means for companies and organizations to create the necessary systems and processes for operational control and continued improvements in energy performance. Public funding is provided to SMEs for energy consulting.

In addition to the EU rules, the German government concluded an agreement with the German business community in 2012 on energy efficiency improvements up to 2022.[9] The agreement is in response to a decision formulated in the Energy Concept 2010 to extend the exemption of energy-intensive industries from the eco-tax, in place since 1999, under certain conditions. The conditionality was linked to verifiable implementation of energy management systems in accordance with the ISO (International Organization for Standardization) 50001 starting in 2013, combined with the agreement to set increased energy efficiency targets that would become binding in 2015. The following efficiency targets have been agreed upon:

- 1.3% energy efficiency increase in 2013 as a condition to apply for the eco-tax exemption in 2015.

[9]BMWi (2012): Vereinbarung zwischen der Regierung der Bundesrepublik Deutschland und der deutschen Wirtschaft zur Steigerung der Energieeffizienz vom 28. September 2012.

- For subsequent years, the targets are 2.6% in 2014, 3.9% in 2015, and 5.25% in 2016 to apply for the respective tax exemptions.
- Monitoring will be conducted by an independent economic institute and targets for tax exemptions in 2019–2022 will be set by 2017.

  The agreement is designed to provide tax exemptions as a financial incentive to ensure that after having slowed to a 1% annual rate of improvement between 2008 and 2012, future energy efficiency improvements stay on track with the overall target.

7.3.3 Policies for the Transport Sector

The transport sector is the second most important sector of the German economy, consuming almost 29% of total final energy. Currently, it is not on track to meet targets for 2020. Due to the diversified structure of the sector, a package of policies is needed to improve the sector's climate performance. The Mobility and Fuels Strategy of the German Government in place since June 2013 takes the difficulties of the sector into account. It is intended not as an overarching mobility strategy but as an initial, concrete contribution to achieving the targets in the transport sector. Since the majority of energy used in the sector is consumed by road transportation (82% in 2012), most policies aim at reducing fuel consumption of vehicles, for instance, by promoting fuel switch and technology improvements. Incentives have also been created through the vehicle tax and emission standards for new cars and light commercial vehicles, as formulated in the corresponding EU directives.

7.4 Energy Efficiency Policies Going Forward

7.4.1 The National Action Plan on Energy Efficiency (NAPE)

To address the slow progress achieved to date on energy efficiency targets, the German government introduced its National Action Plan on Energy Efficiency (NAPE) in 2014 (see BMWi 2014). The Action Plan, summarized in Table 7.2, is estimated to lead to an additional 390–460 PJ of primary energy savings, although this will still not be sufficient to close the existing GHG emissions reduction gap.

Since abatement costs are comparatively low and the savings potential is high, a special focus of this policy is on energy efficiency in buildings. The 2020 targets for residential heat consumption can be reached if the current decline in heat demand continues and if the 2% refurbishment rate is achieved. However, although the NAPE has improved financial support for refurbishment of buildings and tax deductions are planned, more ambitious instruments are necessary to achieve the 2020 targets and the even more stringent 2050 targets. This is due in particular to the following challenges:

Table 7.2 Key measures of the National Action Plan on Energy Efficiency (NAPE)

Measure	Predicted reductions by 2020	
	Volume of reduction in PJ	GHG in Mt CO_2-equivalent
Immediate measures		
Quality assurance and optimization of the existing energy consultations	4.0	0.2
Tax encouragement of energy-saving redevelopment	40.0	2.1
Further development of the CO_2 Building Renovation Program	12.5	0.7
Introduction of a competitive tendering scheme	26–51.5	1.5–3.1
Promotion of contracting (incl. deficiency guarantee)	5.5–10	0.3–0.5
Further development of the KfW Energy-efficiency Program	29.5	2.0
Energy efficiency networks initiative	74.5	5.0
Top-Runner-Strategy—on national and EU-level	85.0	5.1
Obligation for large-scale enterprises to conduct energy audits	50.5	3.4
National efficiency label for old heating systems	10.0	0.7
Further immediate measures of the NAPE	about 10	about 0.5
Sum of immediate measures	**350–380**	**21.5–23.3**
Further measures		
Measures starting in October 2012	43,0	2,5
Provisional estimator for the effect of the additional operating process	up to 40	up to 4
Total	**390–460**	**ca. 25–30**
Measures in the transport sector	110–162	7–10

Values in bold are intermediate and total sum. Source: BMWi (2014, 21)

- Studies have estimated necessary additional annual investment of about 26.4 billion € to achieve the 2020 target. That would mean the current level of about 100 billion € of annual investment in building construction would need to rise to about 126 billion €.[10] The question is how to create incentives for private investors to generate this level of additional investment. Policies and instruments (KfW soft loan programs) currently in place and even the planned increase in financial support for these programs appear insufficient.
- How can higher energy savings be achieved today, for instance, through “deep renovation,” to avoid lock-in effects that could raise mitigation costs in the future?
- Opportunities for refurbishment are currently not being fully utilized. Although the refurbishment rate is about 1% p.a., 3% p.a. of the building stock is subject to

[10]BMVBS (2013): “Maßnahmen zur Umsetzung der Ziele des Energiekonzepts im Gebäudebereich – Zielerreichungsszenario.” BMVBS-Online-Publikation 03/2013. Berlin, Germany.

some non-energy renovation. This indicates potentially missed opportunities for energy efficiency improvement (BPIE 2014, 41). Similarly, what can be done to ensure that these opportunities are utilized without creating problems for non-energy renovation? Such problems may occur, for instance, through the imposition of deep energy efficiency refurbishment mandates that require much higher up-front investment than non-energy renovation.

- By 2020, all refurbished and new heat systems should be on track to meet 2050 targets since no additional refurbishments are expected for buildings already refurbished between 2020 and 2050. The challenge is to create incentives for replacement of outdated heating systems with modern and innovative systems that can help to avoid lock-in effects.

7.4.2 Conflicts Between Targets and Policy Options

7.4.2.1 Heating

The solution to challenges in the area of power generation for heating depends on a number of key issues. There is substantial evidence of fundamental conflicts between the refurbishment rate and projected heat demand reduction as sub-targets for increased energy efficiency in the existing building stock. This will require a rethinking of the relationship between these sub-targets and the overarching target of climate change mitigation through reduction of GHG emissions. The refurbishment rate and the reduction of heat demand are two sub-targets that have been set to encourage carbon-neutral development in the building sector through the implementation of special policy measures. However, one of these two sub-targets alone would be sufficient. The refurbishment rate can serve only as a rough indicator of progress in reducing heat demand given that there is no precise definition of the scope and quality of refurbishments required to achieve energy savings objectives. For instance, refurbishments carried out as part of government-subsidized energy incentive programs may differ significantly in terms of efficiency from renovations carried out by a building owner independently.

In addition, there is also a problem with the definition of heat demand. This term does not distinguish between renewable and fossil heat. However, if heat demand is met completely by renewable energies, it satisfies the overarching national GHG emission reduction target, and any heat reduction impact on climate change is nullified. Therefore, the introduction of the concept of “net heat demand” considers renewable heat at “0” emissions, as the reduction of total heat demand is the more appropriate criterion.[11] Alternatively, targets for the building sector should be re-formulated in terms of primary energy demand, in line with the Energy Efficiency

[11]BMVBS (2013, p. 58): “Maßnahmen zur Umsetzung der Ziele des Energiekonzepts im Gebäudebereich – Zielerreichungsszenario.” BMVBS-Online-Publikation 03/2013. Berlin, Germany.

Ordinance (EnEv), which defines primary energy demand for buildings as "non-renewable primary energy demand" (Löschel et al. 2014a, Z-13). The positive effects of such an approach would be:

- providing building owners more freedom to make decisions on least-cost options for GHG emissions reductions, for instance, on the level of insulation vs. utilization of renewable heat.
- reducing the necessary targets for CO_2-neutral refurbishment of existing stock and thereby lowering the required investment.

Such an approach coincides with ongoing discussions over the application of the Renewable Heat Law to the existing building stock. If renewable heat in existing buildings became obligatory, or if obligatory refurbishment measures could be offset by renewable heat, the choice of measures would be left more open to building or flat owners. This could trigger lower-cost solutions, which would become even more important at later stages in the transition of the building sector, when additional, more advanced insulation technologies become more costly.

Scenario analysis has found that the "net heat demand" approach would help to achieve the 2020 targets at lower refurbishment rates, and that in some cases, it would even lead to overcompliance with the implicit CO_2 reduction target in the building sector. Setting a CO_2 target for the building sector would certainly be an appropriate target adjustment, and it would by no means render ongoing efforts irrelevant. Rather, it would make it possible to reduce the heat demand in buildings, thereby increasing the attraction of higher private investment in refurbishment of buildings, and it would thereby help to overcome the respective obstacles. Merging the two main laws in the building sector—the Energy Efficiency Ordinance (EnEv) and the Renewable Heat Act, which is mentioned as an opportunity in the NAPE—appears to be a viable strategy for increasing the effectiveness of the legal framework.

Apart from improved regulation in 2012, the principle-agent problem in which energy bills are not paid by the purchasing party (building or apartment owner) but by the tenant has still not been dealt with adequately. This issue is of key importance in Germany, since about half of all flats are not owner-occupied. Balancing interests between building or flat owner and tenant is crucial to future investments in energy efficiency. The magnitude of refurbishment costs borne by tenants is an important political issue, and a number of proposals have been made to address this problem. One is the proposal to adjust the rent index, a basic tool for determining rents in new rental contracts, to criteria determining the energy efficiency of the flat in question. Given that the rent index does not include costs of heating and hot water, rents would rise on flats with higher energy efficiency standards, but tenants would save energy costs. The case is the reverse for non-energy-efficient flats. However, such an approach would not solve the problem of social affordability of energy-efficient homes for low-income households, which is also the subject of policy debate. For tenants, the energy savings often only offset the rent increases after a substantial period of time. In addition, the current reform of the housing allowance for the poor needs to take into consideration adjustments for affordability of flats refurbished in line with energy-efficiency standards (BMUB 2014, 33)

A further important and unresolved barrier to energy-efficient refurbishment of buildings is the tradeoff between lower life-cycle costs versus lower up-front costs (energy efficiency investment in buildings usually creates high up-front costs), which is also subject to high transaction costs. Demographic trends such as population aging have also led to a general unwillingness to invest in energy-efficient refurbishment. These issues even affect relatively affordable investments in energy efficiency. Moreover, fluctuations in funding for various support programs are adversely affecting market developments in this sector. Several proposals related to new policies and instruments are currently under discussion. The proposed measures aim to overcome specific barriers and should be viewed as supplementary to the already existing mix of policies and instruments.

Further tightening of the provisions of the EnEV is possible, but the potential impact of these changes is limited. The high up-front costs make it most cost-effective to carry out major renovations simultaneously—for instance, insulating the envelope of a building and simultaneously installing new heat supply systems. In some cases, however, homeowners prefer to carry out renovations individually rather than in combination. Other aspects, including the design of the building, its location, available technologies, etc., also affect the costs of renovations and homeowners' decisions. Administrative law is generally limited and unable to take all these different aspects into account.

As far as the targets for 2050 are concerned, there is a great deal of uncertainty about basic elements that will shape the future structure of the building sector. Factors include the changes in the amount of available living space per capita, the number of new buildings being built, progress in the refurbishment of buildings of different ages, and the technologies used for heating, cooling, and ventilation. Some scenarios assume that about one third of the building stock in 2050 will be new, and that the remaining two thirds already exist today (Öko-Institut and Fraunhofer ISI 2014, xi). In such a scenario, the focus on transformation of the building stock will continue to be of primary importance. A simultaneous switch to renewable heating and cooling in the existing building stock would be imperative. Introducing the obligatory use of renewables in the building stock and in local and central heating systems is currently under discussion.

7.4.2.2 CHP Targets Versus Renewable Heat

The target for increasing electricity generation from CHP to 120 TWh in 2025 may or may not be in line with the planned RES targets for electricity generation and the heat savings targets for buildings up to 2050. The current scenarios for gross and net electricity consumption for 2020 and 2050, respectively, are summarized in Table 7.3; the target scenario for 2050 is about 20% lower than the reference scenario.

Table 7.3 Scenarios for electricity generation (2020 and 2050, in TWh)

	2020	2050
Gross electricity generation		
– Reference scenario	618	561
– Target scenario	576	459
Net electricity generation		
– Reference scenario	556	505
– Target scenario	518	413

Source: EWI, GWS, and Prognos (2014, 5) and own calculations

As CHP installations combined with the respective local heat grids require substantial investments and have an estimated life span of at least 30 years, it is assumed that the 120 TWh will also be achieved by 2050. Due to reduced electricity generation in 2050, CHP electricity will then amount to a share of almost 25% of net electricity generation. A potential conflict with the renewable energy target of 80% could arise unless a majority of CHP is provided by renewable sources.

Another aspect relates to heat demand: Heat generated by CHP plants is used for process heating in industries, for district heating, and for local (decentralized) heating of buildings. According to the forecasts, the share of process heating is expected to increase and to become the main driver of the overall increase in the heat supply by CHP. The share as well as the overall amount of district heating will decline (from 70 to 35%, and from 110 TWh to 64 TWh, respectively) in the period from 2020 to 2050. Financial assistance is also currently being provided to build local heat grids for residential buildings in densely populated areas. In combination with renewable heat and process heat, low-temperature local heat grids could provide flexible heating options. The overall increase of local heating, however, is estimated to increase from 2.5 TWh (2020) to 5.8 TWh by 2050 (EWI, GWS, and Prognos 2014, 219). Taking into consideration the declining residual heat demand due to increased energy efficiency of buildings (insulation) and additional competition from highly-efficient heating technologies (for example, condensing boilers) and renewable energies (heat pumps and solar heating), the CHP target is not likely to be met. If the majority of CHP plants rely on fossil fuels (natural gas) given that the potential for biomass CHP has almost been exhausted, rising CO_2 prices will lead to declining economic advantages of CHP (EWI, GWS, and Prognos 2014, 218). In order to avoid CHP investments that result in stranded assets or lock-in effects, the approach to the building sector needs to be adjusted.

7.4.2.3 Electricity Consumption Reduction Versus New Applications

Although reduction of electricity consumption is one of the targets set in the Energy Concept 2050, it may contradict targets and solutions in other sectors. The target does not distinguish between electricity generated from fossil fuels and from renewables, but focuses mainly on cost savings through efficiency improvements. In terms of absolute numbers, however, it may need to be adjusted. For example, the fuel switch envisaged for the transport sector and the heat sector will increase electricity demand substantially. In the transport sector, increased demand is expected due to the replacement of petrol and diesel with electric mobility and the use of power-to-gas technologies in the production of fuels (mainly hydrogen). The replacement of fossil heat with heat pumps in the building sector will further heighten electricity demand. Depending on scenario assumptions, electricity demand from such "new" applications may even overcompensate for reductions in traditional spheres of electricity consumption. Recent climate change scenarios propose that electricity consumption be examined from a variety of different viewpoints, distinguishing between "classic electricity consumers" (in line with present applications) and "new electricity consumers" in order to avoid conflicting targets (Öko-Institut and Fraunhofer ISI 2014). The additional demand from these new applications is calculated to add up to 300–400 TWh in 2050.[12]

Additionally, for some of the traditional electricity uses, demand may increase in absolute numbers. A modal shift of freight transportation is envisaged from road to rail, which would require not only an increase in railroad investment but would also imply an increase in electricity consumption by railroads. This will not threaten the overarching goal of GHG emissions reduction if the additional electricity is generated from renewables, which is indeed assumed in the scenarios. From this point of view, refocusing the current gross electricity consumption target on non-renewable electricity would be appropriate, but this target should also be accompanied by electricity productivity targets in order to achieve cost effectiveness and spur technological change.

7.5 Conclusion

Energy efficiency is an important pillar of the energiewende, and ambitious efficiency targets of all kinds have been defined. Yet progress is slow, and in some cases, the targets even appear to be contradictory—for instance, reducing electricity consumption while at the same time decarbonizing the transport sector through the use of electrical power. This chapter has provided an overview of the current situation in this sector, the perspectives and potential of energy efficiency policies in Germany, and the challenges going forward.

One of the most pressing tasks for the near future is the significant transformation of the large and multifaceted heating sector. The heating sector, which also includes cooling, hot water supply, and process heat, is responsible for roughly half of final energy demand; most of this sector still relies directly on fossil fuel combustion. According to the regular Monitoring Reports on the Energiewende, current energy

[12] Agora Energiewende. 2015. Wie hoch ist der Stromverbrauch in der Energiewende? - Energiepolitische Zielszenarien 2050—Rückwirkungen auf den Ausbaubedarf von Windenergie und Photovoltaik. Berlin.

efficiency policy has contributed to Germany's failing to meet its overall GHG emissions reduction targets for 2020 (Löschel et al. 2014b, 23, 2015). Scenario results indicate that the current underperformance in efficiency improvements cannot fully be compensated for by additional renewable electricity generation, as this would mean doubling of the amount of renewable electricity generation between 2014 and 2020. However, renewable heat is making an increasingly important contribution to reducing fossil fuel consumption and CO_2 emissions, which will take some of the pressure off energy savings. Central to this transformation is the adjustment and further elaboration of an integrated concept for a carbon-neutral building sector up to 2050, combining efficiency improvement (heat demand reduction) with renewable heat in a coherent manner and including renewable CHP. Heat demand reduction and renewables can be treated as substitutes for achieving the goal of carbon-neutral buildings and, thus, to the overarching GHG emission reduction goal.

The transport sector also poses major challenges and is currently not adequately regulated to reach the desired energy efficiency objectives. It is going through a slow learning process with new fuels and traction systems. Since the abatement costs are relatively high, transport has been low on the climate policy agenda. With the emergence of competitive renewable energies and increasing acceptance of new modes of transportation, this picture may change in the near future. New demand patterns may reduce overall transport demand, allowing the sector to move to a larger share of renewables such as renewable electricity and biofuels.

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