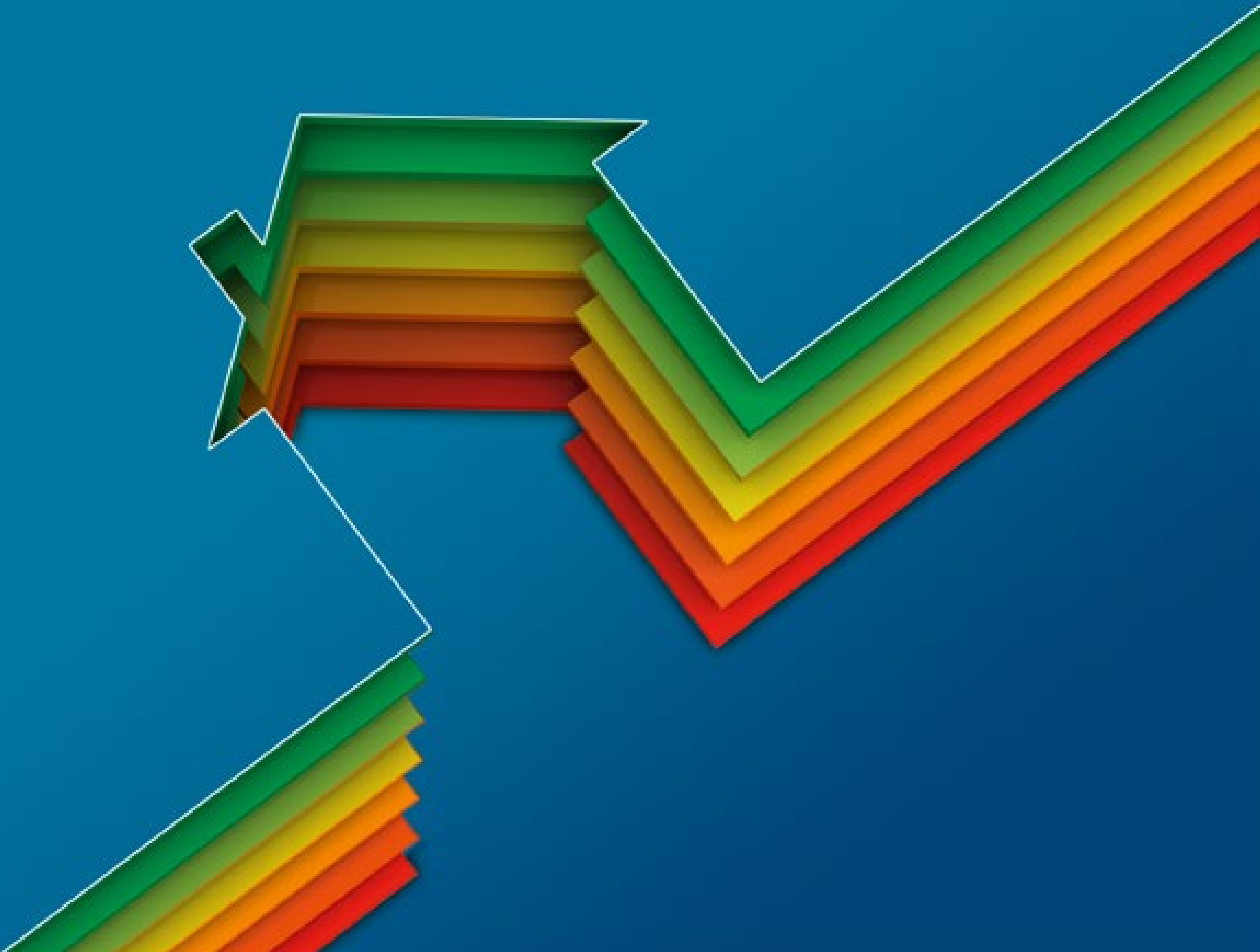
Federal Ministry
for Economic Affairs
and Energy

Energy Efficiency Strategy for Buildings

Methods for achieving a virtually climate-neutral building stock



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Contents

Introduction

The Federal Government's energy policy decisions, the energy concept from September 2010 and the decisions regarding the energy transition from June 2011 have set the stage for reliable, affordable and clean energy supply in Germany. Renewable energy is becoming the central pillar of the country's energy supply, followed by energy efficiency as the second pillar of the energy transition. This is because the cleanest and cheapest energy is energy that is not in fact used. Energy consumption must be gradually reduced parallel to the expansion of renewable energies as a precondition for fossil energy sources to be largely phased out in the longer term. This is why further steering targets for energy efficiency and/or energy savings and for increasing the share of renewable energy in energy consumption were laid down in addition to the political goals of reducing greenhouse gas emissions by 80 to 95 percent by the year 2050 and the exit from nuclear energy by the year 2022.

Today's large number of refugees is posing huge challenges for Germany. There is no doubt that this will raise demand for affordable housing even further. The challenge is to meet the needs of society as a whole. For some time now, rent hikes and serious bottlenecks on housing markets have been frequently seen in many densely populated areas as well as large cities and university cities. Low-income households, but increasingly also households with middle incomes, are finding it difficult to find affordable housing. This translates into demand for some 350,000 to 400,000 new homes. The current challenges do not justify compromising on the energy standards pursuant to the Energy Saving Ordinance (EnEV) and the Renewable Energies Heat Act (EEWärmeG). What is needed is affordable housing for all that meets high energy quality demands. Modern living space featuring a high level of energy efficiency must be available to all citizens including households with low and medium incomes. This applies to those who already live here and to those who are now coming and will stay here. The minimum energy standards for the new homes needed may not be sacrificed. Otherwise living space would be built which in just a few years would have to be seen to be outdated in terms of energy inefficiency and therefore less attractive. Low-income households, in particular, often benefit from high energy efficiency levels which mean low heating costs.

With its National Action Plan on Energy Efficiency (NAPE), the Federal Government launched a comprehensive action package in December 2014. NAPE is an essential building block of the Federal Government's efficiency strategy during the present legislative term. It is instrumental in achieving the targets of the energy concept through energy efficiency. What is needed in addition to greater energy efficiency are the further expansion of renewable energies, new business models, innovation for energy saving measures as well as innovative new products and services in all sectors. NAPE aims at encouraging and involving all stakeholders in society in order to boost energy efficiency and save energy. NAPE is to identify options and opportunities for all stakeholders in society and to create a positive attitude towards the commitment to energy efficiency and renewable energy. For this purpose, a number of immediate actions were initiated by NAPE, including, for instance, the introduction of new competitive tendering procedures for energy efficiency, the further development of promotional measures for building renovation and the market incentive programme for the use of renewable energies in the heat market as well as the introduction of the national label for existing heating systems and heating system checks. With NAPE, the key points for the elaboration of the Energy Efficiency Strategy for Buildings, as one of the downstream work processes of NAPE, were adopted.

With the Climate Action Programme 2020, the Federal Government launched a comprehensive action package also in December 2014 in order to achieve the interim target for 2020, i.e. reducing greenhouse gas emissions by 40 percent compared to the 1990 level.

However, the Federal Government's climate protection goals can only be achieved if environment-friendly and climate-friendly building, energy-efficient neighbourhood and urban development, housing and building issues as well as demographic change, along with energy efficiency and the use of renewable energy in the building and housing sector go hand in hand. This is the purpose of the "Energy Efficiency Strategy for Buildings" and of the "climate-friendly building and living" strategies to be developed within the scope of the Climate Action Plan 2050. The results of the "Alliance for Affordable Living and Building" (Bündnis für bezahlbares Wohnen und Bauen) will be considered here and additional options identified that can help to reduce emissions further. The "climate-friendly building and living strategy" is thus to become an important pillar of the national energy and climate protection policy especially with a view to the goal of achieving a virtually climate-neutral building stock by 2050.

The building sector as a whole, including residential and non-residential buildings, has a key function for the targets of the energy concept as such: It accounts for around 35 percent of final energy consumption and around one third of greenhouse gas emissions. At the same time, energy consumption can be significantly reduced and renewable energies can be effectively used for heat and cold generation. A sensible combination of both can generally help to develop solutions which may even include a virtually climate-neutral building stock. It must be ensured that these solutions are feasible, affordable, economical and, last but not least, reliable, lasting and user-friendly.

Success stories are already visible in the buildings sector: Despite ongoing increases in residential and other useable spaces in Germany, absolute energy consumption in buildings is declining. This means that the permanent improvements in energy efficiency are enabling greater separation of building use and energy consumption. Furthermore, the share of renewable energies in the remaining final energy consumption continues to increase, a fact which also contributes significantly towards reducing carbon emissions in Germany.

The Energy Efficiency Strategy for Buildings is based on the goal of achieving a virtually climate-neutral building stock by 2050 in line with the Federal Government's energy concept. This means that by the year 2050 primary energy demand of buildings must be reduced by 80 percent against the 2008 level through a combination of energy savings and the use of renewable energy. The rationale underlying the Energy Efficiency Strategy for Buildings is generally embedded in the overall political context, most notably the debate on building and housing policy and the Climate Action Plan 2050. At the same time, the Energy Efficiency Strategy for Buildings is orientated towards a long-term horizon until 2050 which means that it can address current, short-term need for action to a limited extent only.

The Energy Efficiency Strategy for Buildings starts from a reference scenario based on the actions so far taken in order to identify the possible gap for reaching the target by the year 2050. The reference scenario is based on an expert report commissioned by the Federal Ministry for Economic

Affairs and Energy (Prognos et. al 2015). Using two target scenarios which consider existing restrictions for increasing energy efficiency and developing renewable energies, the Energy Efficiency Strategy for Buildings then describes a target corridor within which a virtually climate-neutral building stock can be achieved by the year 2050. The scenarios map the current state of knowledge and therefore cannot finally forecast developments by 2050. On the basis of these results, the Energy Efficiency Strategy for Buildings identifies new measures which are yet to be discussed and elaborated in more detail and which can help to close the remaining gap to achieving the target. Moreover, further-reaching fields of action are identified which are to be discussed in a next step beginning in 2016 in a green and white paper process for energy efficiency and in the climate-friendly building and living strategy.

The Energy Efficiency Strategy for Buildings is not only embedded with the National Action Plan on Energy Efficiency in a national overall process for energy efficiency, but also reflects a corresponding development at European level. With a view to the EU's 2030 climate and energy framework, the European Commission is developing an "EU strategy for heating and cooling" in a parallel effort which, as part of an overall strategy and against the background of the current state of EU legislation, will identify options for Member States on how they can contribute at national level towards achieving the targets.

The energy transition in the buildings sector is ultimately a task for society as a whole to which citizens, the federal and federal-state governments, industry and academia will have to contribute. Companies have a key role to play as they develop solution paths and practically viable technologies. Efficiency technologies, new environmental products and energy standards must compete with the conventional products and requirements already established on the market. The government provides the necessary support by promoting research and development of new technologies as well as ongoing support for investment by individual building owners in order to boost energy efficiency or to increase the share of renewable energies.

Efficiency measures are a source of potential profits. Energy-efficient renovation measures and the use of renewable energies ensure modern living comfort and increased well-being, they reduce heating costs and increase independence from energy price hikes. Furthermore, the refinancing time of efficiency measures or the installation of systems using renewable energy can be significantly reduced if these measures are combined with maintenance and rehabilitation measures that are necessary anyway. A building's higher energy quality usually increases its value and can be an additional marketing proposition. However, issues regarding the acceptance of energy-efficient building and renovation projects must be considered even more than before.

The Energy Efficiency Strategy for Buildings is the strategy paper for the energy transition in the buildings sector and addresses both technical and energy aspects as well as first approaches or economic and, in the longer term, social interests of this area. Issues related to interaction between electricity and heat are also considered as a cross-sectoral task. The building strategy maps the current state of knowledge and therefore cannot finally forecast developments by 2050. It is hence important that the Energy Efficiency Strategy for Buildings be dynamically adapted to new, even sector-spanning, results as part of monitoring efforts in conjunction with the energy transition.

I. Targets of the energy transition in the buildings sector

Virtually climate-neutral building stock

According to the energy concept of 28 September 2010 and underlined by the 2014 progress report on the "Energy of the Future" (Energie der Zukunft) monitoring process, the Federal Government aims to achieve a virtually climate-neutral building stock by the middle of the century. Climate-neutral means that energy demand of buildings is only very low with most of the remaining energy demand being covered by renewable energy. This means that by the year 2050 primary energy demand must be reduced by 80 percent against the 2008 level through a combination of energy savings and the use of renewable energies.

Buildings are hence key to the basic goal of an 80 to 95 percent reduction in greenhouse gas emissions by the year 2050 against the 1990 baseline year. The increase in energy efficiency required here can be measured by the decline in final energy consumption whilst the necessary increase in the use of renewable energies can be measured by their growing share in final energy consumption (see number 1.3). Both elements together add up to the "primary energy demand" indicator which is relevant for achieving the goal of a virtually climate-neutral building stock.

The Energy Efficiency Strategy for Buildings determines the Federal Government's range of actions for the energy transition in the buildings sector. The measures and further options regarding energy efficiency and renewable energy on the heat market will be the subject matter of a discussion process. Considering the building stock until 2050, the buildings that will be newly erected by then should not be disregarded. Today's new buildings may not become the rehabilitation cases of tomorrow. This must be considered when erecting today's buildings. Should they fail to meet the criteria of climate neutrality despite this, it must at least be possible to retrofit and/or rehabilitate these buildings as required. The scenarios of the Energy Efficiency Strategy for Buildings therefore consider the time and dynamic aspects of the development forecast for the building stock in view of buildings both newly erected and demolished (Prognos et al. 2015).

The European context

The European Commission has identified a resilient energy union and future-orientated climate policy as one of ten priorities and to this effect published the "Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy" in February 2015 in which it lays down the following five dimensions: energy security, a fully integrated European energy market, energy efficiency, decarbonising the economy, and energy research.

In October 2014, the Member States already adopted a new EU 2030 climate and energy framework. The main elements of the decisions are a reduction in greenhouse gas emissions by at least 40 percent against the year 1990, the further development of renewable energies up to a share of at least 27 percent of final energy consumption, as well as an indicative energy efficiency target of energy savings of at least 27 percent. These targets can only be achieved if energy efficiency is increased significantly in the heat and cold market throughout Europe and if renewable energies are developed significantly at the same time.

The development of the Energy Efficiency Strategy for Buildings is hence embedded in a developing "EU strategy for heating and cooling". With a view to the targets adopted within the EU 2030 climate and energy framework, this European strategy will identify options for Member States to achieve the targets at national level. The EU strategy is based on the idea that the heat and cold market, which accounts for a share of around 50 percent of total final energy consumption in Europe, will have a key role to play when it comes to achieving the EU targets for 2030. The European strategy will probably aim to help Member States to find the most economical combination of energy efficiency and renewable energy in each case.

Different paths to the target of the energy and climate policy for buildings are generally conceivable in Germany. However, there are limits to both increasing energy efficiency and increasing the share of renewable energy for various reasons. These limits which exist from today's perspective will be discussed in detail in the following.

Broader targets of the Federal Government's energy concept

Buildings can go a long way towards achieving the targets of the energy concept. The first progress report adopted by the Cabinet on 3 December 2014 contains a hierarchical structure of the targets of the energy concept (**Fig. 1**).

According to this structure, buildings are making a major contribution towards the climate protection goals (reducing **greenhouse gas emissions**). The two **core goals** of the "strategy level" for buildings, i.e. increasing the share of **renewable energy** and **reducing primary energy consumption**, are also addressed by the target of the climate-neutral building stock.

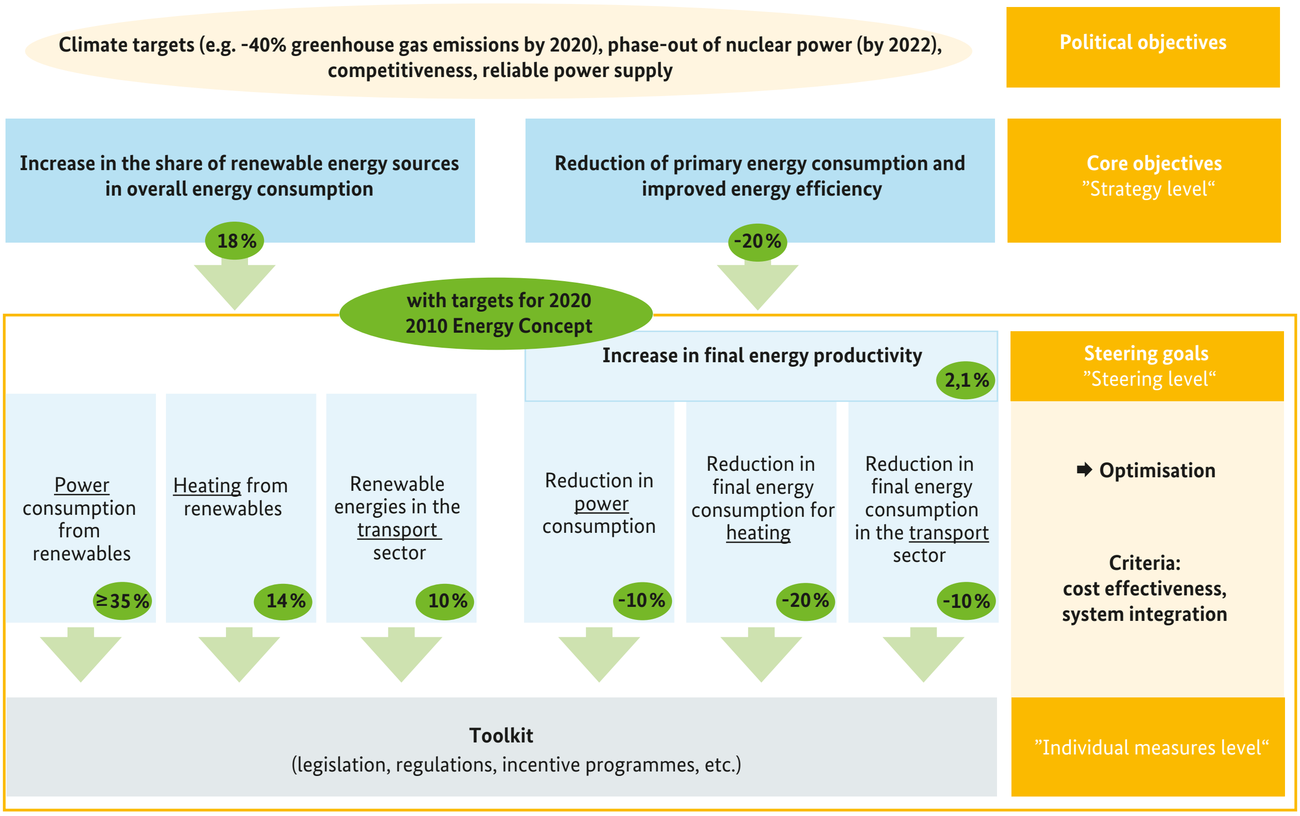
On the middle level, i.e. the steering targets, the buildings sector is addressed by the **"heat from renewable energy"** and **"final energy consumption for heat"** criteria. According to the energy concept, "heat demand" is to be reduced by 20 percent whilst the share of heat from renewable energy sources is to be increased to 14 percent, in each case by the year 2020. Furthermore, the "electricity consumption from renewable energy" and "reduction in electricity consumption" criteria are influenced by the energy consumption of buildings.

At the lowest level, the so-called "actions level", a host of actions and instruments have already been available for many years for buildings. The National Action Plan on Energy Efficiency and the Climate Action Programme 2020 are a sensible addition and strengthen the existing mix of actions. The necessary discussion of a further development of actions and instruments as well as further-reaching fields of action are initiated and identified in the Energy Efficiency Strategy for Buildings.

Reliable information and data regarding the target indicators of the building stock not only facilitate the evaluation of progress achieved and the preparation of forecasts and scenarios, but are also an important basis for the (further) development of the Energy Efficiency Strategy for Buildings. Current information deficits regarding the structure of the building stock, especially for non-residential buildings, will be eliminated in the coming years.

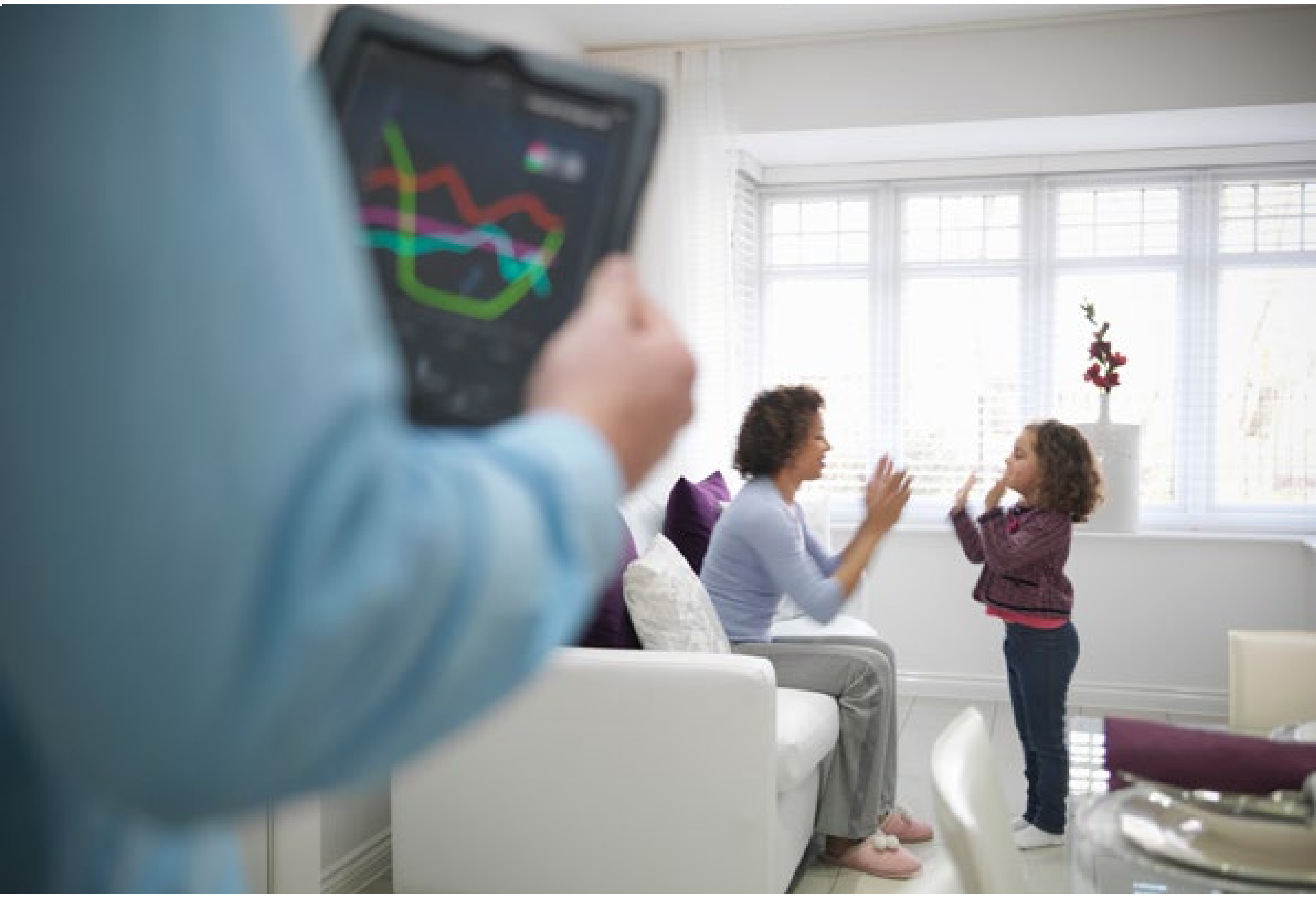
The following chapter will show for key issues and challenges of the buildings sector how the targets of energy and climate policy can be achieved from today's perspective.

Figure 1: Structuring of the targets of the Energy Concept, 2014 progress report



Source: own diagram

II. Energy Efficiency Strategy for Buildings – the 2050 building scenario



1. General conditions and corridor for target achievement

1.1 Development of a corridor for target achievement

Based on today's knowledge and information, the Energy Efficiency Strategy for Buildings identifies several possible paths and options which can help to achieve the target set in different ways and to a different extent. The underlying requirement is a largely technology-open approach which means that there is usually no single ideal path: A very efficient building envelope, for instance, can compensate for less-than optimum technical equipment or failure to use renewable energy. The same applies, of course, to the relationship between technical systems and building parts. An action corridor offers space for various combinations of measures on the path to the target. The action corridor in the buildings sector must also be reconciled with the options for action in the other sectors.

From today's perspective, the availability of renewable energy for electricity and heat generation is limited, with the costs of energy supply competing from an economic perspective with efficiency measures, and energy-related optimisation of the building envelope requires solutions at technical equipment level. Furthermore, technical and physical conditions must be considered which tend to a certain marginal benefit factor, i.e. a window with zero heat loss is not possible. Heat losses, in particular, can be minimised but not completely avoided.

The very heterogeneous building stock has developed historically over decades. This means that a rehabilitation strategy for buildings must be based on the existing building stock and orientated towards existing structures. The resultant restrictions in the building stock must be considered. Many buildings, for instance, cannot be insulated or to a limited extent only. Aspects of built heritage can have a role to play in conjunction with renovation options, or criteria for other buildings worth preserving must be fulfilled. Furthermore, preservation of other attractive buildings and neighbourhoods can also have an important role to play. Adequate rehabilitation solutions are required in such cases.

The Federal Government's goals are very ambitious so that the virtually climate-neutral building stock can only be achieved with highly efficient technologies and a very far-reaching decarbonisation of heat supply for buildings. This calls for correspondingly efficient overall solutions in buildings and very large shares of renewable energy in the provision of energy. Knowledge of existing potential and restrictions in buildings limit the target achievement path accordingly. Moreover, without a conclusive efficiency strategy for buildings, that also considers interactions with other sectors and political areas, such as the Climate Action Plan 2050, it will not be possible to achieve the goals of the energy transition. It is also important not to judge progress by inflexible, absolute energy saving effects alone, but also to additionally consider surface-related data.

The aim is to improve the data stock for buildings further. This specifically applies to the data basis and the energy characteristics of the stock of non-residential buildings. Relevant factors here include, for instance, valid data regarding the current condition of the building stock and its better classification, as well as up-to-date modernisation trends, energy consumption and the use of renewable energy as well as other relevant aspects. See also the Climate Action Programme 2020 ("data for climate-neutral building stock" action).

1.2 The target corridor resulting from the restrictions

In the runup to the preparation of the Energy Efficiency Strategy for Buildings, the Federal Ministry for Economic Affairs and Energy has commissioned a research consortium (Prognos, ifeu and IWU) to model scenarios for a virtually climate-neutral building stock by the year 2050 based on today's state of the art and considering the potentials and restrictions. The assumptions regarding infrastructure decisions as well as upper and lower limits for the use of different technologies and energy sources are the results of research and additional evaluations – also with a view to costs and investments – by the researchers. This applies to costs and investments.

The result of the evaluations by the experts show that an 80 percent reduction in primary energy demand of buildings would be generally possible with today's state of the art. However, the evaluations also show that the existing measures and instruments are not sufficient to exploit this potential and to achieve the target. Further action is necessary.

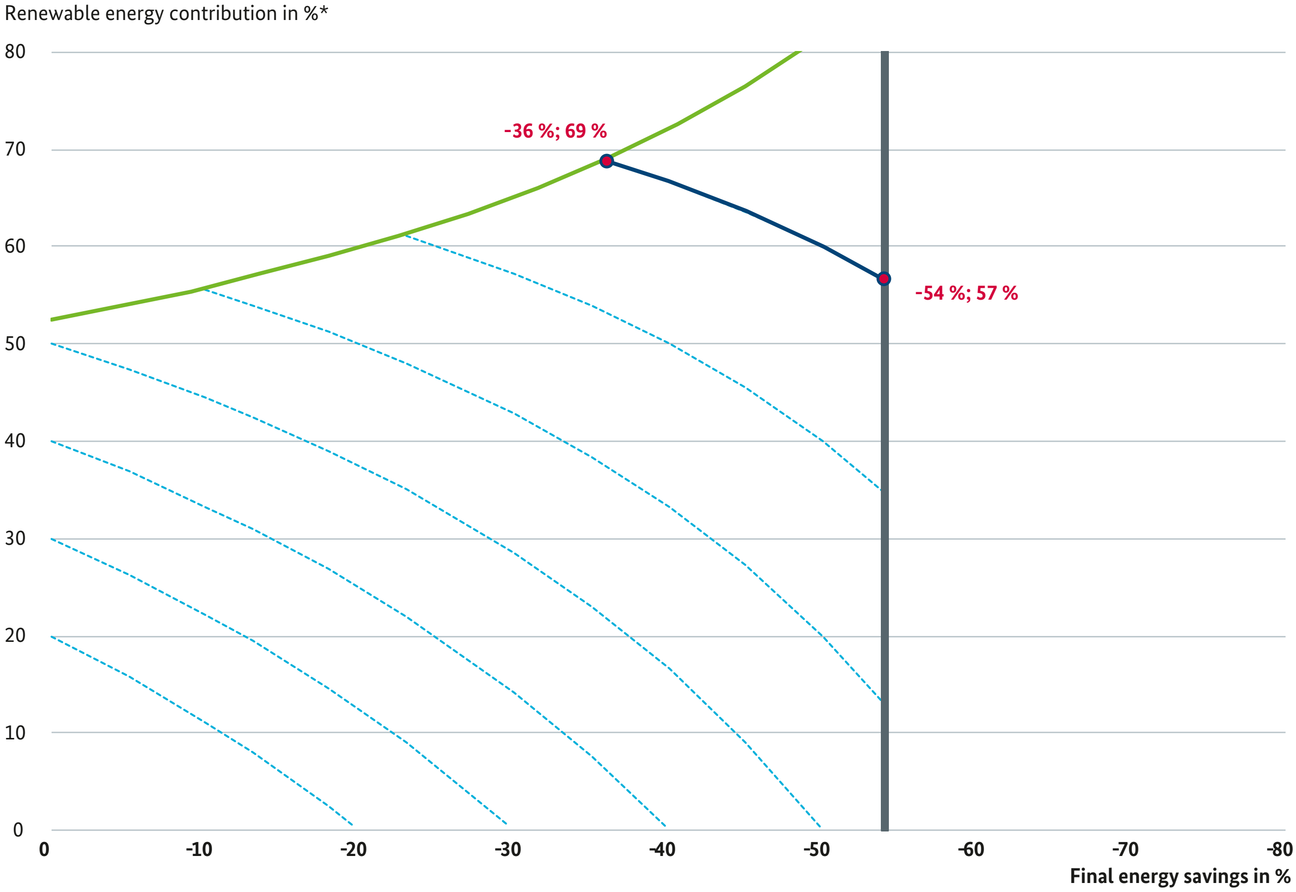
The evaluation of the results of the expert consortium shows that with today's state of knowledge a maximum total energy saving potential of minus 54 percent (final energy saving) can be achieved by the year 2050 compared to the year 2008 when considering all energy consumers, potentials and restrictions in the buildings sector. Energy consumers are heat supply systems for heating and hot water, cooling, ventilation and air conditioning as well as lighting (for non-residential buildings) (source: Energy Saving Ordinance). At the same time, there are limits to potential from today's perspective in the field of renewable energy with regard to its use in buildings: The experts estimate the upper limit to potential for renewable energy, electricity and district heating to total around 1,800 PJ in the year 2050 and the lower, more restrictive limit to potential to total around 1,400 PJ.

The restrictions and/or potentials together translate into a possible, narrowed target corridor: The upper limit to potential for renewable energy (around 1,800 PJ) corresponds to an efficiency increase by around 36 percent for achieving primary energy demand of 80 percent. With this combination, the share of renewable energy totals around 69 percent. The maximum efficiency increase of -54 percent which is possible from today's perspective calls for renewable energy slightly below the lower limit to potential of around 1,400 PJ. With this combination, the share of renewable energy totals around 57 percent (**Fig. 2**).

With regard to energy efficiency, a distinction must be made between the building envelope, the technical systems and lighting (within the meaning of the Energy Saving Ordinance, lighting means permanently installed lightning in non-residential buildings). Whilst even values beyond the total value of -54 percent could be achieved for the building envelope, the model calculations suggest from today's perspective rising energy consumption in the areas of cooling, ventilation and technical equipment despite the efficiency increases of equipment which the experts have considered in their forecast. The largest efficiency potential exists in the area of lighting where significant savings can be expected, for instance, with LED technology.

The following chapters will address the restrictions that exist in the areas of efficiency, renewable energy and building stock in detail.

Figure 2: Result of the target corridor considering the restrictions modelled in the fields of renewable energies and energy efficiency/energy savings, Prognos et al. 2015
Reducing primary energy demand by 80 % compared to 2008
– corridor remaining due to the two restrictions



* The renewable energy contribution expresses the contribution towards a decarbonisation of the general energy supply.

Source: own diagram

1.3 Restrictions for heat generation from renewable energy – assumptions

In buildings, renewable energy can be used in the form of **biomass**, **environmental heat** (such as geothermal energy) as well as **solar thermal energy** and **photovoltaics**. Furthermore, renewable energy can be used via heat grids and as **electricity from renewable energy** in power supply via heat pumps or in the heat market in the form of so-called power-to-X technologies. Additional infrastructures, such as heat grids, heat storage systems, smart systems, etc., will be needed for these purposes.

The total potential of renewable energy including heat grids and electricity from renewable energy that could from today's perspective be used in buildings in the year 2050 is estimated at around 1,400 PJ to around 1,800 PJ ((Prognos et al. 2015). This corresponds to 40 to 50 percent of present final energy consumption by buildings (2008: 3,491 PJ). Renewable energy sources include biomass, solar thermal energy, environmental and ambient heat as well as the use of renewable energy in heat and power grids (including electricity from photovoltaic systems). Heat grids are included in the potential for renewable energy in buildings. At the same time, it is assumed that no major quantities of wood will be imported as fuel from other countries. Furthermore, the experts also expect the potential of electricity from renewable energy sources to be significant, albeit not unlimited.

It should, however, be noted that these assumptions are subject to considerable uncertainty due to the long forecasting period of 35 years until the year 2050. The experts see the greatest uncertainties in the potential of electricity supply from renewable energy, due to fluctuating generation, seasonal dependencies (for instance, photovoltaics in summer, wind in winter), limited storage capacities as well as interaction between heat and electricity. From today's perspective, the experts expect that around 1,400 to around 1,800 PJ of heat from renewable sources will be available for buildings (**Table 1**).

These restrictive conditions translate into the marginal curve shown in **Fig. 3** for the coverage of energy consumption by renewable energy (upper marginal potential).

1.3.1 Biomass

Factors that limit the potential use of thermal biomass from sustainable production in buildings include

- Competition for cultivation areas in the case of liquid and gaseous biomass (competition between energy plant cultivation and other agricultural products, extensification of agriculture and other forms of land use), competition only limited, if at all, for cultivation areas in the case of solid biomass (such as pellets, wood chips, logs often from forests and industry wood residues)
- Competition between forms of use (use in other sectors, especially in the transport sector, for liquid or gaseous biomass, whilst solid biomass can be used for industrial process heat if the use of biomass were increased significantly in this area)
- Limited recycling potential
- Limited import potential due to demand for biomass in producing countries
- Lack of storage capacity in more densely populated areas
- Limitation of the total areas available for biomass use

Biomass potential is typically limited by raw material supply rather than by technical capacity. Competition for cultivation areas refers to competition between agriculture and other forms of landscape use on the one hand as well as between different agricultural uses on the other. It is expected that the entire potential area available for biomass production can be expanded in the long term to a limited extent against 2015 (ifeu: by 20 percent). Competition for use between the different sectors is possible at the level of biomass use for energy purposes. Heat generation, in as far as liquid or gaseous biofuels are used, can compete with uses in the mobility sector. Especially in the fields of mobility as well as power and process heat (high-temperature) generation , biomass is as it stands today often the only possibility to use renewable energy sources and to reduce greenhouse gases.

The maximum biomass potential including waste and imported biomass is currently estimated at 1,300 PJ (IFEU 2015) to 1,600 PJ (FNR 2012). In the long term until 2050, a maximum of around 500 PJ of this will be available for building heating (Prognos et al). To put this into perspective: Up to around 300 PJ of heat for buildings is today already generated from biomass in biomass boilers and cogeneration plants using biomass.

1.3.2 Environmental heat (heat exchangers, heat pumps)

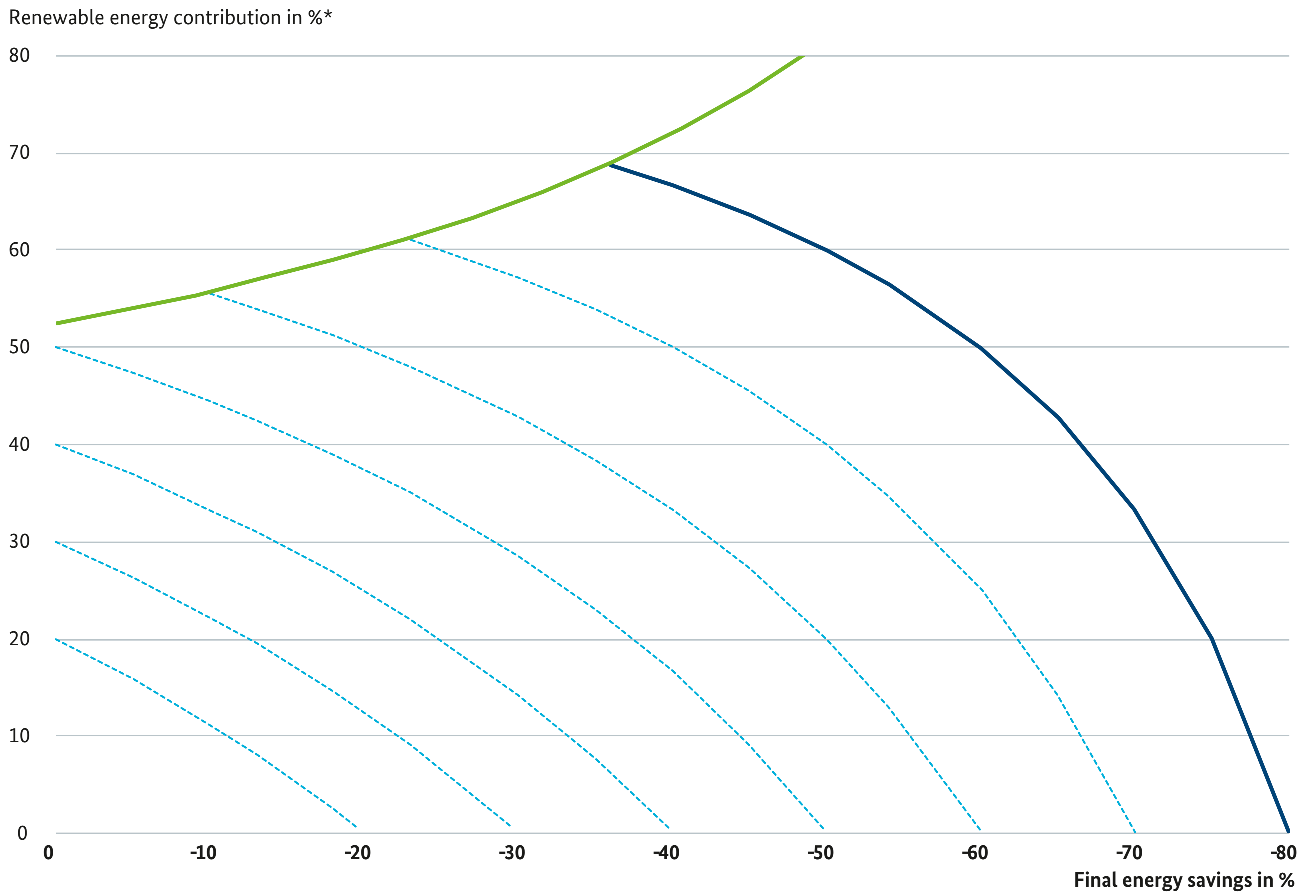
Heat pumps are subject to restrictions in terms of heat demand and heat sources. On the demand side, the temperature level to be provided is determined by the heat transmission system. The lower the necessary flow temperature, the more efficient the heat pumps, so that they are usually less efficient in buildings with conventional radiators than in buildings with panel heaters. This restriction applies especially to existing buildings because conversion, for instance, to underfloor heating and/or panel heaters is often not possible there.

Table 1: Potential for renewable energy in buildings

	Lower limit (in PJ)	Upper limit (in PJ)
Biomass	250 – 290	500
Solar thermal energy	190	250
Ambient heat	210	360
Sub-total	**650**	**1,110**
Plus use of renewable energy in/as		
Heat grids	+ 300	
Electricity from renewable energy	+ 430	
Total	**1,380**	**1,840**
	Mean value: around 1,600 PJ	

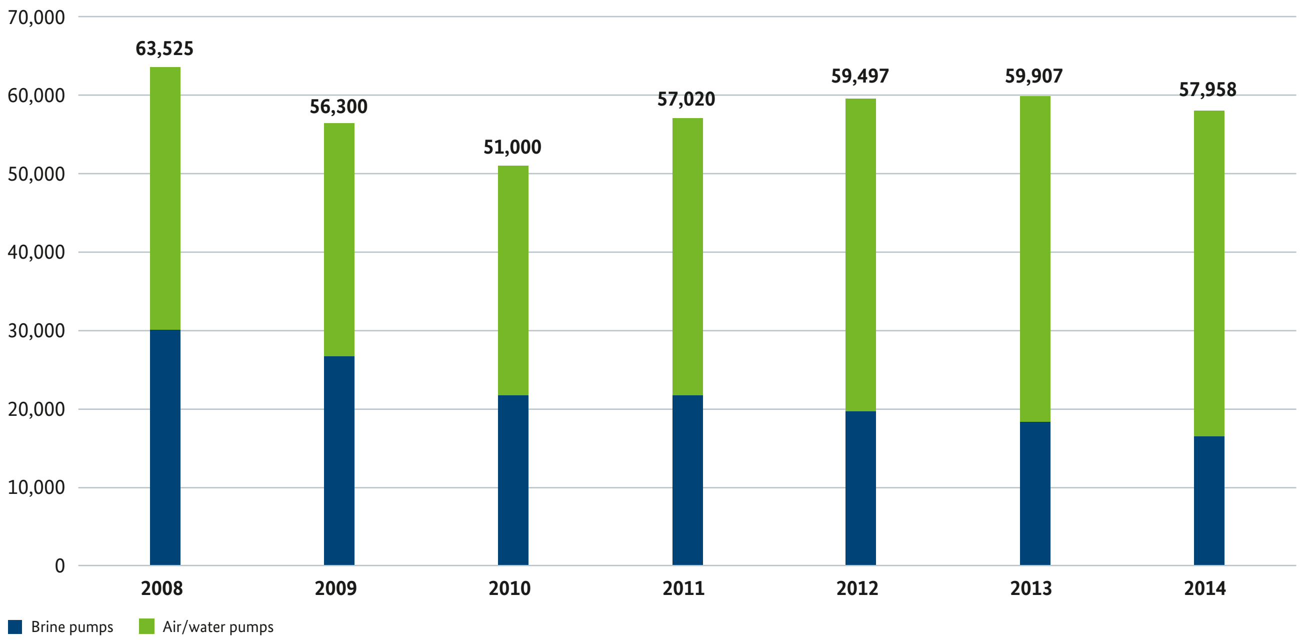
Source: Prognos et al. 2015

Figure 3: Restrictions to the use of renewable energy
Reducing primary energy demand by 80 % compared to 2008
– here restrictions to the coverage share of renewable energy



Source: own diagram

Figure 4: Sales of heat pumps for heating in Germany from 2008 to 2014



Source: bwp 2014

The upper limits assumed for the potential of **heat pumps** of **210 PJ to 360 PJ** are based on assumptions of varying market development rates (IFEU et al. 2014, Prognos et al. 2015). **Fig. 4** shows heat pump sales since 2008.

1.3.3 Solar thermal energy

The potential for solar thermal energy is limited by the following factors:

- Dimensions and orientation of existing roof surfaces
- Competition with photovoltaic modules for surface areas
- Asymptotic yield curve
- Restrictions due to structural stability and design conditions
- Restriction of the surface coverage ratio as a function of building efficiency and storage capacity

The experts estimate the possible lower potential for solar thermal energy at around 190 PJ, however, only on the basis of single-family and two-family homes. The potential for large-scale solar thermal plants is determined to a lesser degree by the availability of surfaces than by the municipal and regional situation, such as the availability of heat grids for feeding in solar heat or other low-cost heat sources (including, for instance, waste heat from combined-cycle power plants) and the willingness to use agricultural land for the installation of **solar thermal plants**. The upper limit can hence be estimated only roughly at around **250 PJ**.

1.3.4 Other applications for PV electricity

Electricity from renewable energy can be used to drive heat pumps and to supply any other electric loads in buildings with dedicated PV supply systems. This concerns, above all, electric hot water boilers (with heat pumps or electronically controlled continuous-flow water heaters), lighting and air conditioning in non-residential buildings as well as the ancillary electrical energy needed to power technical building systems. This means that the currently installed PV capacity will have to be increased. Excessive PV electricity generation can, for instance, be stored in decentralised battery storage systems. This will also reduce the amount of PV electricity fed into the grid. The battery charging process must be combined with PV and load forecasts in order to avoid feed-in peaks into the grid.

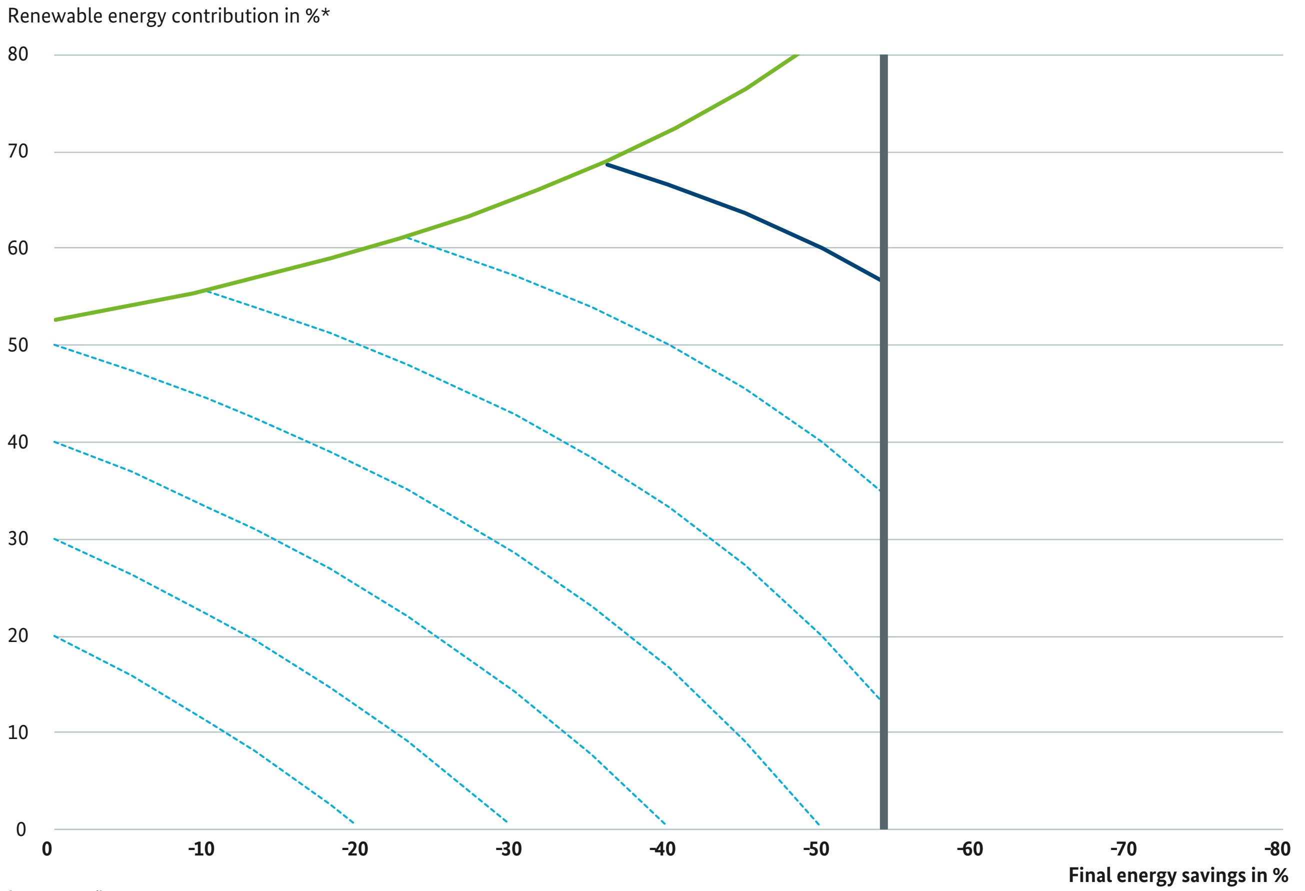
With regard to other electricity from renewable energy, the restrictions do not imply any potential limit; instead, electricity from renewable energy will close the remaining gap to target achievement when all other potential options have been exhausted. Today's consumption totals around 500 PJ (2008). Future electricity from renewable energy used for other purposes will be in the same order of magnitude.

1.4 Restrictions to reducing energy demand through efficiency measures

From today's perspective, the energy efficiency potential is also subject to certain restrictions. The experts have identified a maximum achievable total potential of around -54 percent through efficiency measures for the totality of applications for room and water heating, ventilation and air conditioning, lighting as well as necessary auxiliary energy (Prognos et al. 2015). This means that the minimum final energy demand of close to 3,500 PJ in 2008 will still be in the order of around 1,600 PJ in 2050.

Besides the restrictions for renewable energy discussed earlier in this document, the marginal potential of -54 percent shown in **Fig. 5** applies to energy savings:

Figure 5: Efficiency restrictions (vertical black line) in addition to the restrictions for the use of renewable energy (upper limit, green curve)
Reducing primary energy demand by 80 % compared to 2008
– here restrictions regarding energy efficiency



Source: own diagram

There is hence significant room to increase the potential for energy efficiency in buildings. However, this potential must be differentiated in terms of building envelope insulation, use of efficient windows or other façade elements, air-tightness of buildings as well as use of highly efficient technical systems or lighting.

At the same time, the building as a whole must be examined with a view to its potential for energy efficiency because the individual parts and structural components of a building influence its energy consumption and total energy efficiency in very different ways.

The efficiency restrictions will be explained below.

1.4.1 Maximum potential to increase building envelope efficiency

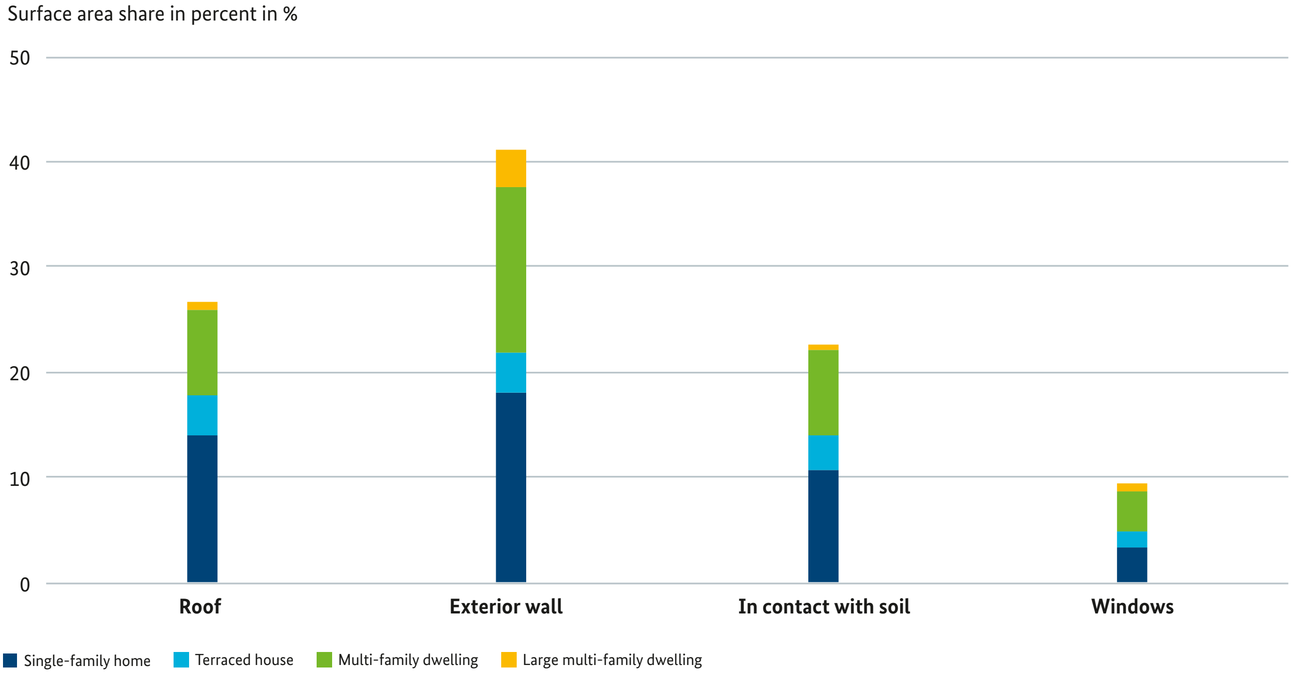
The so-called U value (heat transfer coefficient) of the building elements is an important parameter for the efficiency of the building envelope. Furthermore, the degree of solar radiation permeability has an important role to play for windows and other transparent building elements. This is desirable in winter, but can become an annoying factor in summer with insufficient thermal insulation and overheating of rooms. Solar energy exposure can be a key parameter for cooling buildings.

The building envelope consists of the exterior walls which account for more than 40 percent of the exterior surface, the roofs and/or the top floor ceilings (27 percent) and the building parts in contact with soil (22 percent) in the basement area as well as the windows (10 percent). The respective shares vary depending on the building type, for instance, in the case of roof surfaces (**Fig. 6**).

Exterior wall

Insulation can strongly increase the energy-saving properties of exterior walls. However, there is a technical limit to this improvement. According to the current state of the art, the U value of exterior walls cannot be reduced infinitely. A U value of around 0.1 W/m²K is currently considered to be the maximum value that can be achieved from a technical and economic perspective.

Figure 6: Distribution in percent of the thermal envelope according to building elements and building type



Source: Beuth Hochschule für Technik Berlin, ifeu 2015

In recent years, especially after the introduction of the first Energy Saving Ordinance in 2002, activities in the field of thermal insulation improved significantly. The energy-saving features of insulation materials also improved further. Building envelopes also offer a substantial energy saving potential. Technical and economic restrictions must be considered as well. From a technical perspective, the U value that can be achieved through rehabilitation measures is limited by the existing exterior wall as well as the thickness and thermal conductivity of the insulation material used. Largely independent of the original condition and considering different thermal conductivity rates of building materials, a limit value of 0.1 W/m²K is possible from today's perspective (**Fig. 7**).

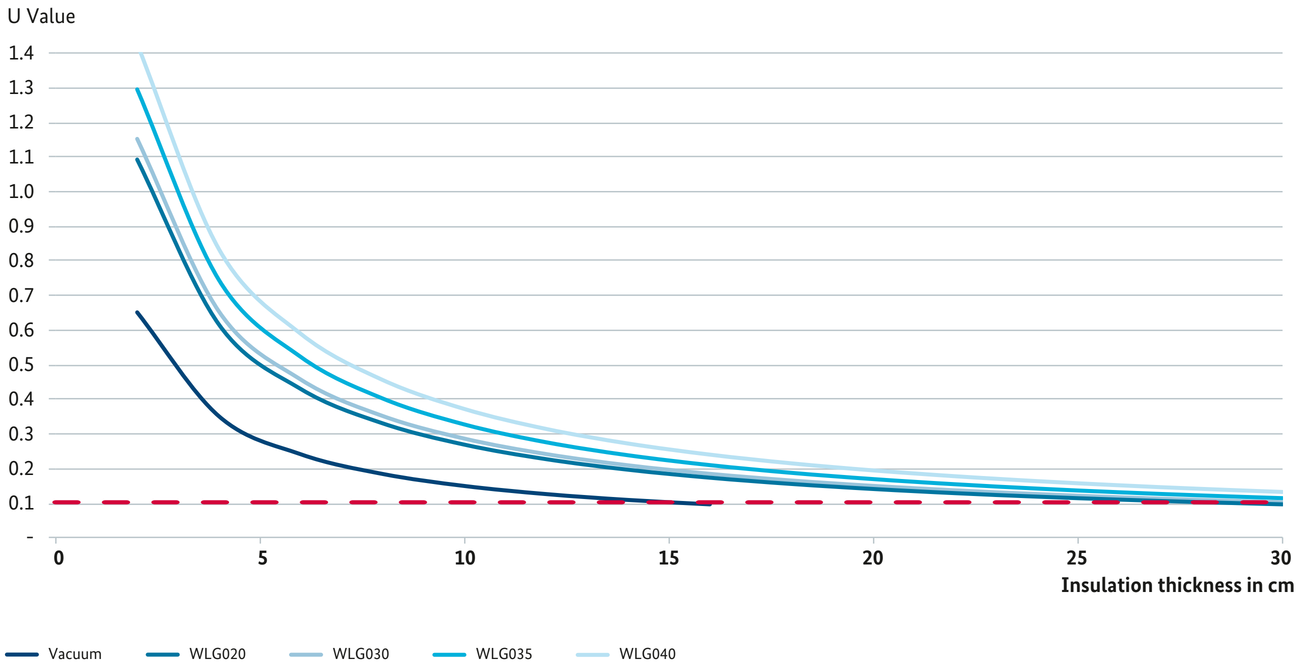
This limit value, which also includes aspects of costs, economic efficiency and ecobalance, applies to conventional insulation materials as well as new materials, such as high-performance vacuum insulation panels or innovative insulation materials, such as PCM, aerogels, etc. From today's perspective, values below this limit value are not to be expected (Prognos et al. 2015).

In practical use, the theoretical U value of 0.1 W/(m²K) is subject to a host of further restrictions. Besides technical restrictions due to structural, physical and geometrical conditions, economic and other restrictions (for instance, protection of built heritage) must be considered. This means that it will not be possible to achieve this limit value for all buildings in the country. These restrictions are taken into consideration in the scenarios.

Windows

The energy-saving quality of new windows (triplex glazing and improved frames) reduces the energy demand of buildings significantly. This effect is particularly felt when windows are replaced as part of renovation projects. A further positive development of energy characteristics can also be expected in future, with a reduction in the mean U values of windows to up to 0.5 W/m²K being possible depending on the level of ambition and technical progress until 2050.

Figure 7: Influence of the thickness of insulation material on the U value of a wall element; U value limit of around 0.1 W/m²K
U value as a function of building material (thermal conductivity group WLG)



Source: own diagram

On average, windows account for up to 25 percent of the façade surface. Since the U value of windows is less favorable than that of exterior walls (a factor of around 5 with new building elements), windows have a crucial impact on the building's energy efficiency. However, sun radiation through windows during the heating period also has a positive impact on the energy balance. In summer, however, sun radiation can cause undesired heating of buildings (cooling demand that results in higher electricity consumption).

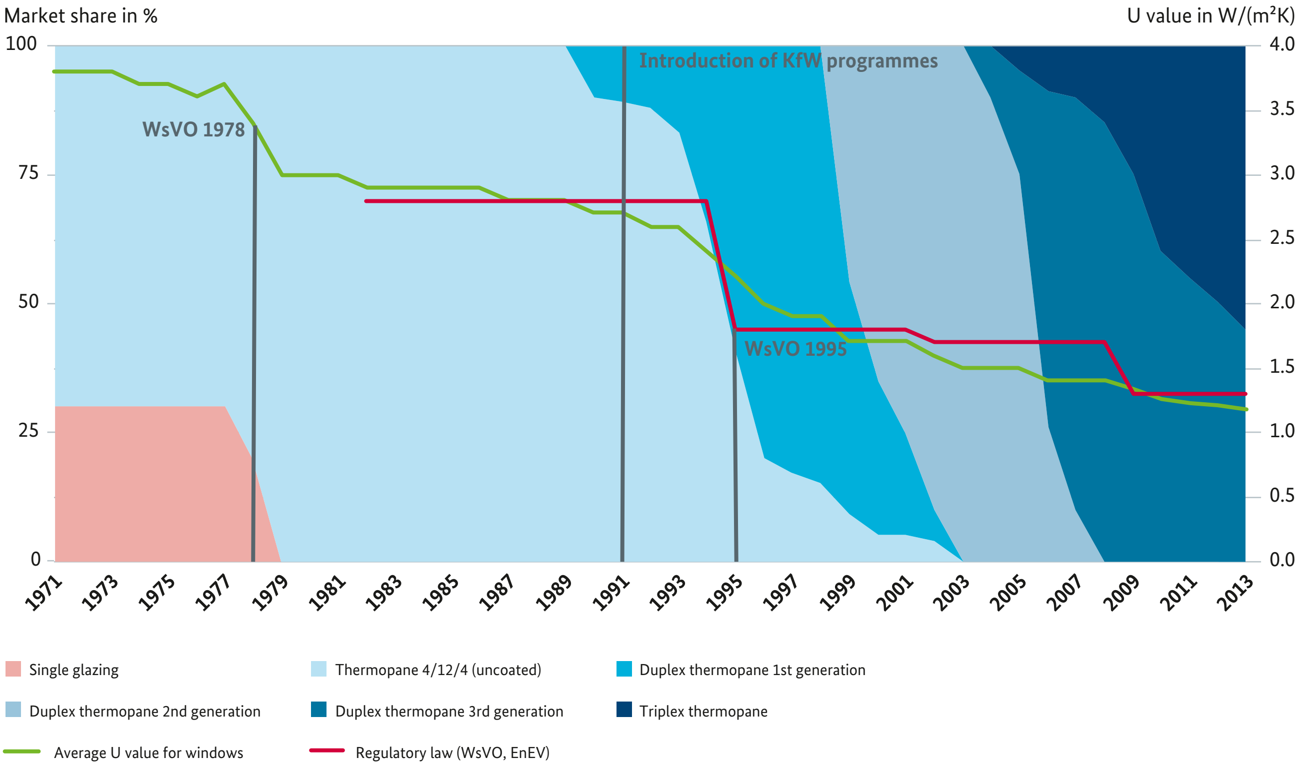
The energy-saving quality of windows has continuously improved since the 1970s. The average U value of newly installed windows currently totals around 1.2 W/m^2K. Today, windows with triplex thermoglazing and a U value as low as 0.8 W/m^2K have become state of the art. The introduction of triplex glazing has enabled another technology leap with significantly better U values (as low as 0.8 W/m^2K). In 2013, windows with triplex glazing already accounted for around 50 percent of sales on the market (**Fig. 8**).

Thermal bridges

Thermal bridges will in future have a stronger influence on the energy efficiency of buildings. With renovation projects on the rise and hence lower heat losses, losses due to thermal bridges will account for above-average shares. Moreover, building with practically no thermal bridges is possible today. By the year 2050, building envelope renovation projects with optimised thermal bridges will offer major savings potential.

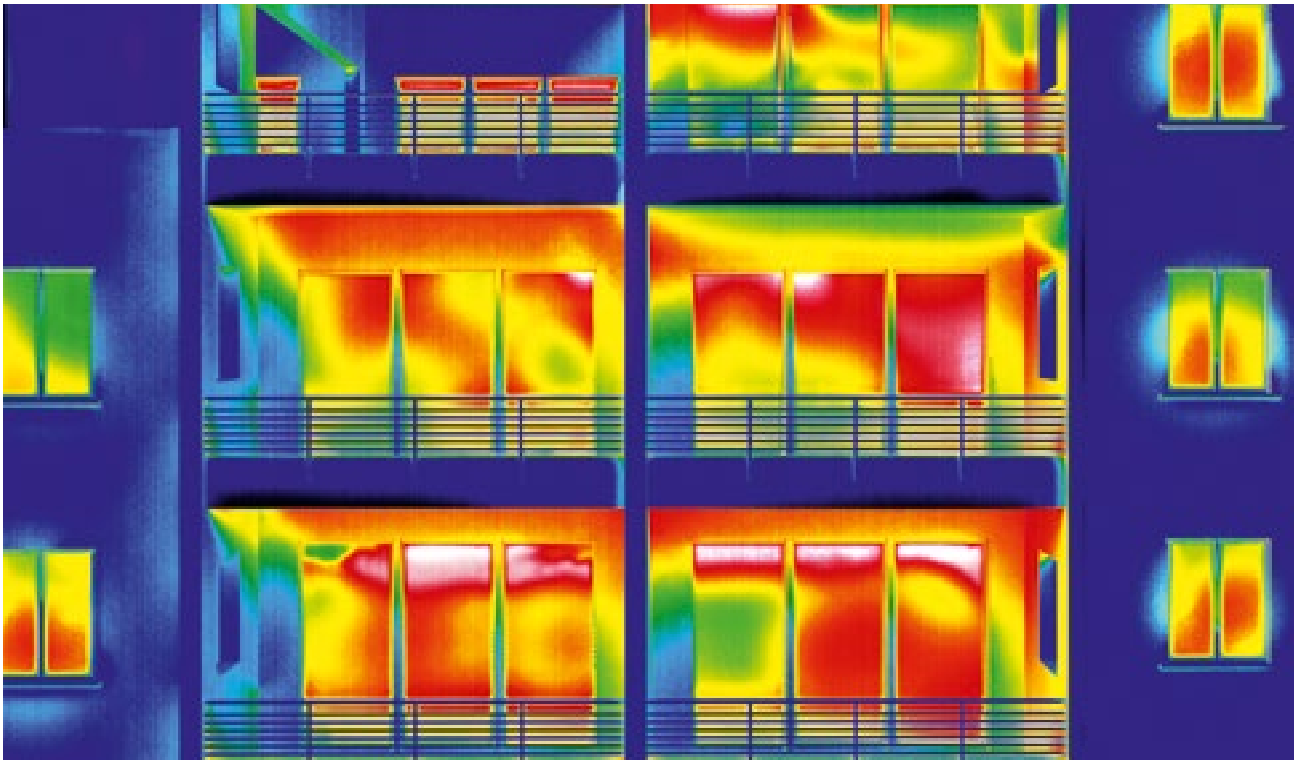
Thermal bridges are thermal flaws in the building envelope and are usually due to less-than-optimum connection details of building elements. The heat loss at these flaws is greater than in "undisturbed" areas of building elements. Typical areas are connections of balconies and windows, corners and transitions between building elements, for instance, between walls and roof, etc.

Figure 8: Development of the energy-saving quality of windows (mean U value)



Source: Prognos, BV Flachglas, 2015

Figure 9: Thermographic image of a thermal bridge in a window lintel area



Source: dena 2008

Apart from higher energy losses, thermal bridges cause particular problems if the temperature of the internal surfaces of the component concerned is too low at these bridges causing increased humidity (condensate). This often means a risk of mould which can also damage the building structure. Better thermal insulation of buildings and the avoidance of thermal bridges mean higher temperatures of internal surfaces and hence not least also gains in user comfort. Optimised design details can today help to eliminate thermal bridges almost completely.

1.4.2 Maximum efficiency boosting potential with heating and other technical systems

The energy efficiency of heating and other technical systems is an important factor when it comes to determining final energy demand. Another crucial factor is the source of energy (gas, oil, environmental heat, solar radiation, etc.) used to cover this demand.

Heating

The greatest potential to boost the energy efficiency of conventional heating systems is to replace constant-temperature and low-temperature boilers with condensing boilers. The average efficiency potential is today considered to correspond to a 15 percent increase in efficiency.

Furthermore, using renewable energy as primary source (see chapter 1.3) also offers substantial potential.

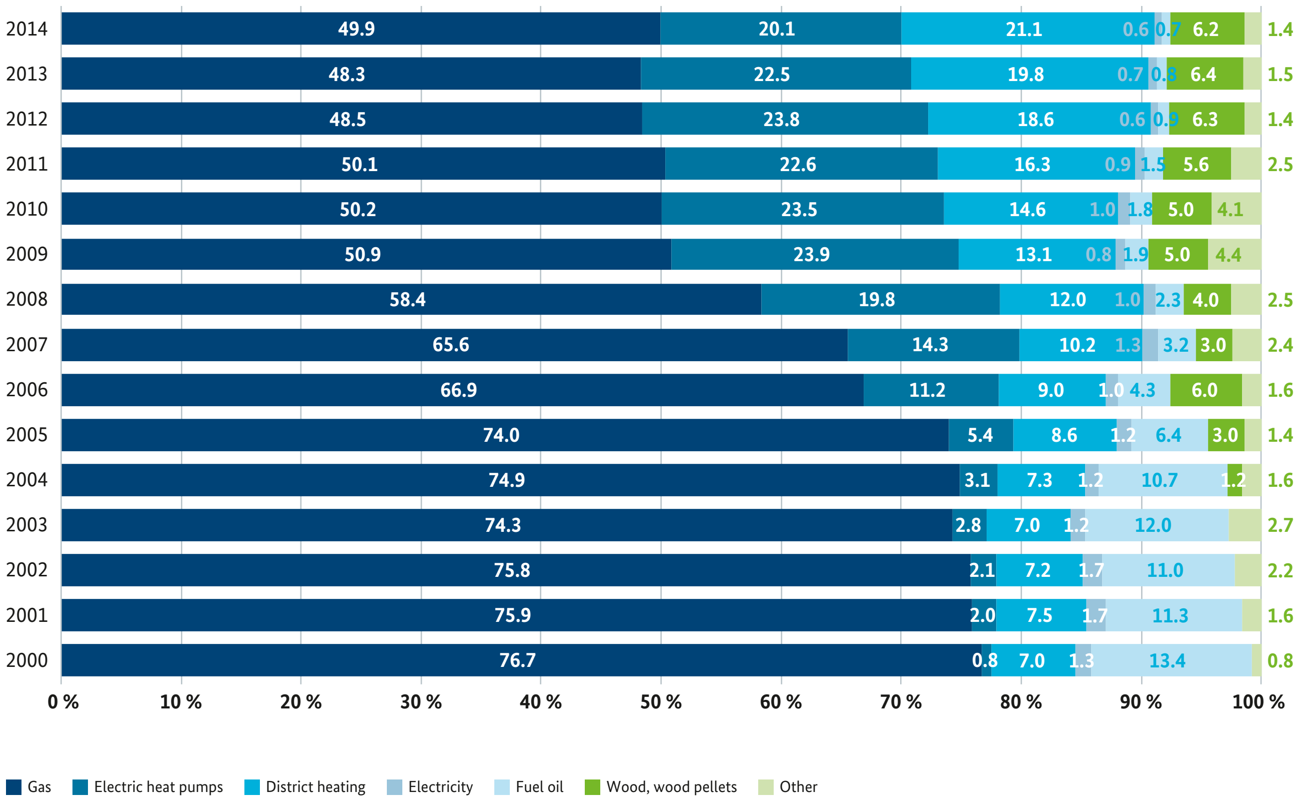
The discussion on restrictions is based on the current structure of heating systems in existing buildings in Germany. At present, oil and gas-fired boilers are the typical system in single and two-family as well as multi-family dwellings.

In 2011, around 21.3 million heat generating units were installed in Germany, more than 10.5 million of which were gas boilers. Oil boilers rank second with around 6 million units. Furthermore, around 0.8 million biomass boilers and 1.5 million heat pumps are installed. Some two million buildings are still heated by inefficient electric night storage heaters. Around 350,000 single and two-family homes as well as 700,000 multi-family dwellings are supplied by heat grids.

The building stock is characterised to a large extent by gas and oil-fired heating systems, with the existing gas and, in particular, oil fired heating systems being severely outdated. The average age of the heating systems in multi-family dwellings totals around 20 years. The average age of the heating systems in single and two-family homes totals 16 years. Outdated constant-temperature boilers account for around 13 percent of the existing central heating systems. Gas and oil-fired low-temperature boilers are particularly widespread, accounting for around 60 percent of all of today's systems. Condensation boilers represent the current state of the art for oil and gas heating systems, but at present account for a share of only around 21 percent.

In recent years, some 600,000 to 700,000 new heat generators were installed each year. Gas is still the most important energy source for **new buildings**. Demand for oil heating in new buildings is down to almost zero. The share of oil as an energy source in new buildings is below 2 percent. Electric heat pumps are installed in a persistently growing share of new buildings. The share of gas-fired heating systems is gradually giving way to heat pumps and currently totals approximately 50 percent. The share of buildings supplied from heat grids is also growing. This is due to the fact that construction activities focus on densely populated urban areas where district heating is often available (**Fig. 10**).

Figure 10: Heating systems in new flats 2000 to 2014



Source: Federal Statistics Office 2015

Energy efficiency can also be achieved with more efficient heat generating units, i.e. higher degrees of utilisation over the year and lower equipment distribution and interface losses. The average final energy saving potential hence totals around 15 percent. The efficiency of a gas-fired condensation boiler is somewhat higher than 96 percent (annual utilization). The annual utilisation of low-temperature boilers totals around 90 to 95 percent and averages at around 85 percent for oil-fired boilers. Oil condensation boilers can reach a value of up to 95 percent.

Heat pumps

Heat pumps are technically mature systems with significant potential regarding the use of renewable energy. Heat pumps can also easily feed electricity from renewable sources into the heat market. Efficient operation of heat pumps is usually only possible in renovated buildings and in conjunction with panel heaters. However, the efficiency of heat pumps can vary significantly in response to extremely cold winter days and incorrect installation and to a greater degree than conventional heating systems.

Heat pumps raise environmental temperatures to a level needed to heat buildings. Typical sources are air, soil, groundwater or exhaust air. The required work is usually supplied in the form of electricity. Gas heat pumps are less common on the market. The following heat pump systems are distinguished in technical terms:

- Brine heat pumps:
  a. Horizontal flat collectors (usually installed close to the surface) or
  b. Vertical soil probes (usually extending up to 100 m deep into the ground) extract heat from the ground (subject to drilling permit)

- Water heat pumps: The required thermal energy is removed from surface-near groundwater (subject to approval under water law)

- Air heap pumps: A ventilation system removes thermal energy from exterior air.

Furthermore, heat pumps are differentiated depending on whether they use water or air in order to supply the building with heat. Panel heating systems (for instance, underfloor heating) or radiator systems are generally suitable for water, whilst controlled ventilation systems are used when air is the heating medium.

The total efficiency varies strongly between the above-mentioned systems. The smaller the temperature difference between the heat source (soil, water, air) and the heat sink (heating system), the greater the efficiency of heat pumps.

The coefficient of performance (CoP) of heat pumps has been increasing for many years. The CoP of **brine-to-water heat pumps** has increased by 25 percent, with the most efficient brine/heat pumps today achieving a CoP value of 5.0. **Water-to-water heat pumps** even achieve significantly higher CoP values of 6.3. **Air-to-water heat pumps** saw a 37 percent increase in the CoP value to up to 4.4 during the same period. Further technical improvement potential exists especially with a view to air-to-water heat pumps (Prognos et al. 2015).

Besides the theoretical CoP values, the real installation situation and the other heating components (storage, distribution, hot-water generation) are crucial parameters for heat pumps (efficiency of the entire system).

Combined heat and power plants (CHP)

Mini, micro or nano CHP systems offer potential to increase heat generation efficiency especially in existing buildings. The higher the electrical degree of utilisation of the system, the lower the resultant primary energy demand due to the electricity credit method. From today's perspective, however, CHP systems are only suitable for larger heat demands (for instance, in multi-family dwellings).

Significant energy savings can be achieved, for instance, by using waste heat, an inevitable by-product of power generation, for instance, for hot water. Cogeneration systems in the lower power range (up to 50 kW) are also called electricity generating heating or combined heat and power (CHP) units. Single and two-family homes use so-called micro CHP units with an electrical output of up to around 2 kW_{el}. Efficiency varies depending on the underlying technical principle (Otto, Diesel, Stirling engine) and total efficiency levels of more than 100 percent are possible.

From an economic perspective, the conditions for using engine-based CHP systems in existing buildings are fulfilled because the required operating times are achieved there due to the higher heat demand.

Large energy saving potential is also offered by fuel cells where, in contrast to engine-based CHP systems, energy is converted by an electrochemical process. Unlike engine-based CHP solutions, fuel cells are also suitable for new buildings because they can also be operated in the lower power range. Due to the small quantities so far installed, it is not yet possible to assess their potential.

Heat grids

Heat grids require a high connection density (densely populated areas) and low temperatures of the heat transfer medium in order to achieve maximum energy efficiency during operation. Energy efficiency can be increased even further by additionally feeding the heat grids from CHP plants. Moreover, CHP plants and energy from renewable sources (see chapter 1.3) can also reduce primary energy demand. A final assessment of the potential of heat grids in the Energy Efficiency Strategy for Buildings is not yet possible today. This is why the generation potential of 300 PJ which is today already used is used as a basis (Prognos et al. 2015).

In densely built-up urban neighbourhoods, heat distribution grids are short and the resultant grid losses low, so that district heating systems can be used there. This can ensure reliable heat supplies in conjunction with renewable energy and combined heat and power systems. However, this potential is strongly dependent upon the number of users connected to such grids and therefore difficult to estimate today. The net losses of heat grid per unit of heated building surface vary strongly and depend on the length of the heat grid as well as the connection density.

In order to boost efficiency, existing heat grids can be further concentrated so that heat density can be increased and distribution losses reduced. Solar thermal modules, photovoltaic systems (power to heat), fuel cell systems or large-scale heat pumps can also be integrated into heat grids.

From today's perspective, the use of heat grids in (rural) areas with a low connection density is difficult for energy-related and economic reasons, but may well make sense if waste heat potential exists.

Heating optimisation – hydraulic balancing

Optimising heating systems through hydraulic balancing is a cost-effective measure for boosting efficiency and should hence be carried out at least when a heating system is to be replaced or when major work on the building envelope is carried out.

A hydraulically balanced heating network ensures that radiators are supplied with the heat which they need at any given time, thereby enabling energy-efficient and economical operation of the heating system. Furthermore, adverse effects on user comfort due, for instance, to insufficient or excessive supply of heat to radiators (rooms) as well as flow noise at radiator control valves can be avoided. Hydraulic balancing can lead to average final energy savings of 8 to 10 kWh/m². However, potential varies greatly depending on the building type and its age (in old buildings, for instance, remedying undersupply for individual radiators can improve user comfort, but at the same time may also increase consumption).

Ventilation systems

Ventilation improves the quality of room air. Automated ventilation systems can avoid the problems (mould, damage to buildings) otherwise frequently found as a result of excessively high humidity. Efficiency increases can be achieved through ventilation systems with heat recovery by minimising ventilation heat losses and at the same time re-using the heat that exists in buildings for heating. However, the extent of this potential is strongly dependent upon the building and its respective use so that no general statement regarding total potential is possible.

Energy-efficient buildings must be as air-tight as possible. This leads to new requirements for the ventilation of such buildings because insufficient air changes in buildings can damage the building or cause mould due to high humidity levels. This damages the users' health and adversely affects user comfort and well-being. Humidity damage is today found in around every fifth home in Germany, often caused by insufficient ventilation (windows). Automated building ventilation is therefore becoming increasingly important.

Ventilation patterns and leaks in the building envelope have an impact not only on room air quality and user comfort, but also on heating energy consumption. Ventilation patterns (through windows) are greatly influenced by personal perception and can therefore differ considerably from the level that would be required to keep humidity at bay. The consequence is unnecessary energy consumption: Heat losses due to ventilation can account for up to one quarter of total losses in buildings with a low renovation standard. Ventilation systems with heat recovery include heat exchangers to recover the heat that exists in the building in order to pre-heat the air which is drawn in from outside before it is directed into the room. This reduces the heating demand of a building directly.

State-of-the-art ventilation systems with heat recovery achieve heat recovery rates of up to 93 percent. The efficient use of a ventilation system with heat recovery requires a certain minimum insulation standard for the building envelope. Ventilation is especially vital in highly efficient, air-tight buildings. Although the share of buildings of this type has increased considerably in recent years, only around one percent of residential buildings and eight percent of non-residential buildings are fitted with a ventilation system with heat recovery. However, this share is expected to increase significantly by the year 2050.

Although final results regarding the total potential of ventilation systems in all existing buildings are not yet available, evaluations suggest that a substantial increase in energy efficiency is possible in renovated buildings and in new buildings fitted with ventilation systems with heat recovery. The ventilation systems were considered accordingly in the scenarios (Prognos et. al 2015).

Air conditioning/cooling of non-residential buildings

Optimising air conditioning and ventilation systems in non-residential buildings with a view to energy consumption offers a significant potential for energy savings, especially in cases where the original systems did not include heat recovery that can now be added.

Up to 420,000 ventilation systems with cooling functionality are installed in the around 3 million non-residential buildings. The average age of these systems totals close to 30 years. Economically extremely effective optimisation steps, such as replacing fans, using demand-based volume flow control and optimising control systems, often enable savings of more than 20 percent in power consumption. The total primary energy saving potential that can be generated from operation optimisation measures and component replacement is estimated at a good **200 PJ** (Prognos et al. 2015).

Lighting (non-residential buildings)

Sensible improvement measures for lighting systems in non-residential buildings which include lighting control systems and the use of efficiency increases offered by LEDs can open up substantial efficiency boosting possibilities.

Many lighting systems (control systems, including light bulbs and fluorescent tubes) in non-residential buildings are outdated. This leads to high energy consumption. Sensible improvement and/or replacement of lighting systems even before the end of their useful life in buildings are currently neither required by the legislator nor implemented at a planning and design level to the extent which is in fact necessary and to be expected. The possible energy saving potential is believed to be high. Payback periods for the replacement of (halogen) bulbs with compact fluorescent tube-light fixture (CFLs) typically range between 1 and 2 years.

Besides fluorescent lighting systems with electronic ballast units, other types of lighting, such as LEDs, are also an option depending on the particular type of use. If space and use times allow the **use of daylight**, this can be improved by daylight-dependent lighting control systems. The effectiveness of suitable systems for daylight-dependent lighting control can reduce energy consumption by 15 to 20 percent.

Building automation and energy management systems

Building automation can boost energy efficiency in buildings. This requires, amongst other things, comprehensive information about building users in order to translate the possibilities to practical use.

Space and building automation systems including smart home functionalities enable greater energy efficiency in residential and non-residential buildings. Building users can control their energy consumption to a very large extent. The energy saving potential that is possible and efficiency advantages of space and building automation systems as well as technical building management can only be exploited if the operation of the automation and building management systems is adapted to user behaviour. If the users are continuously informed about their energy consumption and the savings achieved, they can put automation and building management systems to good use and thereby minimise energy consumption. Various smart home technologies can offer valuable help. The Federal Ministry for Economic Affairs and Energy is planning to commission a study on suitable applications and the precise savings potential of individual smart technologies.

1.4.3 Use of internally generated power in buildings

Combining electricity loads and/or systems with internal generation based on renewable energy is technically feasible and economically often interesting because the costs of generating one kWh of PV electricity are often lower than electricity from the public utility. This is, however, due to the various forms of support and subsidies for electricity generated and consumed internally compared to power supplied by utilities. On the other hand, this support and subsidy regime for electricity generated internally with regard to grid charges and concession fees, the levy in conjunction with the Renewable Energy Act as well as further duties, taxes and levies mean that other electricity customers have to bear a correspondingly higher burden (so-called "desolidarisation" effect). Although the quantities and redistribution effects are at present still relatively small, the potential should not be neglected in the longer term: If, for instance, a photovoltaic system is combined with an electricity storage (for balancing day and night generation and demand), coverage rates of more than 60 percent (monthly balance) can be achieved when considering the power demand of household appliances. Against this background, the Federal Government is planning to develop a target model for the government-imposed components of the electricity price and grid charges which is to serve as an orientation guide during future changes in boundary conditions. It is hence not to be expected that the current support and subsidy regime will last forever in its present form.

The Energy Saving Ordinance (EnEV) includes benefits for electricity generated and consumed internally because PV electricity that is generated directly at the building and not fed into an external grid (internal use) can be included in the building's energy balance. The target value set in the Energy Saving Ordinance (section 5) is therefore easier to achieve.

1.5 Restrictions due to the existing structure of the building stock

This chapter provides an overview of the most important facts and figures of Germany's building stock. Besides technical restrictions for buildings and the limits to the potential of renewable energy in buildings, the existing structure of the building stock is the third major restriction. The discussion will be differentiated according to residential and non-residential building.

1.5.1 Residential buildings

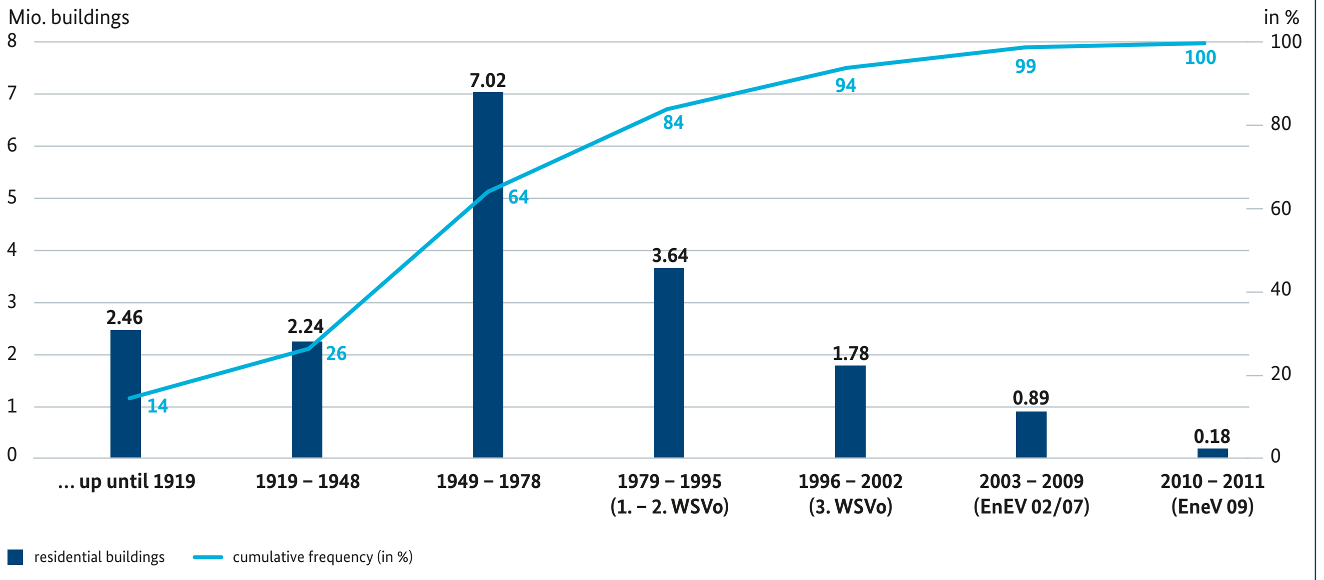
The energy-related potential in residential buildings is determined significantly by the following factors: **building stock**, present **building owner structures** and **tenant structure**. This is because the different interests and boundary conditions strongly influence the decision for energy-related renovation and/or use of renewable energy for heat supply. The detailed determination of the respective starting situation therefore enables the identification of options and restrictions for energy-related renovation measures. These, for their part, must be taken into consideration during the development of the Energy Efficiency Strategy for Buildings because case-specific approaches and made-to-measure solutions are needed for the different demands.

In 2014, the **stock of residential buildings** in Germany comprised around **19 million buildings** with a good **40 million flats**. This figure includes around 14 million single and two-family homes with around 19 million flats and some 5 million multi-family dwellings with close to 21 million flats. More than one million flats in non-residential buildings come on top of this (Destatis). In 2014, around 250,000 new flats were completed in Germany. The new building rate therefore totals around 0.5 percent of all existing buildings. Demand in the coming years will amount to 350,000 to 400,000 flats a year (Wohngeld und Mietenbericht 2014 (2014 Housing allowance and rent survey)).

Besides the number of buildings and living space, the energy quality of the building stock has an important role to play when it comes to assessing the potential for energy-related renovation. A key parameter for this building characteristic is the age and renovation condition of a building. The age of a building can also serve as an indicator for a possible need for revamping or repair measures.

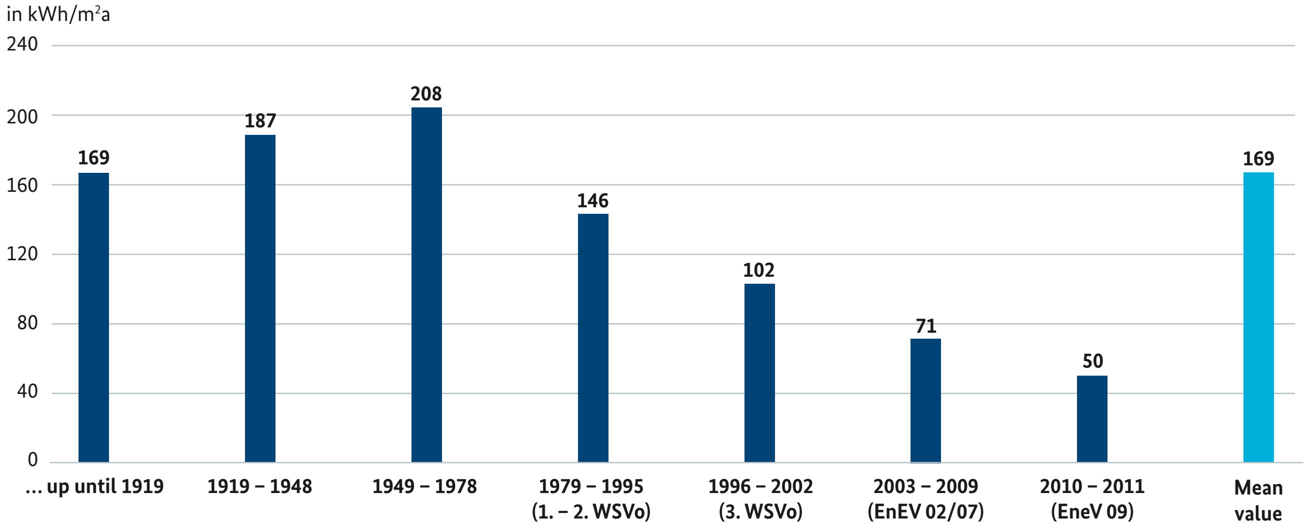
Most of today's buildings were erected after World War II. More than 26 percent of residential buildings were built before 1948, half of them (13 percent) before 1919. These buildings are often listed or subject to grandfathering requirements so that renovation measures must usually comply with built heritage standards. Some 7 million buildings were erected between 1949 and the first ordinance laying down minimum energy efficiency requirements (1st Thermal Insulation Ordinance – Thermal Insulation (WSVo)). This means that around 64 percent of today's building stock was erected without any obligation to adhere to any energy efficiency standards. Another 3.6 million buildings (20 percent) were erected before the 3rd Thermal Insulation Ordinance came into effect. Another 2 million residential buildings (10 percent) were built by 2002. The first Energy Saving Ordinance (EnEV 2002) came into effect in 2002. Over 1 million new residential buildings (6 percent) have been built since (**Fig. 11**).

Figure 11: Distribution of residential building stock



Source: own diagram 2014

Figure 12: Overview of average final energy consumption per unit of space of building stock according to year of construction



Source: Federal Ministry for Economic Affairs and Energy 2014

The current average consumption per unit of space shown in Fig. 12 results from this distribution of the building stock according to year of construction as well as an estimate of renovation activities so far performed in the different age groups (in analogy to an evaluation by IWU, 2010). We can see that energy consumption per unit of space is highest in the 1949 to 1978 age group. This group, which is also the largest group with some 7 million buildings, therefore also offers the largest energy saving potential per unit of space. The second most frequent age group up to 1995 (around 3.6 million buildings) also shows considerable energy saving potential of on average close to 150 kWh/m²a. Potential also exists in buildings completed before 1948. The energy-related condition of buildings completed after 1995 is already good; the energy saving potential must be examined from case to case in this group. Since the Energy Saving Ordinance from 2002 at the latest, potential has to be classified as limited from today's perspective (**Fig. 12**).

According to official figures from the Federal Statistical Office, the owner structure in Germany is split up into two groups: Of the more than 40 million flats and residential buildings, around 17 million flats and homes are used by their owners. This corresponds to a share of around 43 percent. The largest share of flats in Germany is rented (around 57 percent).

These figures cannot be transferred to the individual federal states because regional differences are considerable: Whilst ownership rates in the city states of Berlin (15 percent) and Hamburg (24 percent) are far below the German average, ownership in the Saarland (63 percent) and Rhineland-Palatinate is much higher.

Of the close to 23 million rented flats, around 15 million are owned by private small-scale owners and 8 million by companies in the professional housing sector. These professional housing companies can be broken down as follows: private housing sector (around 4 million flats), municipal and other public housing companies (more than 2 million), cooperatives (around 2 million) and other owners of a good 1 million flats (individual owners as members of large housing companies, churches, etc.).

A special situation exists for **communities of owners** who own close to 10 million freehold flats. Energy-saving renovation measures are usually necessary for the community's joint assets (building envelope, central heating system), so that a majority (so-called qualified majority) of the flat owners must approve any renovation measures. Furthermore, the reserves of the community of owners are often too low to fully finance the necessary energy-saving investments.

The tenant structure in Germany is also very mixed with around 18 million tenant households. Special attention must be paid to the group of recipients of housing benefits and social welfare payments. In 2013, the public sector supported around 4.4 million households with 16.5 bn euros in the form of housing benefits and/or payment of housing and heating costs as part of basic social security. 11 percent of all households received support for all or part of their housing costs. Energy-saving measures could cause higher burdens on municipal budgets for basic social security payments due to higher gross rents including heating costs. If energy-saving measures are performed and if rents without heating costs rise, public budgets will be burdened with higher expenditure on housing allowances and basic social security payments.

The **age structure** of property **owners** (owner-users or small-scale landlords) and the resultant remaining use horizon is another important aspect that influences both motivation and economic capabilities: Almost half of these persons are over 60 years old.

Considering demographic trends, a considerable rate of change in property ownership can be expected in the coming years. Such change will open possible investment windows because the transfer of ownership always raises the question of possible revamping and therefore energy-related renovation of the building.

The evaluation of the structure of the building stock and ownership situation shows that measures can usually be carried out easier in existing buildings if the investor also benefits from lower energy bills and if the investor does not depend on decisions by other co-owners. Owner-users of single-family homes are faced with other obstacles, such as creditworthiness or capability. These measures are more difficult in the case of communities of owners where various aspects are involved, from the presence of a quorum at meetings right through to the need for unanimous decisions for investments in favour of energy-related renovation measures.

In the case of buildings which are rented out, the challenge is to offer owners adequate incentives to invest (profitability of measures) and at the same time not to overstrain users. The system of cost apportioning in the form of rent increases in response to modernisation measures has proven to be generally successful in this respect. Further models are worth discussing.

Just like the building classification exercise, differentiated solutions will have to be developed for different user and owner groups with a view to the owner, investor and user structure.

Modernisation and new construction trends

Construction volume has been growing continuously for several years (**Table 2**). In 2014, around 183 bn euros was invested in **housing construction**. This corresponds to a good 5 percent increase against 2013 and around 17 percent against 2010. Of total investment, 53 bn euros (29 percent) was invested in new and around 130 bn euros (71 percent) in existing buildings. Renovation costs with energy relevance (including building-related power generation by PV modules) are estimated to be close to 35 bn euros, corresponding to a share of around 27 percent in total renovation expenditure.

Table 2: Real construction volume according to sectors

Billion euros	2010	2011	2012	2013	2014
Housing construction	**151.8**	**164.8**	**171.5**	**175.1**	**183.3**
of which new buildings	32.9	41.0	44.3	47.8	53.0
of which existing buildings	118.9	123.9	127.2	127.2	130.1
of which energy-related renovation	40.1	40.2	37.3	35.4	34.8
Construction volume of non-residential buildings	**82.9**	**88.1**	**87.3**	**87.6**	**89.5**
of which new buildings	27.3	29.6	30.4	31.7	31.3
of which existing buildings	55.6	58.0	56.8	55.8	58.1
of which energy-related renovation	16.6	17.7	17.1	17.0	17.5

Source: DIW 2015

1.5.2 Non-residential buildings

In view of the current data situation, the Energy Efficiency Strategy for Buildings cannot make any reliable, technically sound statements regarding the pathways necessary to achieve a virtually climate-neutral stock of non-residential buildings. The data situation for non-residential buildings therefore needs to be improved first. The scenarios reflect the current state of knowledge, so that the forecast is subject to some uncertainty.

In the same year, 89.5 bn euros was invested in the construction of non-residential buildings (**Table 2**). Construction volume thus increased by around 2 percent against 2013 and around 7 percent against 2010. Just like in housing construction, the largest part, i.e. 58.1 bn euros (65 percent), was invested in existing buildings. 31 bn euros (35 percent) was invested in new buildings. Costs with energy relevance are estimated to be close to 18 bn euros, corresponding to a share of around 30 percent of total renovation costs in the stock of non-residential buildings.

A well-founded description of the owner and user structures of non-residential buildings is currently not possible either. Considerable demand for studies, surveys and projections exists in this respect. There is a clear need to improve the data situation in the coming years.

Additional information and data regarding the very heterogeneous owner and tenant structures are particularly important. Appropriate information regarding the energy-relevant condition and the space used is available for certain types of use. Especially for hall-type buildings (logistics halls, superstores, manufacturing halls, sports halls), it was possible to compile a much more consolidated data base because this market is made up of a small number of planners and suppliers only.

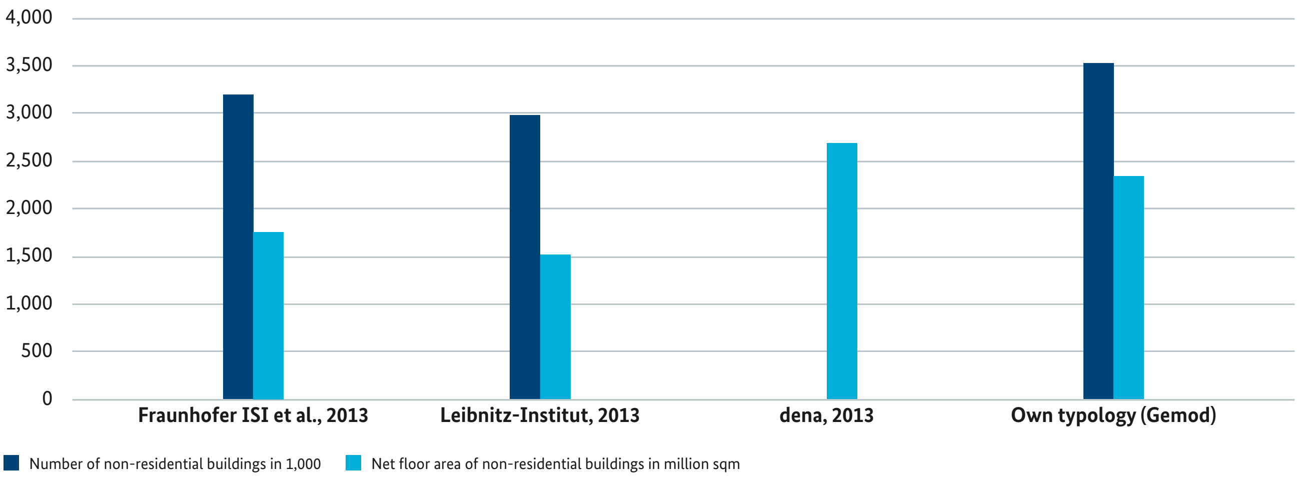
An important exercise for the future will be to transfer the experience made with data capture and processing for hall-type buildings to other types of use and categories of non-residential buildings so that a largely consolidated overall picture of the stock of heated non-residential buildings can be gradually developed.

The following estimates were therefore made for the target scenarios with regard to the stock of non-residential buildings (Prognos et al. 2015):

Types of use

In view of the incomplete data situation, the current stock of heated non-residential buildings can only be extrapolated. These extrapolations suggest that a stock of at least 3 million heated non-residential buildings exists in Germany with a total net floor area of 1.5 to 2.5 billion square metres (**Fig. 13**).

Figure 13: Comparison of the number and net floor area of non-residential buildings in different surveys



Source: Beuth/ifeu 2015

Table 3: Estimate of use classes of heated non-residential buildings according to quantity, surface area and net floor area

Use class	Quantity (x 1,000)	Share (in %)	Net floor area (in million sqm)	Share of net floor area (in %)
Commercial and industrial use	1,780	60	577	38
Trade and services	304	10	173	11
Office and administration	295	10	266	17.5
Hotels and catering	148	5	83	5.5
Education	141	5	218	14.3
Curative treatment	122	4	82	5.4
Sports	114	3.5	55	3.6
Culture and entertainment	83	2.5	70	4.6
Total	**2,986**	**100**	**1,525**	**100**

Source: BMVBS 2013, own diagram

Non-residential buildings can be divided into eight different use categories (**Table 3**).

The "commercial and industrial use" category accounts for the largest share (60 percent) of heated non-residential buildings in terms of both total number and surface area. This is followed at a considerable distance by the "trade and services" (10 percent) as well as "office and administration" (10 percent) use categories. The future analysis will have to focus on these main categories first.

Besides use, the age of non-residential buildings is another important parameter when it comes to assessing their energy saving potential. First results are available for the use categories ("education", "office and administration", "commercial and industrial use" as well as "trade and services") shown in Table 4. A large share of the buildings belong to age class 1 (BAK1), i.e. they were built before 1975. The "commercial and industrial use" category is an exception where all age classes are distributed almost equally. Shopping malls are another exception, with 65 percent being completed after 1995 (**Table 4**).

Table 4: Distribution of non-residential buildings according to age classes (BAK) in percent

No.	Use class	BAK 1 (until 1975)	BAK 2 (1997 – 1983)	BAK 3 (1984 – 1994)	BAK 4 (since 1995)
1.1	General education schools	80	6	6	8
1.2	Universities and research	80	6	6	8
1.3	Day-care centres for children	80	6	6	8
2.1	Government buildings and courthouses	82	5	6	7
2.2	Administration, police and fire department buildings	82	5	6	7
2.3	General office buildings	55	8	15	22
3.1	Factory buildings	20	20	30	30
3.2	Warehouses	20	20	30	30
3.3	Workshop buildings	35	20	20	25
3.4	General industrial and commercial buildings	35	20	20	25
5.1	Department stores	75	5	10	10
5.2	Shopping centres, malls	15	5	15	65
5.3	General retail buildings	75	5	10	10

Source: BMVBS 2013

Non-residential buildings are usually subject to other requirements than residential buildings. This applies to both rented property and property owned by a company. However, issues, such as rent increases after modernisation projects or the owner's willingness and ability to invest are also relevant for non-residential buildings.

2. Reference scenario – the effect of political measures up until now

The **reference scenario** is based on a "business as usual" concept and shows the expected development of primary energy demand in buildings from the baseline year 2008 until the year 2050 if the instruments of current energy and climate policy are maintained in their present form and design. This is the necessary basis for answering the question as to how large the additional need for action is in the buildings sector in order to achieve the targets of energy and climate policy.

The design of the reference scenario assumes a moderate pace of technical progress and a moderate increase in renovation activities:

- In the reference scenario, the average renovation rate rises only slightly to 1.1 to 1.2 percent (full renovation equivalents).
- In the reference scenario, the living area which undergoes energy refurbishment each year rises slightly from around 45 million sqm in 2008 to 50 million sqm in 2050.
- Renovation efficiency (full renovation equivalents) rises by around 20 percent to average efficiency increases of close to 40 percent.

For comparison, a significantly higher level of renovation activities was assumed for the two target scenarios:

- In the "renewable energy" target scenario, the renovation rate increases slightly more and reaches a level of around 1.3 to 1.5 percent for single and two-family homes. Annual renovation activities increase to around 55 million sqm of living area. Renovation efficiency (full renovation equivalents) rises by around 30 percent to average efficiency increases of close to 50 percent.
- In the "energy efficiency" scenario, the renovation rate increases to around 2 percent and the living area renovated each year increases from 45 million sqm to more than 80 million sqm. Renovation efficiency (full renovation equivalents) rises by around 50 percent to average efficiency increases of close to 70 percent.

Furthermore, political measures and instruments adopted no later than by the end of 2013 were considered. The measures and instruments introduced or developed further from 2014 will be explained in the 3rd part of the Energy Efficiency Strategy for Buildings. The actions of the National Action Plan on Energy Efficiency (NAPE) are therefore included.

Other important factors for the calculation of the reference scenario are the assumptions regarding the future development of energy prices, socio-economic factors (such as population density or the number of households) as well as primary energy factors. This information is presented in the supporting scientific report (Prognos et al. 2015).

The considerations regarding the scenarios take into account the Federal Government's overarching longer-term goals. These include the 50 percent reduction in total primary energy consumption and the reduction of carbon emissions by at least 80 percent, in each case by the year 2050. In order to achieve these goals, the three sectors, i.e. electricity, heat and transport, have to achieve the reduction targets set for carbon emissions and primary energy consumption. This means that the buildings sector must reduce its carbon emissions by at least 80 percent and additionally make a reasonable contribution towards the primary energy consumption targets. The scenario which is used here is based on a reduction target in the order of 80 percent according to the target set in the energy concept for buildings.

2.1 Development of primary energy demand

"Primary energy demand" as defined in the energy concept is the indicator by which the aim of achieving a climate-neutral building stock is measured.

A building's primary energy demand must be determined on the basis of the technical standards and specifications to which the Energy Saving Ordinance refers (DIN V 18599: 2011-12 as corrected by DIN V 18599-5 correction 1: 2013-05 and by DIN V 18599-8 correction 1: 2013-05 or alternatively DIN V 4108-6: 2003-06 and DIN V 4701-10: 2003-08 as amended by A1: 2012-07). The standard defines "primary energy demand" as the calculated energy quantity which, in addition to the energy content of the necessary fuel and the auxiliary energy for the technical equipment, also includes those energy quantities that result from upstream process chains outside the building during the extraction, conversion and distribution of the fuels used in each case. Primary energy demand is determined from the final energy demand, with the final energy being subject to weighting factors that reflect their environmental impact (primary energy factors).

The values for the non-renewable portion according to DIN V 18599-1: 2011-12 must be applied to the primary energy factors used in the calculation method. In this context, the primary energy factor for the non-renewable "fuel oil EL" portion (value of 1.1) must be used for liquid biomass and the value for the non-renewable "gas H" portion (value of 1.1) for gaseous biomass. A value of 0.5 can be used for liquid or gaseous biomass within the meaning of section 2 (1) No. 4 of the Renewable Energies Heat Act if the liquid or gaseous biomass is generated in a direct spatial context with the building. In the case of electricity, a value of 1.8 must be used as the primary energy factor for the non-renewable portion (as of 1 January 2016).

The primary energy factors applicable to the 2008 baseline year as well as projections until the year 2050 (Prognos et al) are shown in Table **5**. The lower primary energy factors for electricity and district heating result from the assumed increase in the share of renewable energy in the mix of energy sources.

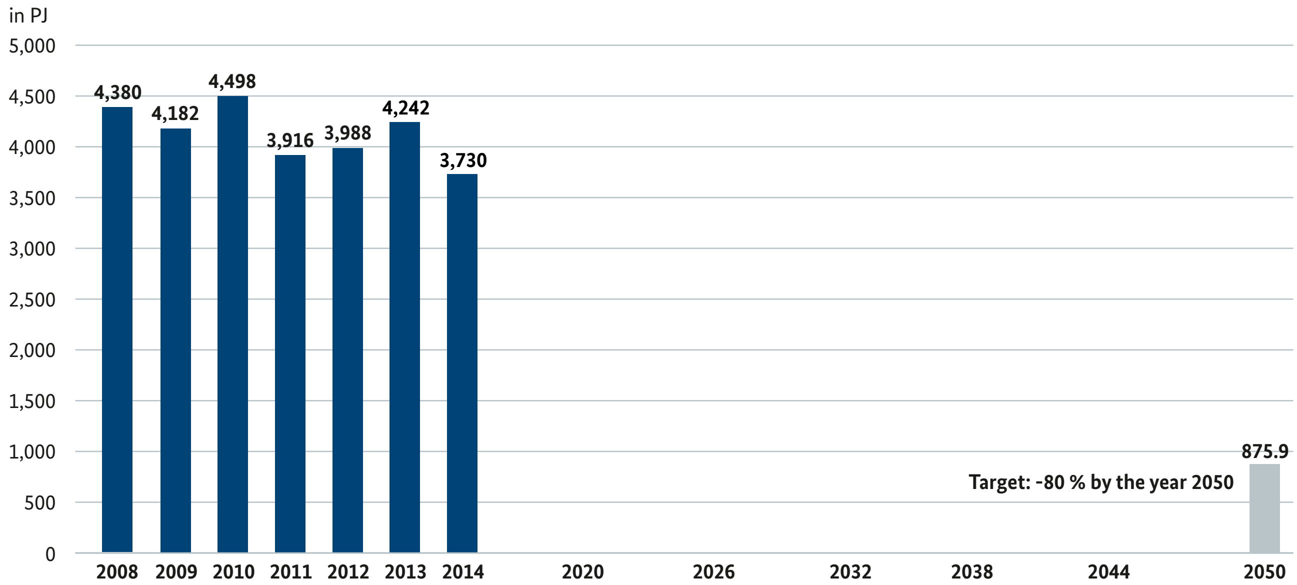
The measured primary energy demand is subject to annual fluctuations, especially due to climate influences. This means that primary energy demand falls in a mild winter when fuel demand decreases. Primary energy demand measured in 2014 totalled 3,730 PJ or 11.8 percent less than in the previous year (2013: 4,228 PJ). Against the 2008 target reference year, primary energy demand fell by 14.8 percent (2008: 4,380 PJ) (**Fig. 14**).

Table 5: Primary energy factors for calculating primary energy demand

	2008	2020	2030	2040	2050
Primary energy factor (fP) non-renewable					
Fossil fuels	1.1				
Liquid/gaseous biomass	0.5				
Solid biomass	0.2				
Electricity (mix)	2.6	1.8	0.9	0.6	0.4
District heating (mix)	1.1	0.8	0.8	0.6	0.5
Environmental heat, ambient heat, solar thermal energy, geothermal energy, etc.	0.2				

Source: DIN V 18599-1, supplemented by EnEV 2014

Figure 14: Development of the measured primary energy demand for buildings and trend until 2050



Source: Federal Ministry for Economic Affairs and Energy on the basis of data from AGEB 09/2015, monitoring report 2015

Primary energy demand trend forecast in the reference scenario

In the reference scenario, the primary energy demand of buildings declines significantly to 1,667 PJ by the year 2050, i.e. around 61 percent below the starting value in 2008 (Table 6). The decline in primary energy demand is due to the reduction in final energy (-30 percent) as well as the increased use of renewable energy.

In the reference scenario until the year 2050, the energy source structure of primary energy demand changes as follows (**Table 6**):

Primary energy demand declines for all applications (heating, hot water, cooling/ventilation/technical systems and lighting). The reduction is particularly strong in electricity-based applications, i.e. cooling/ventilation/technical systems and lighting, due to a much higher share of renewable

Table 6: Primary energy demand in the reference scenario, according to energy sources, 2008 to 2050

Reference scenario				Change against 2008	
Energy sources	**2008 (in PJ)**	**2020 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	956	653	277	-32	-71
Gases	1,614	1,466	979	-9	-39
Electricity	1,301	1,001	209	-23	-84
Heat grids	325	199	95	-39	-71
Renewable energy sources	58	75	88	+29	+51
Biomass	58	75	88	+29	+51
Solar thermal energy	0	0	0		
Ambient/environmental heat (without electricity)	0	0	0		
Others	40	47	19	+19	-53
Insgesamt	**4,293**	**3,441**	**1,667**	**-20**	**-61**

Source: Prognos et al. 2015

Table 7: Primary energy demand in the reference scenario, according to applications, 2008 to 2050

Reference scenario					Change against 2008		
Applications	**2008 (in PJ)**	**2020 (in PJ)**	**2030 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2030 (in %)**	**2050 (in %)**
Heating	2,901	2,367	1,856	1,324	-18	-36	-54
Hot water	470	417	304	179	-11	-35	-62
Cooling/ventilation/technical systems	370	299	178	108	-19	-52	-71
Lighting	552	358	164	55	-35	-70	-90
Total	**4,293**	**3,441**	**2,502**	**1,667**	**-20**	**-42**	**-61**

Source: Prognos et al. 2015

energy in the provision of the electricity needed by these applications (**Table 7**).

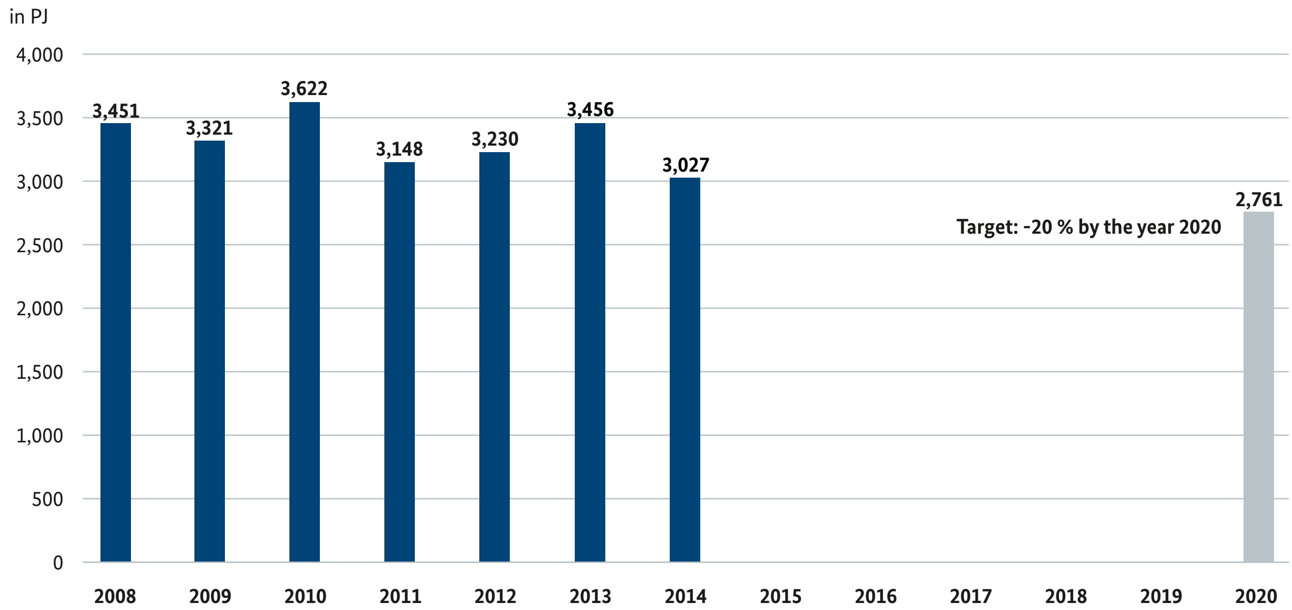
2.2 Development of final energy consumption since 2008

Consumption for heating, cooling and water heating is classified as building-relevant final energy consumption. The final energy balance of non-residential buildings includes power consumption for (permanently installed) lighting. Process energy, for instance, for household appliances and computers, is not included.

Energy consumption in buildings has been declining since 2008. This applies to the entire building stock as well as the individual building-relevant applications. However, this trend is not uniform. Heating, in particular, is subject to significant seasonal and climate-dependent fluctuations (**Fig. 15**).

Against the previous year (in parentheses against the 2008 baseline year), final energy consumption by households fell by 14.9 percent (15.3) and by the business, trade and services sector by 10.2 percent (10.8). Although final energy consumption by industry fell by 1.7 percent against the

Figure 15: Final energy consumption in buildings



Source: Federal Ministry for Economic Affairs and Energy on the basis of data from AGEB 09/2015, monitoring report 2015 previous year, it increased by 5.9 percent against the baseline year. Efficiency advances are reflected by the long-term trend since 2008: Final energy consumption in all three sectors was reduced on average by 2.2 percent per annum against 2008.

The building-specific share of final energy consumption in Germany totalled 35 percent in 2014. 27 percentage points of this was used for heating and cooling, around 5 percent for hot water and close to 3 percent for lighting. Broken down according to sectors, households accounted for the largest share – 21 percent – of building-related energy consumption, followed by the business, trade and services sector with 10 and industrial buildings with around 3 percent. Energy consumption with no building relevance accounts for the remaining 65 percent (**Fig. 16**).

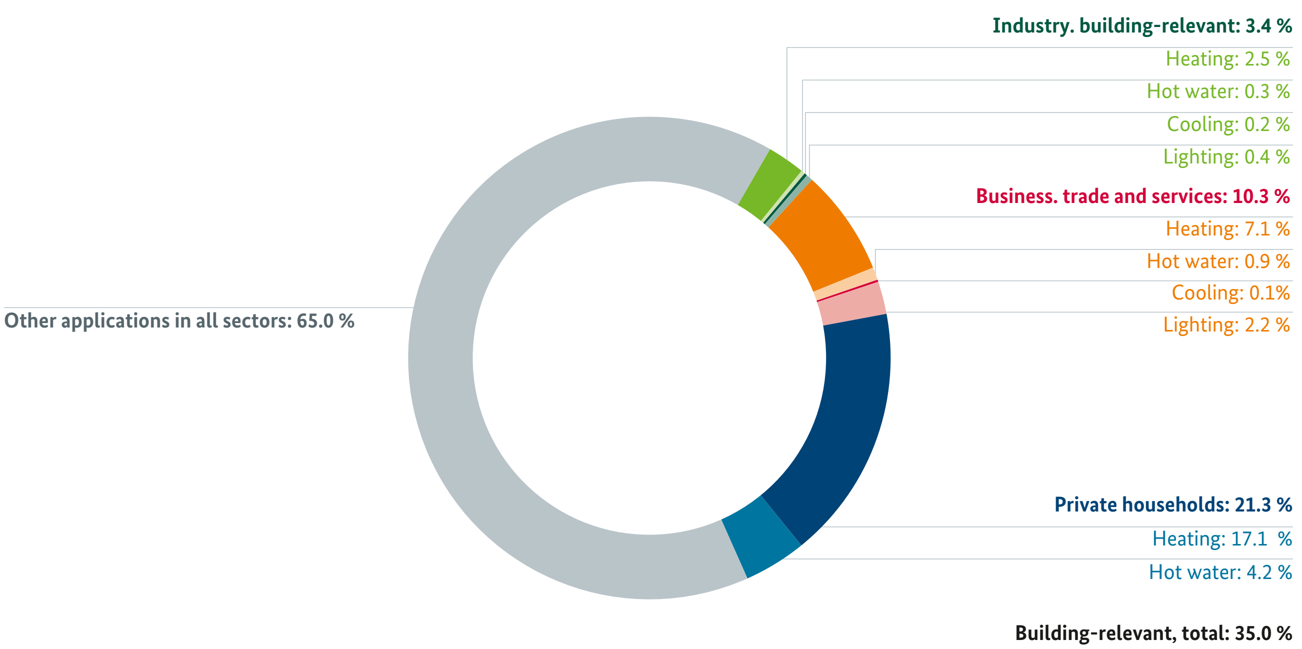
Residential buildings account for almost two thirds, non-residential buildings for one third of building-relevant consumption. Despite the very different uses, final energy is used by all sectors primarily for heating (80 percent in residential and more than 70 percent in non-residential buildings). Hot water is certainly more important in residential buildings whilst lighting is a relevant factor for final energy consumption only in non-residential buildings. Cooling is of minor importance in all sectors.

Development of specific energy consumption in residential buildings since 2008

For an assessment of the progress of energy-specific improvement of the building stock, data on absolute final energy consumption will be correlated with the development of total heated space. In 2014, a specific final energy consumption per square metre of living space of 120 kWh/m² is calculated for residential buildings; this value has fallen by 21.9 percent since 2008 (2008: 153 kWh/m²) (**Fig. 17**).

By additionally adjusting specific final energy consumption for heating by temperature fluctuations[1], consumption values can be compared without the influence of climatic conditions. The temperature-adjusted specific final energy consumption for heating has also fallen signifi-

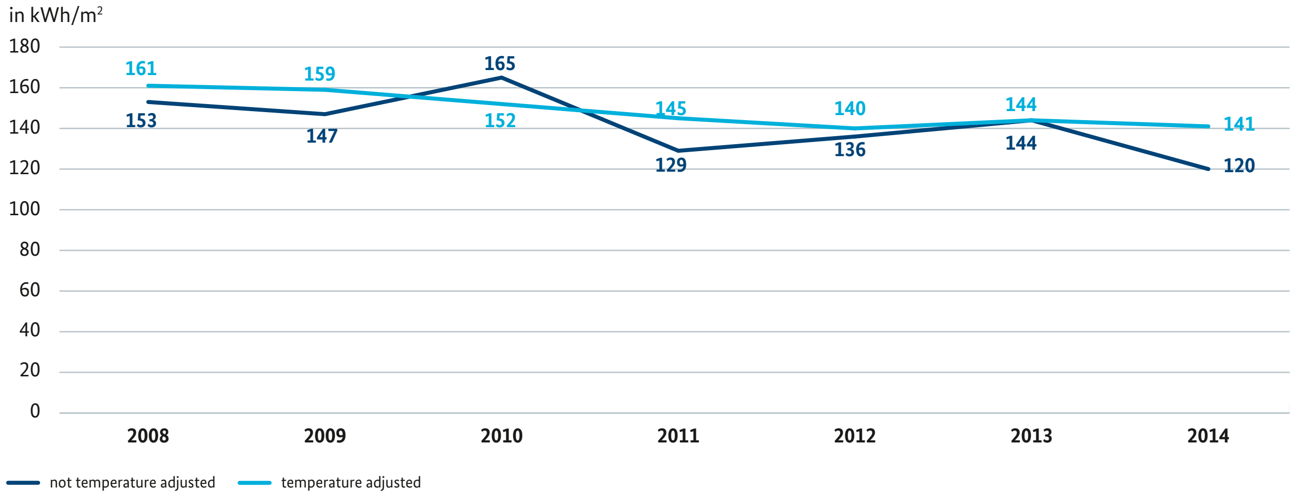
Figure 16: Share of building-relevant final energy consumption in total final energy consumption in 2014



Source: Federal Ministry for Economic Affairs and Energy on the basis of data from AGEB 2015

3 The statistical method of temperature adjustment eliminates the influence of temperature fluctuations on room temperature by correlating the current values with a long-term temperature mean value.

Figure 17: Development of specific final energy consumption for heating by private households

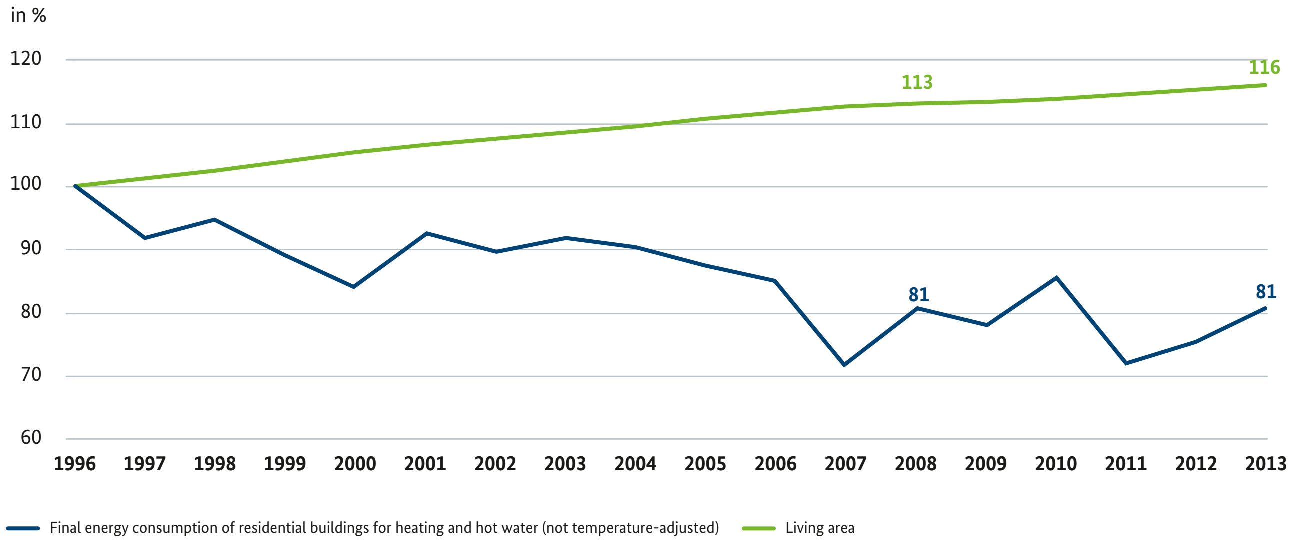


Source: Federal Statistical Office 10/2015, monitoring report 2015

cantly in recent years. In 2014, final energy consumption by private households for heating totals around 141 kWh/m², i.e. 12.6 percent below 2008 levels (161 kWh/m²).

At the same time, one sees that heat demand and the development of living space are becoming increasingly disconnected. However, with regard to total final energy demand, it should be noted that the increase in heated space offsets part of the efficiency gains. Whilst climate-adjusted final energy consumption per square metre of living space in residential buildings fell between 2008 and 2014 by around 12 percent to 3,027 PJ, total living space increased by around 3 percent during the same period and now totals around 3.4 billion square metres (**Fig. 18**).

Figure 18: Development of living space and energy consumption for heating in residential buildings



Source: monitoring report 2015, own diagram

Increasing the energy efficiency of buildings ultimately makes final energy demand for heating and hot water independent from the development of living space. Although heated living space increased by 16 percent against 1996, final energy demand of residential buildings fell by 19 percent during the same period. One can generally say that energy efficiency hikes will in the long term lead to greater independence of energy consumption from external influences.

In their reference scenarios, the experts expect that final energy consumption in 2050 will be 30 percent below the baseline value of the year 2008 (**Table 8**).

A differentiated analysis of the composition of energy consumption according to energy sources shows significant differences compared to overall development. The share of mineral oil and gas as fossil fuels, for instance, will decline from 68 percent in 2008 to around 47 percent in 2050, whilst the share of renewable energy will increase substantially. In 2050, renewable energy will cover 22 percent of demand (2008: 9 percent). Electricity consumption will increase by 9 percent during the observation period. The share of electricity in the final energy mix will therefore increase from 15 percent in 2008 to 23 percent in 2050. Supply through heat grids will also decrease significantly (38 percent). However, the share of heat grids in final energy consumption will decline only insignificantly from 9 percent in 2008 to 8 percent in 2050.

A differentiated view of the development of final energy consumption in the reference scenario according to applications shows that not all applications contribute towards reduction (**Table 9**). The decline in final energy consumption is primarily due to savings in the field of heating. Hot water and lighting applications also show a clear downward trend, whilst energy demand for cooling, ventilation, technical systems will increase significantly by 84 percent, primarily due to cooling demand for buildings which is expected to increase in the future.

Table 8: Final energy consumption, according to energy sources, 2008 to 2050

Reference scenario				**Change against 2008**	
Energy sources	**2008 (in PJ)**	**2020 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	869	594	252	-32	-71
Gases	1,466	1,332	890	-9	-39
Electricity	506	556	553	+10	+9
Heat grids	303	256	187	-15	-38
Renewable energy sources	310	402	548	+30	+77
Biomass	290	305	320	+5	+10
Solar thermal energy	10	45	106	Factor 4	Factor 10
Ambient/environmental heat (without electricity)	10	52	122	Factor 5	Factor 12
Others	36	41	16	+12	-56
Insgesamt	**3,491**	**3,181**	**2,446**	**-9**	**-30**

Source: Prognos et al. 2015

Table 9: Final energy consumption in the different scenarios, according to applications, 2008 to 2050

Reference scenario					**Change against 2008**		
Applications	**2008 (in PJ)**	**2020 (in PJ)**	**2030 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2030 (in %)**	**2050 (in %)**
Heating	2,755	2,437	2,092	1,701	-12	-24	-38
Hot water	375	376	367	334	0	-2	-11
Cooling/ventilation/technical systems	146	168	192	269	15	32	84
Lighting	215	200	178	143	-7	-17	-34
Total	**3,491**	**3,181**	**2,829**	**2,446**	**-9**	**-19**	**-30**

Source: Prognos et al. 2015

2.3 Development of renewable energy in buildings

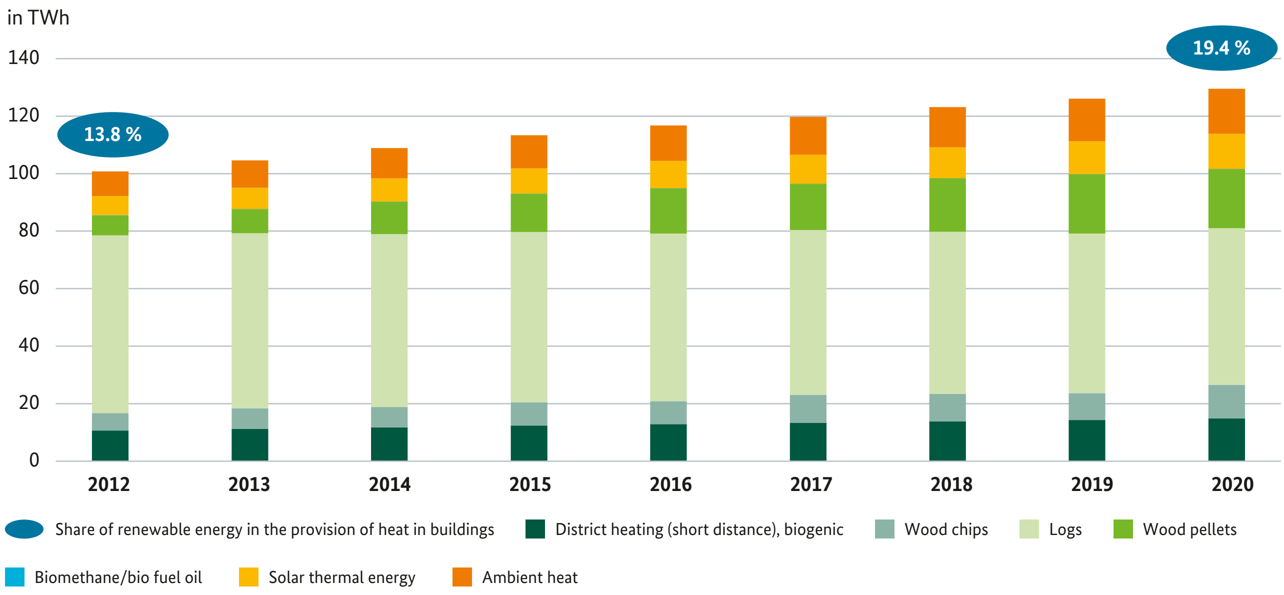
The share of renewable energy in total final energy consumption for heating and cooling totalled around 12 percent in 2014. Since 2008, climate-adjusted consumption increased by around one third from around 360 PJ to around 500 PJ. Fuels from biomass are by far the most important fuels, but the shares of solar thermal energy and heat pumps in final energy consumption also increased significantly in recent years. According to current forecasts, the target laid down in section 1 (2) of the Renewable Energy Act, i.e. to increase the share of renewable energy to at least 14 percent by the year 2020, is likely to be achieved.

In the buildings sector, the share of renewable energy in final energy consumption for heating and cooling can already be expected to be even higher. In 2012, this share already totalled close to 14 percent in the business, trade and services sectors. Forecasts show that this share could increase to probably around 19 percent by the year 2020.

For the period from 2012 to 2020, the forecast suggests that heat supply from biogenic energy sources is set to increase by around 42 PJ. Furthermore, the number of installed heat pumps will probably continue to increase steadily, with the number of newly installed units per annum likely to stabilise at approximately the average level of recent years. The use of environmental heat is therefore likely to almost double from around 30 PJ in 2012 to more than 56 PJ in 2020. The use of solar thermal energy will also increase, with heat supplied by this technology probably rising from around 19 PJ to close to 42 PJ by the year 2020 (**Fig. 19**).

The proliferation of heat generating plants using renewable energy has already led to significant changes in the heating structure in Germany. A forecast for the buildings sector (without industry) suggests that this development will continue, at least in the coming years, and that this trend will probably be characterised by a marked reduction in the share of oil-fired heating systems and a further increase in the share of heat from renewable sources (**Fig. 20**).

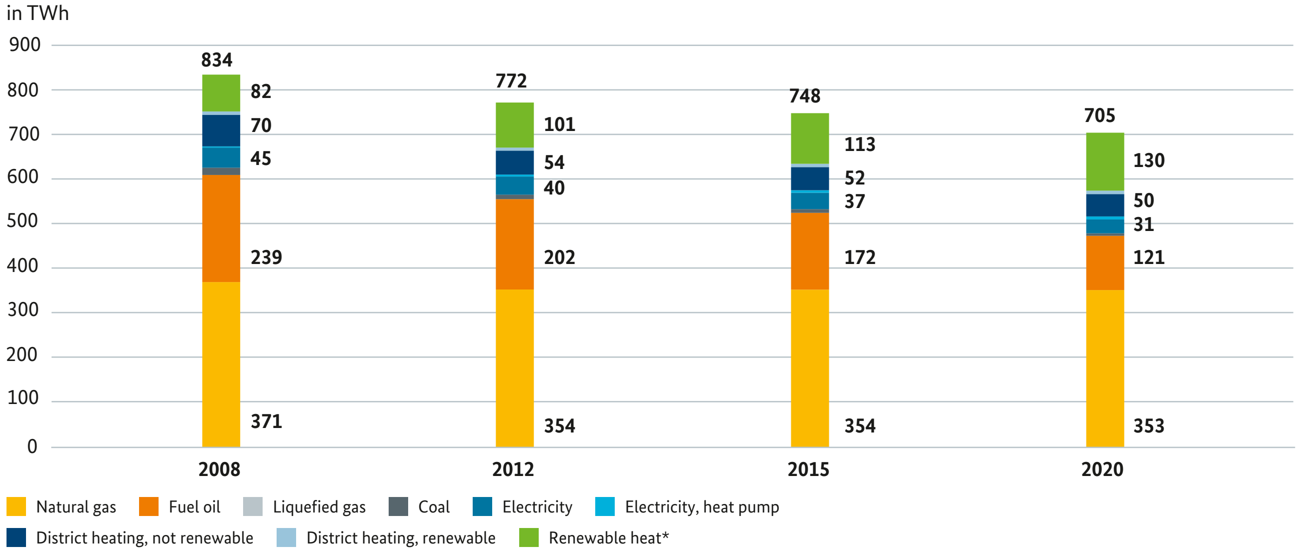
Figure 19: Share of renewable energy in the provision of heat in buildings*



* without heating in industry and renewable energy for district heating including biogenic district heating

Source: experience report on the Renewable Energies Heat Act 2015

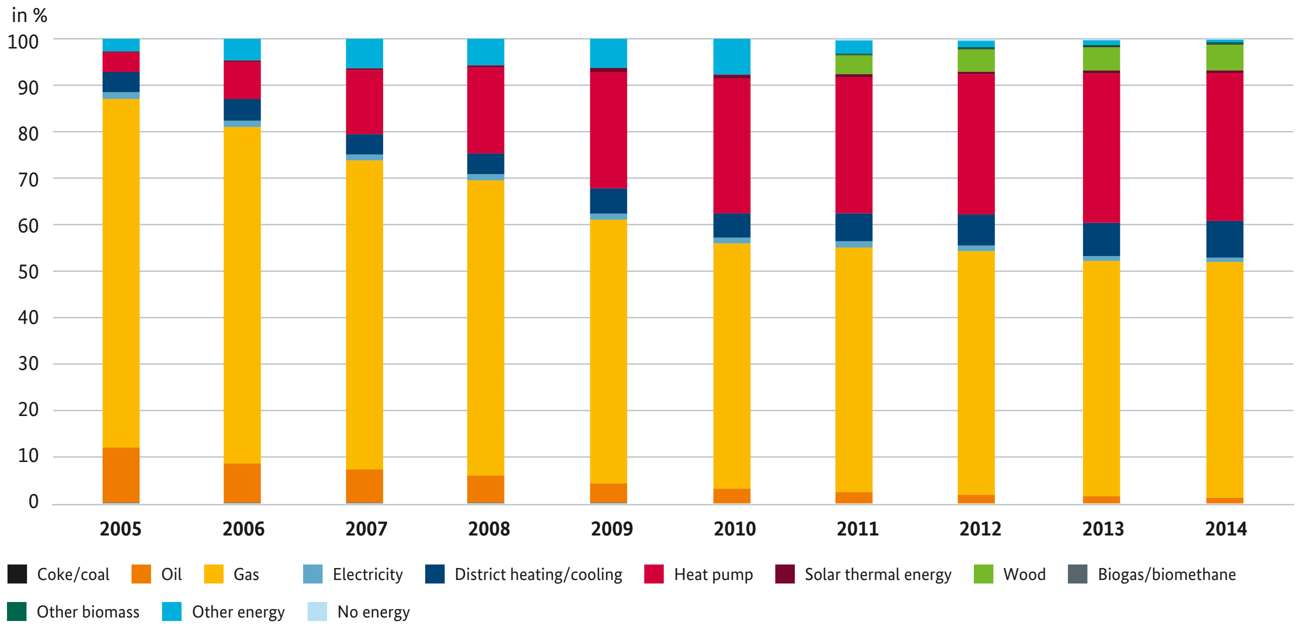
Figure 20: Development forecast for heating structure and energy demand for heating, hot water and air conditioning in buildings until 2020 (without industry)*



* heat from renewable energy without renewable energy in district heating including biogenic district heating

Source: own calculations, experience report on the Renewable Energies Heat Act 2015

Figure 21: Development of the heating structure in completed residential buildings*



* Before 2011, wood as a fuel was included under the "Other" item [heating energy] in statistics on completed buildings.

Source: Destatis2015a, own diagram

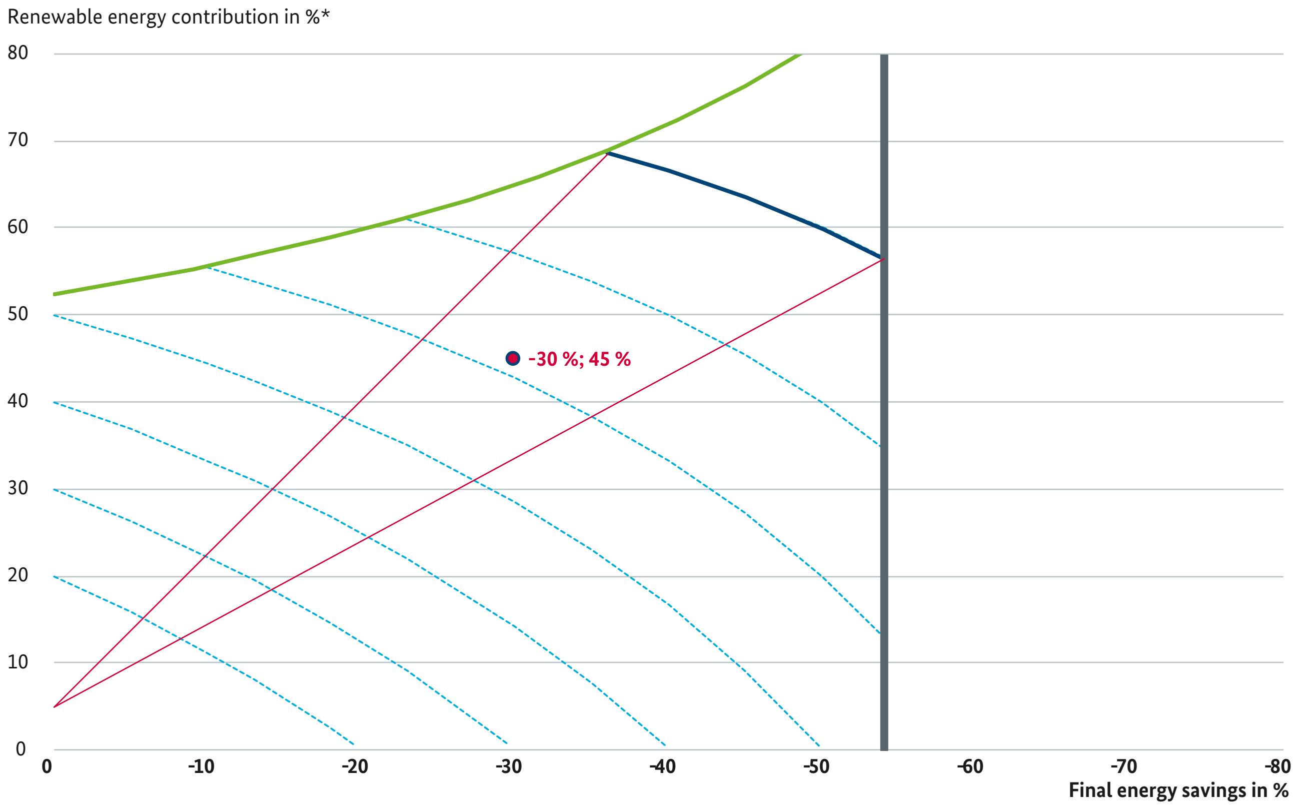
Although the stock of heat generating systems is still dominated by systems based on fossil fuels, accounting for a share of around 90 percent, many fossil-fired installations are already relatively old in view of the relatively low replacement rate of just 3 percent. Although gas-fired installations still accounted for the majority of heating systems sold in 2014, heating systems using renewable energy have for some years achieved a relatively constant share of on average around 12 percent of total sales. Since the installation of heating systems based on renewable energy usually means a shift from fossil to renewable technology and since replacement investments so very rarely replace systems that already use renewable energy, this stable – albeit relatively low – annual rate of new renewable-energy systems will lead to a steady, yet still too small increase in the share of renewable energy on the heat market. Especially in newly completed residential buildings, the share of first-time installations of heating systems using renewable energy was found to be continuously increasing in recent years, even though this trend has slowed down somewhat since 2011.

2.4 Conclusions from the reference scenario

The conclusions that can be drawn from the reference scenario can be summarised as follows:

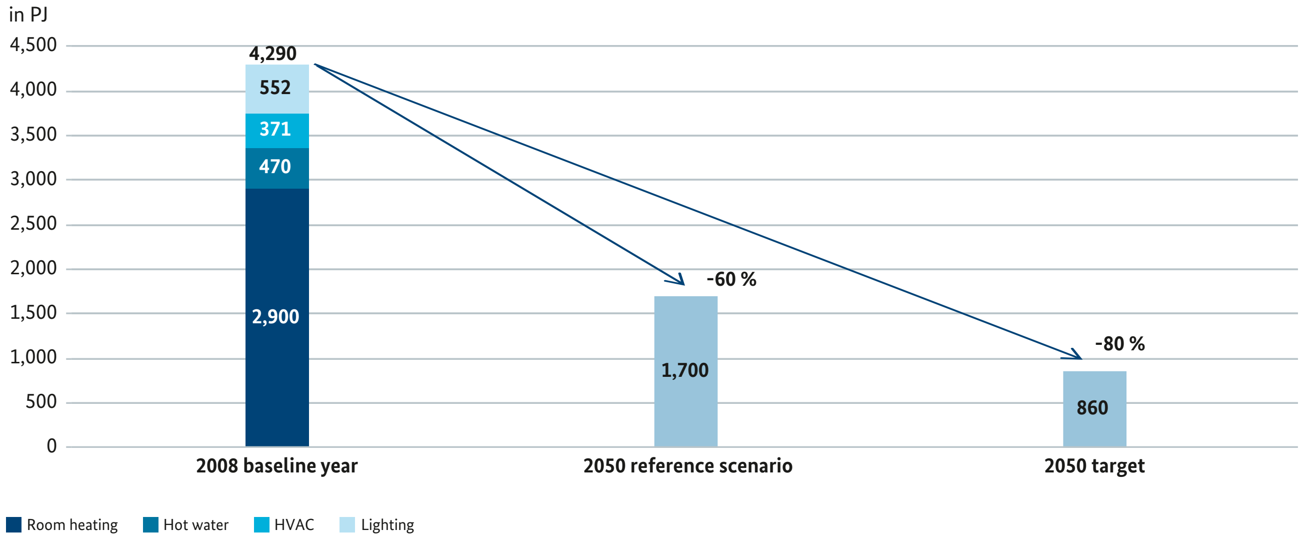
- Primary energy demand will decline significantly by around 60 percent by the year 2050 against the 2008 baseline value.
- This will be due to both the decline in final energy (around -30 percent) and the increased use of renewable energy (increase to 45 percent) (**Fig. 22**).

Figure 22: Result of the reference scenario in the target corridor
Reducing primary energy demand by 80 % compared to 2008
– reference scenario until 2050



Source: own diagram

Figure 23: Primary energy demand resulting from the reference scenario and comparison with the target value in 2050



Source: Beuth University of Applied Sciences, Institute for Energy and Environmental Research 2015, Prognos et al. 2015

However, the following is clear: The reduction in primary energy demand under the assumptions made here and according to the current state of knowledge will not suffice to achieve the targets of the energy concept, i.e. an 80 percent reduction against the year 2008. **The gap between the reference scenario and target achievement totals around 800 PJ (Fig. 23).**

The reference or "business as usual" scenario suggests that it will not be possible to achieve the set targets on the basis of assumed moderate technical progress based on the instruments of energy and climate protection policy available at the end of 2013. The following target scenarios will consider not just the actions decided upon after 2014, including NAPE, but additionally other effects that will lead to target achievement.

3. "Energy efficiency" and "renewable energy" target scenarios

The aim of a virtually climate-neutral building stock by 2050 can only be achieved through a combination of energy savings and increased use of renewable energy. Both approaches are subject to restrictions, from which a corridor for possible pathways to target achievement was determined in chapter 1. Their consequences differ depending on weighting, i.e. focus on increasing energy efficiency or on developing renewable energy. In order to explain this better, two target scenarios were developed as examples with the possible target paths being discussed at the edge of the respective corridor in each case:

- **"Energy efficiency" target scenario**
  This scenario relies on an increase in energy efficiency by energy savings up to the maximum value of -54 percent that can be achieved from today's perspective and subsequently covers the remaining target achievement gap by using renewable energies with a share of at least 57 percent.

- **"Renewable energy sources" target scenario**
  This scenario primarily relies on the development of renewable energies up to the maximum potential limit of 69 percent in final energy consumption that can be achieved from today's perspective and subsequently covers the remaining target achievement gap by increasing energy efficiency through energy savings of at least -36 percent.

Both target scenarios open up a corridor that is characterised by different weighting of the "energy efficiency" and "renewable energy" factors. The result is a target corridor of **minus 36 percent to minus 54 percent through energy savings** (energy efficiency) as well as the **expansion of renewable energy to a value between 57 and 69 percent** of final energy consumption.

The real development of energy supply from renewable energy sources and energy savings through increased efficiency in new buildings and renovation of existing buildings over the next 35 years will probably take place within the corridor opened up by the two scenarios. Due to interdependencies and competition for use between the electricity, buildings, industry and transport[2] sectors, it is possible that a scenario that leads to lower costs in the buildings sector could nevertheless lead to higher costs for the economy as a whole.

First expert assessments of the costs for each sector in the two scenarios are so far only available for residential buildings. These expect that, with an isolated view of the buildings sector, by the year 2050 the "renewable energy" target scenario will lead to lower costs than the sum of investment and use costs than the "energy efficiency" scenario (chapter II.6). Compared to the reference scenario, the experts suggest moderate cost increases in the "renewable energy" scenario by the year 2050.

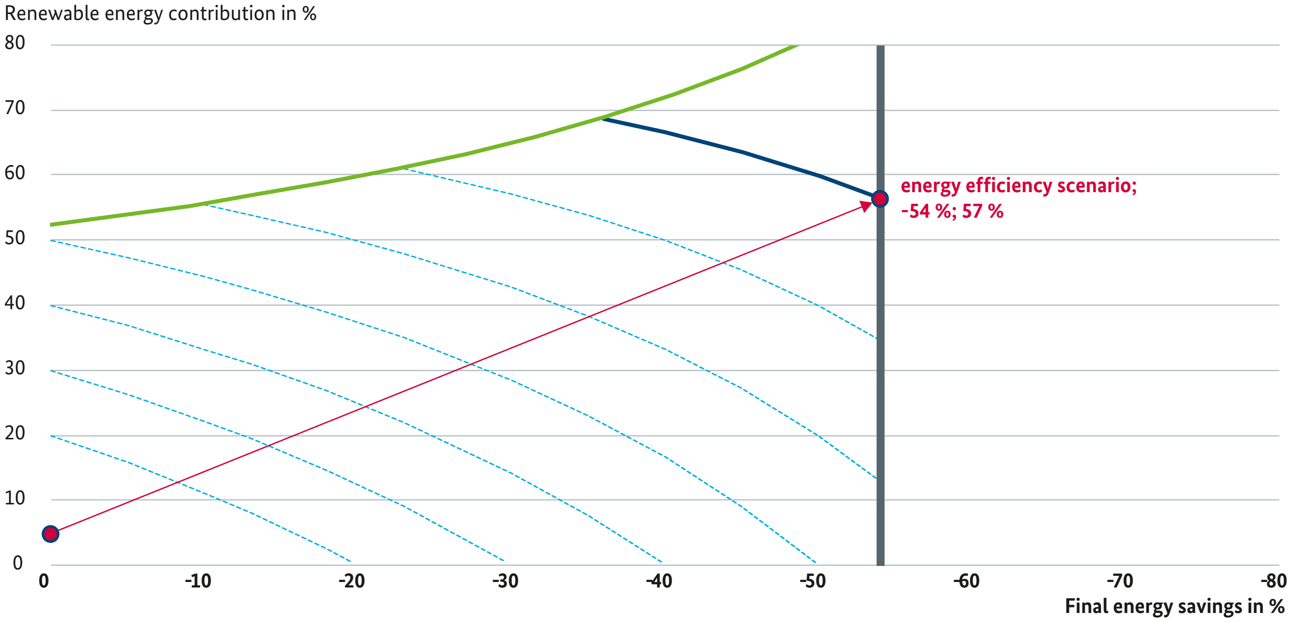
As a next step, the scenarios will then have to be put into a general economic perspective. Energy price measures will have a very significant impact on the results. Their trend until 2050 is difficult to forecast. This and other reasons show that the Energy Efficiency Strategy for Buildings cannot be an instrument that will remain unchanged 2050. Instead, it must be a dynamic tool that will have to be developed further in response to changing conditions and, in particular, to technical progress.

Costs and investments in non-residential buildings too will first have to be updated further.

3.1 Climate-neutral building stock through increased efficiency – the "energy efficiency" target scenario

In the "energy efficiency" scenario, the target of an 80 percent reduction in primary energy demand is achieved to a significant extent by boosting energy efficiency up to the maximum possible limit of 54 percent, with fossil fuels being replaced by renewable energy to the extent required for target achievement.

Figure 24: The "energy efficiency" scenario with a -54 % efficiency increase and a 57 % renewable energy contribution
Reducing primary energy demand by 80 % compared to 2008
– energy efficiency scenario for target achievement



Source: Prognos et al. 2015, own diagram 2015

4 With regard to biomass, no major competition for use between buildings and the transport sector is to be expected because buildings mainly use solid biomass.

3.1.1 Development of primary energy demand

In the “efficiency” target scenario, primary energy demand will decrease by 80 percent to 840 PJ by the year 2050. The share of electricity will fall by 88 percent, i.e. from 1,301 PJ to 156 PJ, due not only to increased energy efficiency but also to the share of renewable energy in power generation and district heating which is expected to be very high in 2050. The share of fossil fuels, i.e. oil (-91 percent) and gas (-73 percent), will also decrease significantly, as too will the contribution of heat grids (-74 percent). The development of renewable energy assumed in the scenario will lead to an increase (by 24 percent) in biomass-based primary energy demand (upstream process chain: logging, processing, transport, etc.) by the year 2050. Renewable energy from solar thermal energy and ambient/environmental heat does not involve any primary energy demand (according to the balancing rules pursuant to the Energy Saving Ordinance) (**Table 10**).

An analysis of the reduction in primary energy demand according to applications provides a relatively homogeneous picture by 2050. Reduction is strongest for lighting (94 percent) due to the high share of renewable energy in power generation until 2050 and due to significant efficiency gains in lighting systems (for instance, due to the use of LED technology). Savings will be lowest for hot water. Certain minimum consumption (hygiene) and temperature (comfort and health) levels must be maintained, so that primary energy savings in this area will be mainly due to the substitution of fossil fuels with renewable energy (**Table 11**).

Table 10: Primary energy demand according to energy sources, 2008 to 2050

"Efficiency" target scenario				Change against 2008	
Energy sources	**2008 (in PJ)**	**2020 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	956	567	83	-41	-91
Gases	1,614	1,373	444	-15	-73
Electricity	1,301	788	156	-39	-88
Heat grids	325	204	83	-37	-74
Renewable energy sources	58	91	72	+57	+24
Biomass	58	91	72	+57	+24
Solar thermal energy	0	0	0	-	-
Ambient/environmental heat (without electricity)	0	0	0	-	-
Others	40	38	3	-5	-92
Insgesamt	**4,293**	**3,061**	**840**	**-29**	**-80**

Source: Prognos et al. 2015

Table 11: Primary energy demand in the “energy efficiency” scenario, according to applications, 2008 to 2050

"Efficiency" target scenario					Change against 2008		
Applications	**2008 (in PJ)**	**2020 (in PJ)**	**2030 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2030 (in %)**	**2050 (in %)**
Heating	2,901	2,179	1,432	588	-25	-51	-80
Hot water	470	375	276	138	-20	-41	-71
Cooling/ventilation/technical systems	370	234	156	80	-37	-58	-79
Lighting	552	272	133	35	-51	-76	-94
Total	**4,293**	**3,061**	**1,997**	**840**	**-29**	**-53**	**-80**

Source: Prognos et al. 2015

3.1.2 Development of final energy consumption and renewable energy

In the "efficiency" target scenario, final energy consumption decreases by 54 percent against the reference scenario. At the same time, the energy mix changes to a larger extent than in the reference scenario. In 2050, the share of fossil fuels in final energy consumption will be 91 percent (oil) and 72 percent (gas) below 2008 levels. The contribution by heat grids is also 46 percent lower. Electricity consumption also decreases by 18 percent by the year 2050. Renewable energy increased steeply by a total of +73 percent. The distribution to the different renewable sources shows that biomass consumption declines (-15 percent) whilst solar thermal energy and ambient heat increased significantly (from 10 PJ in 2008 to 143 and 149 PJ, respectively, in 2050). With regard to biomass, the "efficiency" target scenario expects consumption to initially increase by the year 2030 and then to decline by 2050 (**Table 12**).

The change in energy consumption varies considerably within the applications. Whilst heating declines steeply by 64 percent, this value only totals 17 percent for hot water. Lighting also shows a substantial 58 percent decline in final energy consumption. The only increase is seen for cooling, ventilation and other technical systems (control, etc.) (**Table 13**).

In the "energy efficiency" target scenario, **electricity consumption** declines significantly from 506 PJ (in 2008) to **413 PJ** in 2050. In 2050, a large share of this (284 PJ) will be needed for cooling, ventilation, lighting and technical systems. If the power consumption of heat pumps (around 37 PJ) is subtracted, around 92 PJ will remain in 2050 for other electricity-based applications (auxiliary energy, electronic flow-through water heaters, hot-water heat pumps, etc.).

Table 12: Final energy consumption, according to energy sources, 2008 to 2050

"Efficiency" target scenario				Change against 2008	
Energy sources	**2008 (in PJ)**	**2020 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	869	515	75	-41	-91
Gases	1,466	1,248	403	-15	-72
Electricity	506	529	413	+5	-18
Heat grids	303	262	165	-13	-46
Renewable energy sources	310	471	538	+52	+73
Biomass	290	340	246	+17	-15
Solar thermal energy	10	63	143	+513	+1,291
Ambient/environmental heat (without electricity)	10	68	149	+576	+1,373
Others	36	33	2	-10	-94
Insgesamt	**3,491**	**3,059**	**1,597**	**-12**	**-54**

Source: Prognos et al. 2015

Table 13: Final energy consumption, according to applications, 2008 to 2050

"Efficiency" target scenario					Change against 2008		
Applications	**2008 (in PJ)**	**2020 (in PJ)**	**2030 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2030 (in %)**	**2050 (in %)**
Heating	2,755	2,346	1,786	1,002	-15	-35	-64
Hot water	375	371	354	311	-1	-6	-17
Cooling/ventilation/technical systems	146	159	168	193	9	16	32
Lighting	215	183	145	91	-15	-33	-58
Total	**3,491**	**3,059**	**2,453**	**1,597**	**-12**	**-30**	**-54**

Source: Prognos et al. 2015

3.1.3 Assessment of the "energy efficiency" target scenario

Remaining primary energy demand in 2050 is forecast at around 840 PJ. In terms of useful area, average consumption for residential buildings totals a good 40 kWh/m² (2008: 227 kWh/m²) **and for non-residential buildings around 52 kWh/m²** (2008: 265 kWh/m²)**. This mean value would correspond to an energy-efficient building 55 as currently subsidised by KfW.**

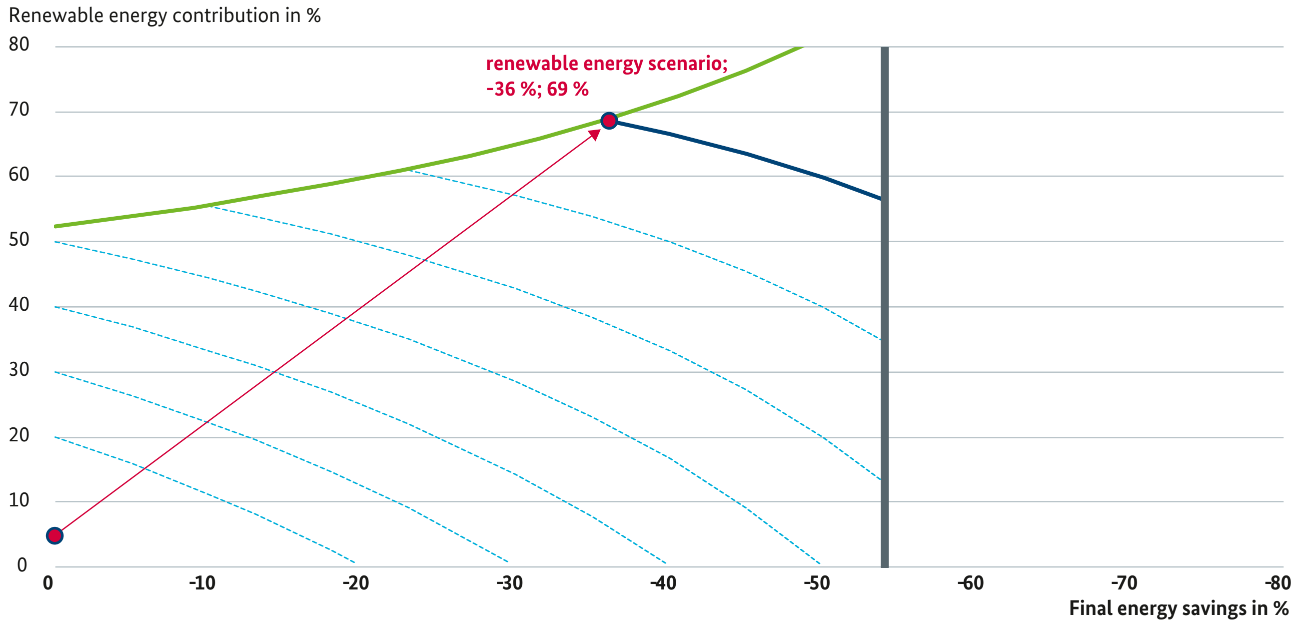
In terms of useful area, final energy consumption totals around 74 kWh/m² for residential buildings in 2050 (2008: 185 kWh/m²) **and close to 100 kWh/m² for non-residential buildings** (2008: 215 kWh/m²)**.**

The "efficiency" target scenario shows that the climate-neutral building stock could be achieved for all existing buildings in their totality within the given restrictions through primary efficiency improvement and secondary use of renewable energy. The "energy efficiency" scenario generally features a low level of resource use for fuels, but requires additional resources, for instance, for insulation measures. A high level of building efficiency in conjunction with highly efficient energy supply technology means for the "energy efficiency" target scenario that electricity consumption forecast for the buildings sector (for heating, lighting, etc.) will decline by the year 2050 by around 93 PJ against the 2008 level. Biomass that will be needed in 2050 for renewable heating of listed buildings or other buildings which are difficult to insulate will total around 250 PJ and will hence be lower than the 2008 level (290 PJ) thanks to higher building efficiency. With this scenario, a larger share of liquid biomass would be available to other sectors (for instance, air transport) than in the "renewable energy" scenario where substitution costs are higher than in the buildings sector.

3.2 Climate-neutral building stock through increased use of renewable energy – the "renewable energy" target scenario

In the "renewable energy" target scenario, the aim of an 80 percent reduction in primary energy demand is essentially achieved by increasing the share of renewable energy up to the potential limit of around 69 percent with energy efficiency requiring an only moderate increase up to a value of -36 percent (**Fig. 25**).

Figure 25: Diagram of the "renewable energy" scenario for target achievement
Reducing primary energy demand by 80 % compared to 2008
– renewable energy scenario for target achievement



Source: own diagram

3.2.1 Development of primary energy demand

In the “renewable energy” target scenario, primary energy demand will decrease by around 80 percent to 827 PJ by the year 2050. Similar to the “efficiency” target scenario, the shares of electricity (-85 percent) and heat grids (-59 percent) decline significantly, with the share of fossil fuels, i.e. oil (-97 percent) and gas (-80 percent) , in primary energy demand declining even more. The development of renewable energy assumed in the scenario and the proportionate use of biogas and sewage gas in the biomass mix (larger non-renewable shares than in the case of solid biomass) will lead to an increase (by 24 percent) in biomass-based primary energy demand (upstream process chain: logging, processing, transport, etc.) from 5 PJ to 137 PJ by the year 2050. Renewable energy from solar thermal energy and environmental/ambient heat does not involve any primary energy demand (according to the balancing rules pursuant to the Energy Saving Ordinance) (**Table 14**).

In the case of the “renewable energy” target scenario, the reduction pattern is relatively homogeneous up to the year 2050 with a view to the reduction in primary energy use according to applications. Lighting once again accounts for the largest reduction of 93 percent, for the same reasons (large share of power generation from renewable sources as well as efficiency increases due, for instance, to LED technology). Consumption for heating and hot water will decline by 80 percent, with primary energy demand for cooling, ventilation and other technical systems falling by 73 percent (**Table 15**).

Table 14: Primary energy demand in the “renewable energy” target scenario according to energy sources, 2008 to 2050

"Renewable energy" target scenario				Change against 2008	
Energy sources	**2008 (in PJ)**	**2020 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	956	503	33	-47	-97
Gases	1,614	1,341	322	-17	-80
Electricity	1,301	833	198	-36	-85
Heat grids	325	226	134	-31	-59
Renewable energy sources	58	122	137	+110	+136
Biomass	58	122	137	+110	+136
Solar thermal energy	0	0	0		
Ambient/environmental heat (without electricity)	0	0	0		
Others	40	30	2	-26	-94
Insgesamt	**4,293**	**3,055**	**827**	**-29**	**-81**

Source: Prognos et al. 2015

Table 15: Primary energy demand in the “renewable energy” target scenario, according to applications, 2008 to 2050

"Renewable energy" target scenario					Change against 2008		
Applications	**2008 (in PJ)**	**2020 (in PJ)**	**2030 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2030 (in %)**	**2050 (in %)**
Heating	2,901	2,159	1,442	592	-26	-50	-80
Hot water	470	373	252	93	-21	-46	-80
Cooling/ventilation/technical systems	370	244	171	102	-34	-54	-73
Lighting	552	279	142	40	-49	-74	-93
Total	**4,293**	**3,055**	**2,008**	**827**	**-29**	**-53**	**-81**

Source: Prognos et al. 2015

3.2.2 Development of final energy consumption and renewable energy

In the “renewable energy” target scenario, final energy consumption declines by 36 percent. The final energy mix also changes in the “renewable energy” target scenario. In 2050, the share of fossil fuels in final energy consumption will be 97 percent (oil) and 80 percent (gas) below 2008 levels. The contribution by heat grids is also 13 percent lower. In contrast to the “efficiency” target scenario, electricity consumption will increase by a moderate 3 percent from 506 PJ to 524 PJ by the year 2050. However, electricity consumption will see its maximum of a good 560 PJ in the decade from 2020 to 2030 before decreasing to the above-mentioned value by the year 2050.

In the “renewable energy” scenario, the potential of renewable energy to lower final energy consumption is used up to the maximum value determined in chapter 4, increasing from 310 PJ in 2008 to 1,130 PJ in 2050. The share of biomass will increase by 71 percent to 496 PJ. The increase in the use of solar thermal energy and ambient/environmental heat will be even stronger than in the “energy efficiency” scenario: From 10 PJ in each of the cases, solar thermal energy will increase to 294 PJ and ambient heat to even 339 PJ. Biomass will already reach a maximum plateau of around 500 PJ in 2030 that will continue until 2050 (**Table 16**).

Similar to the “efficiency” target scenario, the change in final energy consumption in the “renewable energy” scenario varies strongly within the different applications. Whilst heating declines by 43 percent, hot water is down by only 13 percent for much the same reasons (hygiene, user comfort and health). Lighting also shows a substantial 52 percent decline in final energy consumption. With this scenario, consumption by cooling, ventilation and other systems will increase significantly by 73 percent due most likely to increasing user comfort demands and because of significantly higher temperatures in summer as a consequence of climate change (**Table 17**).

Table 16: Final energy consumption, according to energy sources, 2008 to 2050

"Renewable energy" target scenario				Change against 2008	
Energy sources	**2008 (in PJ)**	**2020 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	869	457	30	-47	-97
Gases	1,466	1,219	293	-17	-80
Electricity	506	559	524	+10	+3
Heat grids	303	291	265	-4	-13
Renewable energy sources	310	598	1,130	+93	+264
Biomass	290	411	496	+42	+71
Solar thermal energy	10	103	294	+896	+2,758
Ambient/environmental heat (without electricity)	10	84	339	+729	+3,255
Others	36	26	2	-29	-94
Insgesamt	**3,491**	**3,150**	**2,243**	**-10**	**-36**

Source: Prognos; IFEU; IWU 2015

Table 17: Final energy consumption, according to applications, 2008 to 2050

"Renewable energy" target scenario					Change against 2008		
Applications	**2008 (in PJ)**	**2020 (in PJ)**	**2030 (in PJ)**	**2050 (in PJ)**	**2020 (in %)**	**2030 (in %)**	**2050 (in %)**
Heating	2,755	2,426	2,060	1,560	-12	-25	-43
Hot water	375	371	358	328	-1	-5	-13
Cooling/ventilation/technical systems	146	165	185	252	13	27	73
Lighting	215	188	154	104	-13	-28	-52
Total	**3,491**	**3,150**	**2,757**	**2,243**	**-10**	**-21**	**-36**

Source: Prognos; IFEU; IWU 2015

In the "renewable energy" target scenario, **electricity consumption** increases slightly from 506 PJ (in 2008) to **524 PJ** in 2050. In view of the lower increase in efficiency compared to the "energy efficiency" target scenario, an even larger amount (356 PJ) will be needed in 2050 in the "renewable energy" scenario for cooling, ventilation, lighting and technical systems. If the power consumption of heat pumps (around 85 PJ) is subtracted, around 55 PJ will remain in 2050 for other electricity-based applications (auxiliary energy, electronic flow-through water heaters, hot-water heat pumps, etc.).

3.2.3 Conclusions regarding the "renewable energy" target scenario

The conclusions that can be drawn suggest that the primary energy demand remaining in 2050 in the "renewable energy" target scenario can be estimated to be somewhere below 840 PJ. In terms of useful area, average consumption for residential buildings totals a good 40 kWh/m² (2008: 227 kWh/m²) **and for non-residential buildings around 52 kWh/m²** (2008: 265 kWh/m²)**. Similar to the "energy efficiency" target scenario, this mean value corresponds to an energy-efficient building 55 as currently subsidised by KfW.**

In terms of useful area, final energy consumption is around 30 percent higher than in the "energy efficiency" target scenario and totals around 104 kWh/m² for residential buildings in 2050 (2008: 185 kWh/m²) **and close to 139 kWh/m² for non-residential buildings** (2008: 215 kWh/m²).

The "renewable energy" target scenario suggests that the climate-neutral building stock can be achieved for all existing buildings in their totality within the given restrictions by increasing the share of renewable energy as a primary and increasing efficiency as a secondary measure. With this scenario, electricity accounts for a large share of renewable energy with total electricity consumption totalling around 524 PJ in 2050, i.e. only slightly higher than the 2008 level (506 PJ). Compared to the "energy efficiency" target scenario, forecast power consumption will be around 111 PJ higher in 2050. This has consequences for power generation and distribution, but in conjunction with heat storage solutions can also lead to greater flexibility when it comes to levelling off fluctuating power supply from renewable sources.

Biomass is forecast to total around 500 PJ in 2050 in the "renewable energy" target scenario. However, several authors point out that in a largely decarbonised world the available biomass potential will be needed not just for the buildings sector, but also by the transport sector (liquid biomass) and by industry (solid biomass) because there are at present no technically and economically viable alternatives in these areas. As part of the future development of the building strategy, these conditions will have to be considered from an energy perspective, also with a view to cross-sector optimisation of the total costs of future energy supply. The Climate Action Plan 2050 will identify interactions with regard to greenhouse gas emissions. Furthermore, the assumptions for the transport sector are discussed in detail in the Mobility and Fuel Strategy (MFS).

4. Interaction between electricity and heat

4.1 The role of interaction between electricity and heat

A situation where the electricity and heat sectors are coupled, i.e. if electricity is used to supply heat (for instance, by heat pumps or in the form of power-to-X schemes (e.g. methane gas)), is referred to as sector coupling. A reduction in greenhouse gas emissions is possible if the electricity used originates from renewable sources and if it is used with maximum efficiency because power from renewable energy is not abundant from today's perspective. Moreover, electricity generation and transport also lead to costs which must be able to compete with those of other energy sources. It is therefore vital that highly efficient technology is used for coupled electricity and heat in buildings.

In the short term, technologies that use electricity for heat generation are also an important flexibility option in addition to grid expansion. This is particularly important with a view to the growing amount of electricity generated by volatile sources, such as wind and photovoltaics, which is fed into the grid. Under certain conditions, such as at times of strong wind and/or weak loads, temporary amounts of "excess current" can be converted to heat and stored in heat storage systems. Short-term demand flexibility can, for instance, be achieved through the use of heat storage systems in buildings. Moreover, CHP systems with heat storage capability can also be used to level electricity supply and demand and to ensure the efficient use of electricity from renewable sources in the long term.

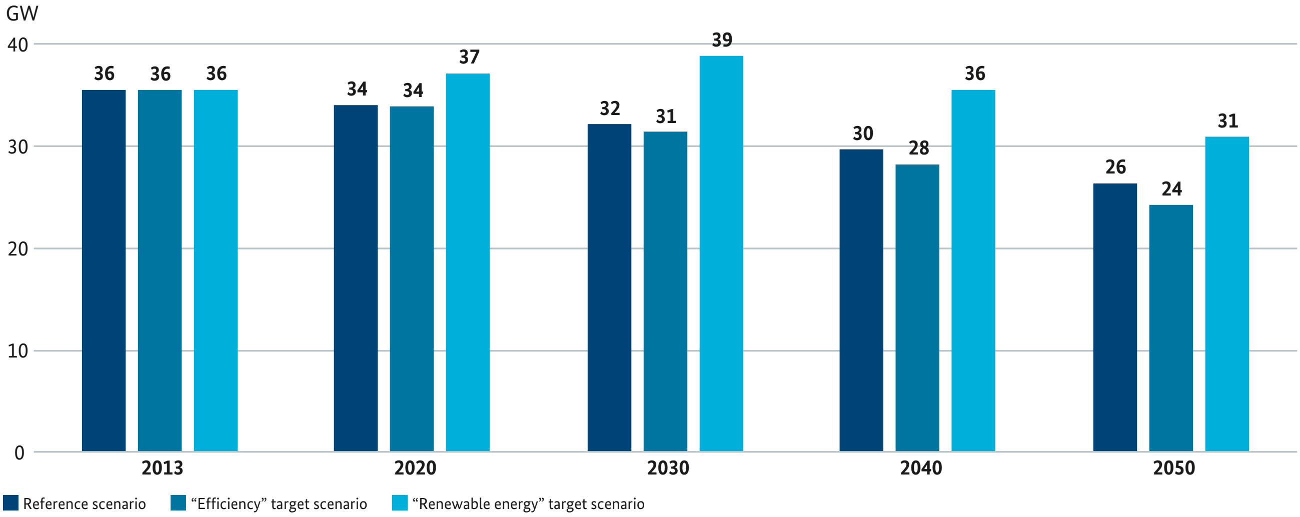
From today's perspective, a wide range of flexibility options should be provided which can be used in order to increase demand flexibility in the short to medium term whilst at the same time supporting the use of *efficient* sector coupling technologies in the medium to long term. Whilst the use of even less efficient technologies may be acceptable under certain conditions in the short term – in as far as this is economically justifiable from the plant operator's perspective – such less efficient systems must be replaced with efficient systems in the long term, such as heat pumps which use environmental heat in order to produce a multiple of heat from a given unit of electrical energy. Moreover, decisions in favour of less efficient infrastructures may not lead to path dependencies that would favour inefficient technologies.

4.2 Sector coupling from the target scenarios

The connected power of electric heat generating units will decrease until 2050. The scenarios assume a connected power of 24 to 31 gigawatt (today: 36 GW) in 2050. In the "renewable energy" target scenario, however, a temporary increase to 39 GW by the year 2030 is expected, followed by a decline up to 2050 (Fig. 26).

The connected power which will be needed, in addition to heat supply, for cooling, ventilation and technical systems will increase until 2050 from 18 GW to close to 21 GW in the "energy efficiency" and to around 29 GW in the "renewable energy" target scenario (Table 18).

Figure 26: Electrical power currently installed and estimated capacity needed in future for electricity generation for heat supply



Source: Prognos et al. 2015

Table 18: Connected power (in GW) additionally needed for cooling, ventilation and technical systems

Connected power in GW	2008 (in GW)	2020 (in GW)	2030 (in GW)	2050 (in GW)
Reference scenario		19	21	31
"Efficiency" target scenario		18	19	21
"Renewable energy" target scenario	18	19	21	29

Source: Prognos et al. 2015

In the “energy efficiency” and “renewable energy” target scenarios as well as in the reference scenario, the development of grid connection capacity was examined in addition to power consumption. Power consumption for heat supply until 2050 will develop differently in the different scenarios.

In the *reference and “efficiency” scenarios*, power consumption decreases despite increasing sector coupling due to the installation of more heat pumps and in 2030 will be around 10 percent lower than today (Prognos et all 2015). This development can be explained by the simultaneous implementation of significant efficiency increases which will lead to a significant reduction in heat demand for buildings and power consumption by heat pumps compared to today’s demand levels. The decline in demand is even stronger in the long term. By 2050, consumption will then be around 25 to 30 percent below today’s level.

In the *“energy efficiency” scenario* too, efficiency can be increased through the use of efficient generation technology. However, due to the significantly faster expansion of heat pump technology, power consumption will initially increase by 10 percent compared to the “energy efficiency” scenario. However, power consumption for heat generation will then also decline until 2050 and reach a level of around 10 percent below today’s consumption (Prognos et al. 2015).

Although power consumption by heat pumps increases in all the scenarios, the long-term reduction in electricity consumption can be explained by the fact that for every direct electric heating system which is taken out of service heat pumps can supply three to four times the amount of heat with the same power consumption. Direct electric heating systems in residential buildings currently use around 20 TWh of electricity per annum corresponding to a connected power of around 15 GW. The complete deinstallation of direct electric heating systems by the year 2050 strongly supports the electricity sector in its efforts to integrate heat pumps. This effect is increased by declining demand for heat in renovated buildings. The improved quality of building envelopes in conjunction with panel-type and under floor heating additionally leads to a significant improvement in the annual performance factor of heat pump systems.

The scenarios suggest that practically no more direct electric heating systems other than water heaters will be in use on the heat market in 2050. In the field of decentralised water heating too, the systems which are currently common on the market (hydraulically controlled flow-through heaters) will be replaced with systems that are much more efficient (electronically controlled flow-through heaters, hot-water heat pumps). The connected power currently required for direct electric heating systems (up to 15 GW) is hence available for substitution by heat pump technology.

The installed power and/or grid connection capacity of electric heating and hot water systems follows a trend similar to that of power consumption. In the *reference and “efficiency” scenarios*, installed power declines to 31 and 32 GW, respectively, by the year 2030 and to 24 to 26 GW by the year 2050. In the *“renewable energy”* target scenario, more electric heat pumps are installed in the short to medium term. Installed power will therefore increase to 37 GW by 2020 and to 39 GW by 2030 and will then decrease to 31 GW by the year 2050 (**Fig. 26**).

Electric heat pumps which are operated in optimum compliance with overall system requirements are flexible loads capable of shifting loads over several hours in conjunction with a heat storage system connected to them. Most of the installed capacity of heat pumps can therefore be considered to constitute flexible capacity. When integrated into smart grids, they can respond to excess supply and shortage situations and thereby compensate fluctuating feed-in conditions from renewable energy to a certain extent. This will enable better control and balancing of the electricity grid which in the longer term will increasingly depend on significant shares of volatile feed-in sources.

In the long term, installed capacity will decrease in all the scenarios due to the implementation of efficient sector coupling. However, this does not mean that requirements for the electricity market will decrease. Efficient sector coupling calls for a high degree of coordination between electricity supply and demand. A critical load situation could arise during peaks in demand on cold winter days, in particular, if feed-in rates from renewable energy sources are low at the same time. This is a challenge for generation and management as well as for storage systems.

As a result of climate change (growing number of days when cooling is required), a significant increase in surfaces to be cooled, mechanical ventilation of buildings and increased user requirements, energy consumption by cooling and ventilation systems will continue to increase until the year 2050 despite improved efficiency. The connected power for these applications will also increase because final energy consumption for this area will rise from 146 PJ in 2008 (baseline year) to 193 PJ in the "energy efficiency" target scenario and to 252 PJ in the "renewable energy" target scenario (year 2050).

The demand profile, especially for cooling applications, fits very well into the supply profile of PV plants and is therefore easier to handle than the heat demand profile.

The next step will require the development of a set of tools that

- enable the flexible use of electricity from renewable sources in the short term without generating infrastructural path dependencies which would favour inefficient technology and
- create conditions which support the use of efficient and use-adequate technologies for sector coupling in the medium and long term.

5. Assessment of greenhouse gas reduction

5.1 The role of greenhouse gas emissions in the buildings sector

According to the Federal Government's energy concept, greenhouse gas emissions in Germany are to be reduced by 80 to 95 percent by the year 2050. In addition to this, intermediate targets have been set (2020: 40 percent, 2030: 55 percent and 2040: 70 percent). The reduction values in each case refer to the 1990 baseline year (according to the Kyoto Protocol).

Although no specific reduction paths have been laid down for the individual sectors, the development in the buildings sector is crucial for target achievement because of the extent of the emissions generated in this sector. In 2014, buildings accounted for close to 30 percent of all greenhouse gas emissions in Germany.

Greenhouse gas emissions in the buildings sector are made up of the shares from the "private households", "business, trade and services" as well as the "industry" sectors. Emissions by power generation and district heating plants are assigned to the "energy" sector. This means that there is no clear-cut statistical assignment of greenhouse gas emissions to the buildings sector (**Table 19**).

Table 19: Definition of sectors according to the source principle

Sector	Explanation of the respective emission types considered
Energy sector	Public electricity and heat supply, including gas compressors
Industry	Incineration and combustion processes as well as internal power supply for the manufacturing sector and emissions from industrial processes
Households	Incineration and combustion processes in private households (primarily fuel for heating, cooking and hot water)
Transport sector	Fuel combustion for road, rail and water transport as well as national aviation (without construction machinery)
Business, trade and services	Incineration and combustion processes in business, trade and services (primarily fuel for heating, cooking and hot water)
Agriculture	Emissions from animal husbandry, fertiliser management and agricultural fuel
Other	Waste management (primarily landfill gas), waste water management

Source: BMUB 2014

Table 20: Distribution of direct and indirect emissions from buildings in the “industry”, “business, trade and services” and “households” sectors

Sources of carbon emissions	Non-residential buildings (in %)		Residential buildings (in %)	Total (in %)
	Industry	Business, trade and services	Households	
Directly at the building	1.2	4.6	11.6	**17.4**
Indirectly with electricity or heat grids	1.7	6.6	3.8	**12.1**
Total	**2.9**	**11.2**	**15.4**	**29.5**

Source: Federal Ministry for Economic Affairs and Energy on the basis of data from AGEB 2011

Due to the required holistic energy and cost efficiency as well as system integration, the Energy Efficiency Strategy for Buildings treats emissions by buildings as a single complex. This means that those greenhouse gas shares of the individual source sectors which are directly influenced by the buildings sector are examined (so-called “source balance”):

- “Households”: emissions from residential buildings for heating, cooling, ventilation
- “Business, trade, services”: emissions from these non-residential buildings for heating, cooling, ventilation, lighting
- “Industry”: emissions from these non-residential buildings for heating, cooling, ventilation, lighting
- “Energy sector”: emissions from electricity and district heating supply for buildings

Other carbon emissions due to electricity consumed, for instance, by household appliances, information and communication technology or processes, etc. are not assigned to the buildings sector.

Of the building share of around 30 percent of total emissions in Germany, direct emissions at the building account for around 17 percent whilst indirect emissions due to electricity or energy consumption from heat grids account for around 12 percent. Residential buildings account for around half (15 percent) the emission share of the buildings sector, with the “business, trade and services” sector accounting for around 11 percent and industry for around 3 percent (**Table 20**).

The definition and its allocation from the emission sectors to the buildings sector also correspond to the measurement and balancing of energy consumption values.

5.2 Energy-related carbon emissions of the reference and target scenarios

Carbon emissions from the combustion of fossil fuels decline in all the scenarios up to the year 2050 (**Table 21**). The reduction in emissions is due on the one hand to declining final energy consumption and on the other to declining emission intensity of final consumption due to the increasing share of renewable energy sources in the electricity mix and in heat grids.

In the **reference scenario**, energy-related carbon emissions decline from 303 million tonnes in 2008 to only 114 million tonnes in 2050. This corresponds to a 62 percent reduction against the year 2008.

In the **“energy efficiency” target scenario**, carbon emissions decline to around 57 million tonnes in 2050. This corresponds to an 81 percent reduction against the year 2008.

In the **“renewable energy” target scenario**, the decline in carbon emissions is even greater. Emissions in 2050 are down to just 55 million tonnes. This corresponds to an 82 percent decline against the year 2008.

The results of the forecast for both scenarios show that the buildings sector can contribute at least 80 percent towards the reduction in greenhouse gases against 2008. In terms of the 1990 baseline year of the Kyoto Protocol, this contribution can even exceed 80 percent (work completed upfront in the building stock between 1990 and 2008). This is, first and foremost, the result of comprehensive rehabilitation measures for existing buildings in the new east German federal states after reunification.

Table 21: Carbon emissions from the combustion of fossil fuels in the different scenarios, 2008 to 2050

Reference scenario					Change against 2008	
Energy sources	**2008 (in Mio. t)**	**2020 (in Mio. t)**	**2030 (in Mio. t)**	**2050 (in Mio. t)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	77	53	37	22	-32	-71
Gases	102	93	78	62	-9	-39
Electricity	91	68	55	19	-26	-79
District heating	27	17	16	7	-38	-72
Renewable energy sources					-	-
Biomass	2	2	2	2	+5	+10
Solar thermal energy	0	0	0	0	-	-
Ambient heat	0	0	0	0	-	-
Others	4	4	3	2	+12	-56
Total	**303**	**236**	**191**	**114**	**-22**	**-62**

"Efficiency" target scenario					Change against 2008	
Energy sources	**2008 (in Mio. t)**	**2020 (in Mio. t)**	**2030 (in Mio. t)**	**2050 (in Mio. t)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	77	46	24	7	-41	-91
Gases	102	87	60	28	-15	-72
Electricity	91	64	49	14	-29	-85
District heating	27	17	16	7	-36	-75
Renewable energy sources					-	-
Biomass	2	2	2	2	+17	-15
Solar thermal energy	0	0	0	0	-	-
Ambient heat	0	0	0	0	-	-
Other	4	4	2	0	-10	-94
Total	**303**	**220**	**152**	**57**	**-27**	**-81**

"Renewable energy" target scenario					Change against 2008	
Energy source	**2008 (in Mio. t)**	**2020 (in Mio. t)**	**2030 (in Mio. t)**	**2050 (in Mio. t)**	**2020 (in %)**	**2050 (in %)**
Petroleum products	77	41	19	3	-47	-97
Gases	102	85	55	20	-17	-80
Electricity	91	68	56	18	-25	-81
District heating	27	19	19	11	-30	-60
Renewable energy sources					-	-
Biomass	2	3	3	3	+42	+71
Solar thermal energy	0	0	0	0	-	-
Ambient heat	0	0	0	0	-	-
Others	4	3	1	0	-29	-94
Total	**303**	**218**	**153**	**55**	**-28**	**-82**

Source: Prognos et al. 2015

6. Investment and costs of use

6.1 Introduction

An economic assessment of the residential building stock must differentiate between the different stakeholders and their different interests. This applies, in particular, to owner-occupiers and landlords ranging, for their part, from so-called "lay landlords", cooperatives, private or municipal housing societies right through to large, supraregional real property groups. Housing companies with locations spread across Germany will act differently than single owner-occupiers. One important group which deserves special attention are communities of property owners because a majority of votes is required there for decisions related to energy-relevant renovation measures. Finally, economic considerations must also include rented flats where landlords can re-finance investments by increasing rent.

Non-residential buildings also require separate assessment with a view to the profitability of measures because buildings and therefore renovation costs are directly linked to the company whose credit limit or equity stock would be affected.

However, what all economic considerations have in common is that energy-saving renovation or the construction of an energy-efficient building will first generate costs for energy-saving measures which must first be paid and subsequently refinanced during the use phase (energy cost savings). Full costs and energy-related costs must therefore be distinguished when it comes to re-financing. The full costs represent the total sum invested in the project. Part of this is usually treated as maintenance costs to be borne by the owner/landlord, with another part representing measures which enhance the value of the property and a third part being energy-related measures. Especially if there is major backlog in maintenance or value-improving measures so that buildings are in need of full-scale rehabilitation, maintenance will account for a relatively large share of the renovation costs. These maintenance costs must be deducted from modernisation costs and cannot be passed on to tenants in the form of higher rent. The resultant rent increases can only be justified by improved living quality (user convenience, comfort, etc.), energy savings, greater efficiency and carbon emission savings. However, many tenants cannot afford combinations of comprehensive modernisation measures. Solutions must be found which are acceptable for all stakeholders.

The situation is similar for owner-occupants although they can, of course, decide for themselves which additional energy efficiency measures are to be performed. These owners are also interested in reasonable payback periods for energy-related measures.

Energy saving laws and regulations have to consider the need for economic efficiency so that only those minimum requirements apply which usually pay off within a reasonable time. Furthermore, subsidies and support for energy-saving measures (KfW, MAP, etc.) reduce the refinancing costs of these measures significantly (loans, grants, etc.). Subsidies must be deducted from modernisation costs and this also benefits tenants.

6.2 Full costs and energy-related additional renovation costs

The **full costs** of renovation include all repair costs including costs for energy-saving measures for the building envelope (thermal insulation/windows and all related ancillary costs), costs for any additional construction and planning work in order to avoid thermal bridges as well as costs for energy-related technical equipment (heating/ventilation) (cost groups 300 and 400 DIN 276).

Repair costs are costs to restore the functioning condition of (technical) systems, devices, building components and functional units of the building. Repair often also includes the replacement of components. Energy-related building renovation usually includes repair work.

Energy-related additional costs are those cost shares which are necessary to achieve energy savings in contrast to mere repair work, i.e. the cost shares incurred for components with energy relevance and additional costs for a building part. If the measure is carried out before repair work is required, repair costs do not have to be deducted.

Table 22: Assumptions for full costs and energy-related additional costs in residential buildings, mean values

	KfW Efficiency House Standard (EH)	Full costs	Of which energy-related additional costs
		Euro per sqm of living area	
Single and two-family home	EH100	450	135
	EH85	470	155
	EH70	520	205
	EH55	590	275
Multi-family dwelling	EH100	310	95
	EH85	345	130
	EH70	400	185
	EH55	465	250

Source: Prognos et al. 2015

The Energy Efficiency Strategy for Buildings contains the following assumptions for the distribution of full costs according to repair and energy-related additional costs depending on the energy-related condition to be achieved. The costs assumed here are mean values which were evaluated and assumed by the experts (**Table 22**).

6.3 Financing investment

The capital market has already developed offers for financing energy efficiency measures in many areas. Contracting models are often a good starting point for independent development, definition and financing of energy saving and infrastructure investment. The aim is to especially promote the market for energy-saving contracting models further, for instance, by expanding the scope of guarantees to contracting models for small and medium-sized enterprises as provided for in NAPE. Further new approaches (such as crowd funding) are additionally available on the market to cushion saving risks through new insurance products as well as financing of efficiency investment.

However, measures in terms of capital offers and risk protection alone are not sufficient to overcome existing obstacles to financing efficiency investment. Existing – economically attractive – investment potential is currently not sufficiently used. Identifying and implementing suitable measures to boost demand are therefore becoming increasingly important. In order to expand the investment framework for energy efficiency in buildings, the instruments must therefore:

a) address the fact that many projects are small as well as the complexity of project development (transaction cost reduction),

b) accept or compensate for the often long payback periods (for instance, by focusing more on life cycle costs) and

c) reduce complexity and create transparency.

Owner-occupants

Investment decisions by owner-occupants begin with a profitability analysis which can be a static or dynamic exercise. The depreciation (amortisation) method is a common approach. This static method attaches equal economic weight to costs and expenses and this distorts results over a longer period of time. Dynamic methods are therefore more suitable for long-term investment in buildings because these methods consider the development of payment flows (revenue and expenses) over the course of time. This method enables the identification and valuation of the financial impacts of an investment decision of a longer period of time. The annuity and the net present value methods are particularly common for private owners.

Private small-scale landlords

The dynamic method also provides important support for private small-scale landlords for investment decisions because the result of this investment calculation is the net present value. An ultimately positive net present value of an investment represents an “asset surplus” which the investment yields in addition to the capital invested and the required minimum rate of return. If several renovation alternatives are to be compared, the most profitable option is the one with the highest positive net present value.

Housing sector

Investment decisions by the housing sector are determined by a host of – often conflicting – aspects and aims. Questions of profitability must always be seen in the context of social compatibility and long-term rentability and against the background of the conditions of the neighbourhood and urban development. Furthermore, modernisation projects must also consider aspects of age-compliant living. Decisions by a company in the housing sector are therefore often subject to conflicting social, ecological and cultural requirements for housing construction and profitability. Investment in energy-saving measures leads to higher rents (excluding heating costs) which are used to refinance the underlying expenditure. The question as to whether reduced operating costs (including heating costs) will compensate for the increase in rent (excluding heating costs) must be answered by examining which components of the increase in rent (excluding heating costs) are driven by energy-related additional costs and which cost components are due to other non-energy related measures designed to improve living value.

Non-residential buildings owned by companies

Similar to the situation with housing companies, profitability has a key role to play in investment decisions for non-residential buildings. However, an important difference is the fact that buildings which are used for a company's own purposes do not generate revenue. Investment in a building's energy efficiency is therefore often secondary to a company's core business so that the issue itself and therefore knowledge of the savings potential are often not the focus of interest. Information regarding possible savings and their profitability is therefore particularly important. The profitability analysis is frequently influenced by short-term return and high depreciation expectations. The range of uses of non-residential buildings is generally very wide so that the focus must be more on the respective uses in order to evaluate the potential offered, for instance, by state-of-the-art technical systems compared to the building envelope.

Rented non-residential buildings offer more freedom in terms of their tenancy agreements than residential buildings, for instance, by offering more possibilities for rent increases (excluding heating costs) in response to savings due to improved efficiency. Long-term tenancy agreements could be an obstacle to energy-saving investment in rented buildings.

6.4 Contracting to service providers

A central feature and important part of contracting arrangements is financing of the contracting measures. Contractors offer specialised technical implementation and financing as a one-stop service. Unlike other forms of external financing, such as leasing, contracting schemes link the customer's payment obligations to the concrete success of the technical implementation, for instance, in the form of guaranteed energy savings or energy supply tariffs. The ESC aims at financing energy saving measures through the financial savings achieved. The contractor opens up savings potential at his own risk during the term of the agreement and, depending on the contractually agreed model, receives a contracting rate out of the savings. In the event that compulsory measures involving significant investment sums are carried out as part of the ESC, financial support can be provided for the contractor in the form of a once-off construction cost grant.

6.5 Rebound effects

The phenomenon that a calculated saving potential does not fully translate into real energy savings after renovation is discussed under the term "rebound effect". Savings actually achieved after renovation are sometimes lower than forecast. This can be due, for instance, to increased user comfort expectations. Tenants may be tempted, for instance, to save less energy after renovation and set higher room temperatures or the same temperature for all rooms of a building.

6.6 Development of living costs

It must be ensured that low-income tenants and owners will not be put at a disadvantage by the development of energy-efficient buildings. However, ensuring affordable living is a challenge especially in large cities, densely populated areas and much sought-after university cities. Low-income households, but increasingly also households with middle incomes, are finding it difficult to find affordable housing. But cities are attractive not just for university students and young employees, but increasingly also for elderly people who use nearby culture and leisure offerings. Increasing demand thus leads to rising rents and property prices. Furthermore, space and resources are limited.

The picture is different in rural areas and many smaller cities where the challenge is to avoid vacancies.

Modification of existing buildings to meet the needs of the elderly is therefore another focus of housing policy. The current supply of housing suitable for the elderly is by far below the level needed to cover the growing demand because the share of old people is increasing continuously. But it is ultimately not only the number of buildings in cities and rural regions that needs to be adapted to demographic change, but also their quality in terms of energy. Energy-related renovation can lead to final energy savings and, given rising energy costs, also reduce costs for households in the longer term. However, it will be mainly high-income households who will initially be able to afford more expensive, energy-optimised housing which ultimately helps to save costs. At the same time, there is a risk of low-income households being displaced to buildings in an insufficient energy-related condition. These social and geographical inequalities must be avoided.

An evaluation by IWU suggests that living space consumption rises below average and that the share of heating costs falls as incomes rise. An increase in energy costs therefore has a regressive effect in terms of distribution policy. This means that lower-income households are burdened more than higher-income households in relation to their respective income levels. The same applies to rents. Lower-income households are therefore more susceptible to energy poverty which occurs if too high a share of a household's income must be spent on energy in order to achieve a reasonable quality of living. Inefficient buildings, high energy prices along with low incomes or a lack of knowledge regarding the potential for savings are conditions that can lead to energy poverty. Assuming an unchanged amount of rent including heating costs, it is assumed that energy-saving renovation of a building can reduce living costs and that there is considerable potential to relieve households affected by energy poverty.

Financial burdens on private households in Germany should not be generally underestimated. In 2013, every fifth citizen (18 percent) in Germany considered themselves to be economically weighed down by their monthly living costs. Among the poor population, this even applied to 30 percent, i.e. almost every third citizen. The burden was slightly lower than in 2008 (total of 24 percent, threatened by poverty: 36 percent). 9 percent of the population threatened by poverty stated that they failed to pay utility bills (total population: 4 percent). 5 percent of those threatened by poverty were also in default with mortgage or rent payments (total: 2 percent) (Destatis).

6.7 Assumptions for cost-of-living estimates

The Energy Efficiency Strategy for Buildings provides a picture of the average cost-of-living structure in Germany through a first rough analysis of living costs. The evaluations are a first approach towards addressing the cost-of-living issue as a whole.

The analysis is based on the microsimulation model of Institut für Wohnen und Umwelt (IWU) which, for its part, is based on a building model that uses the building stock with data from 2008 (baseline year). Changes due to new buildings are not updated in the model so that it can only estimate activities and changes on the basis of existing buildings. However, specific activities in the building stock can be examined without considering influences due to new building activities.

In order to enable a comparison of the costs of living today and in the future, construction price increases are assumed to be equal to average price increase rates in Germany.

Table 23 shows the costs for energy sources. The estimate is based on generally moderately rising energy prices which will increase above proportion due to the increasing shortage of oil and biomass until 2050.

All calculations were carried out with real prices from 2013.

The cost-of-living estimate is based on a uniform return expectation by investors and owners of 7 percent in real terms. Accordingly, the allocation to living costs is therefore not based on the maximum value of 11 percent p.a. which is currently possible, but instead on the possible rate of return of 7 percent and the life cycle of the renovation measures.

Table 23: Real prices for the cost-of-living analysis, including 19 percent VAT

Energy source	2008 (Price in ct./kWh)	2050 (Price in ct./kWh)	Change against 2008 (in %)
Electricity (heat pump)	16.6	20.1	+21
Gas	7.3	9.6	+32
Oil	8.0	12.5	+56
District heating	8.1	10.7	+33
Biomass (wood, pellets)	5.0	"Efficiency" target scenario: 7.4	"Efficiency" target scenario: +46
		"Renewable energy" target scenario: 9.6	"Renewable energy" target scenario: +90

Source: Prognos et al. based on the energy reference forecast

This general view does not enable a more differentiated analysis of individual building segments or regional differences.

6.8 Development of full and modernisation costs

The forecast for investment in the building envelope and heating systems (without disposal costs) until 2030 and the estimate until 2050 assume that the reference scenario up to the year 2050 will require **full costs of 1,018 bn euros** compared to the year 2008. Energy-related additional costs total around 300 bn euros (**Table 24**).

In the “efficiency” target scenario, **full costs are forecast to increase to around 1,535 bn euros** and the share of energy-related additional costs (modernisation costs) to around 562 bn euros by 2050. Compared to the reference scenario, full costs therefore increase from 1,018 bn euros by **517 bn euros** and the share of energy-related additional costs from 294 bn euros by around 268 bn euros.

In the “renewable energy” target scenario, full costs **are forecast to increase to around 1,137 bn euros** and the share of energy-related additional costs (modernisation costs) to around 384 bn euros by 2050. Compared to the reference scenario, full costs therefore increase by around **119 bn euros** and energy-related additional costs by around 90 bn euros.

Table 24: Development of full and modernisation costs in billion euros

	Full costs from 2008 up to ...			Modernisation costs from 2008 up to ...		
	2020	2030	**2050**	2020	2030	**2050**
Reference scenario						
Building envelope	170	328	**728**	54	106	**236**
Heating system	79	98	**290**	17	34	**58**
Total	249	426	**1018**	71	140	**294**
"Energy efficiency" target scenario						
Building envelope	203	501	**1,234**	68	188	**481**
Heating system	82	109	**302**	20	47	**81**
Total	285	609	**1,535**	88	234	**562**
"Renewable energy sources" target scenario						
Building envelope	174	347	**788**	55	114	**266**
Heating system	83	122	**348**	21	58	**118**
Total	257	469	**1,137**	76	172	**384**

Source: Federal Statistical Office: SUF EVS 2008; own calculations, Prognos et al. 2015

However, the results of this cost calculation which is focused on the buildings sector do not automatically mean that the two target scenarios are **effective for the national economy**. In the next step, the Energy Efficiency Strategy for Buildings must therefore be put into the context of the national economy. Interdependencies and competition for use between the electricity, buildings, industry and transport sectors, for instance, can lead to higher costs for the economy as a whole.

As shown in chapter 4, cost increases in the "energy efficiency" scenario are strongly focused on measures related to the building envelope. Full costs therefore increase by 517 bn euros (+50 percent) against the reference scenario, whilst energy-related additional costs almost double (+268 bn euros). By contrast, additional costs for measures related to technical systems are significantly lower compared to the reference scenario totalling just around 12 bn euros (+4 percent) and around 23 bn euros (+40 percent) in the case of energy-related additional costs.

Unlike the "energy efficiency" scenario, the "renewable energy" target scenario does not focus on the building envelope or technical systems. Full costs for technical systems and the building envelope each increase by around 60 bn euros compared to the reference scenario. Energy-related additional costs are at the same level for technical systems and in the order of 30 bn euros for the building envelope.

6.9 Energy-saving renovation as a profit model

In 2008, costs for housing and heating/hot water totalled close to 230 bn euros. Given an expected return of 7 percent, energy-saving renovation carried out in the "efficiency" target scenario up to 2050 leads to an increase in **housing costs** of around **43 bn euros** per annum. Energy cost savings total close to 19 bn euros during the same period. Total housing costs rise by around **24 bn euros** (**Table 25**).

Given an expected return of 7 percent, energy-saving renovation carried out in the "renewable energy" target scenario until 2050 leads to an increase in **housing costs** of around **30 bn euros** per annum. Energy cost savings total around 23 bn euros per annum. Total costs for flat and home users in 2050 are around **8 bn euros** (i.e. around 3 percent) higher than in the 2008 baseline year.

In the "energy efficiency" scenario, additional investment compared to the reference scenario is not compensated for by lower energy costs. Housing costs therefore increase by around 14 bn euros for all buildings in their totality. In the "renewable energy" target scenario, total costs in 2050 are around 4 bn euros lower than in the reference scenario. Whilst housing costs rise by around 7 bn euros, 10 bn euros will be saved in energy costs.

Table 25: Housing costs per annum in billion euros with an expected return of 7 percent

	Cost of living				Absolute changes against 2008		
	2008	2020	2030	**2050**	2020	2030	**2050**
Reference scenario							
Accommodation	**183**	189	194	**206**	6	11	**23**
Heating/hot water	**46**	42	41	**33**	-4	-5	**-13**
Living	**229**	231	235	**240**	2	6	**11**
"Energy efficiency" target scenario							
Accommodation		190	201	**226**	7	18	**43**
Heating/hot water		42	38	**27**	-4	-8	**-19**
Living		231	239	**253**	2	10	**24**
"Renewable energy sources" target scenario							
Accommodation		189	197	**213**	6	14	**30**
Heating/hot water		42	37	**23**	-4	-9	**-23**
Living		231	234	**236**	2	5	**7**

Source: Federal Statistical Office: SUF EVS 2008; own calculations

If the cost of living is put in terms of living area, the cost of living will increase by a relatively moderate rate in all scenarios under the assumptions made. In all cases, savings are higher than housing costs due to rent increases resulting from renovation. The total cost increase per square metre (around 3 percent) is lowest in the "renewable energy" target scenario, compared to around 10 percent in the "energy efficiency" target scenario.

6.10 Evaluation of investment and use cost estimates

The overall picture of the building stock shows that on average overproportionate cost increases do not have to be expected in both target scenarios, i.e. "efficiency" and "renewable energy" and that both of them follow similar lines as the reference development – on condition that increases in building costs will remain within the range of general living cost increases and that energy prices remain within the range of the assumptions made.

For the avoidance of doubt, it should be noted that both target scenarios only indicate potential and/or restriction limits. Real development over the coming 35 years is likely to remain within the corridor defined by the scenarios.

Compared to the "efficiency" target scenario, the "renewable energy" target scenario is significantly lower in terms of total investment and investment in the building envelope and only insignificantly higher in terms of technical systems. In the "renewable energy" target scenario, the potential of renewable energy is exhausted up to the upper limit. This means that competition for use may in the long term lead to higher energy prices for biomass than those assumed. The "renewable energy" target scenario is therefore considered to be less robust in terms of energy prices. At the same time, it involves a greater risk with regard to energy price and system cost estimates. Possible competition for use by the different sectors must be examined from a macroeconomic perspective. Furthermore, the Energy Efficiency Strategy for Buildings is designed as a dynamically changing concept which would have to be adjusted to changed conditions or new results.

In contrast to this, the "energy efficiency" target scenario has a lesser impact on other sectors. This advantage can be achieved through greater efficiency of the building envelope and other applications, such as cooling and lighting. This efficiency level requires substantial investment so that costs in the buildings sector are higher than in the "renewable energy" target scenario. Energy dependence declines at the same time.

In view of the long horizon up to 2050 and the resultant uncertainty of cost estimates, the results as a whole should be understood as an initial guidance instrument. As the Energy Efficiency Strategy for Buildings will be developed further, cross-sector optimisation of the total costs of future energy supply must be taken into consideration.

6.11 Alliance for Affordable Living and Building and Building Cost Reduction Commission

Under the leadership of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, the "Alliance for Affordable Living and Building" was set up as a central instrument for intensifying housing construction in a joint effort together with federal states, municipalities, the housing and construction sectors as well as other stakeholders in society. A major component of the Alliance is the Building Cost Reduction Commission which, pursuant to the coalition agreement, has the task of "examining price-driving and over-dimensioned building standards and costs of materials and processes".

The Commission's final report containing more than 60 cost-cutting recommendations will be submitted by the end of the year. The work performed so far within the scope of the "Alliance for Affordable Living and Building" shows that increasing living space, fit-out features and technical equipment are the real cost drivers in housing construction. These parameters are often influenced by rules and regulations issued by municipalities, federal states and, to some extent, by the Federal Government and should be reduced. In contrast to this, work performed by the construction trade is not among the major cost drivers, nor is the Energy Saving Ordinance. Further measures will be presented at the Alliance's final forum in March 2016. Essential issues include the provision of building land, increasing building density in inner cities, for instance, by converting attics and existing buildings to other forms of use.

7. Activities by the public sector

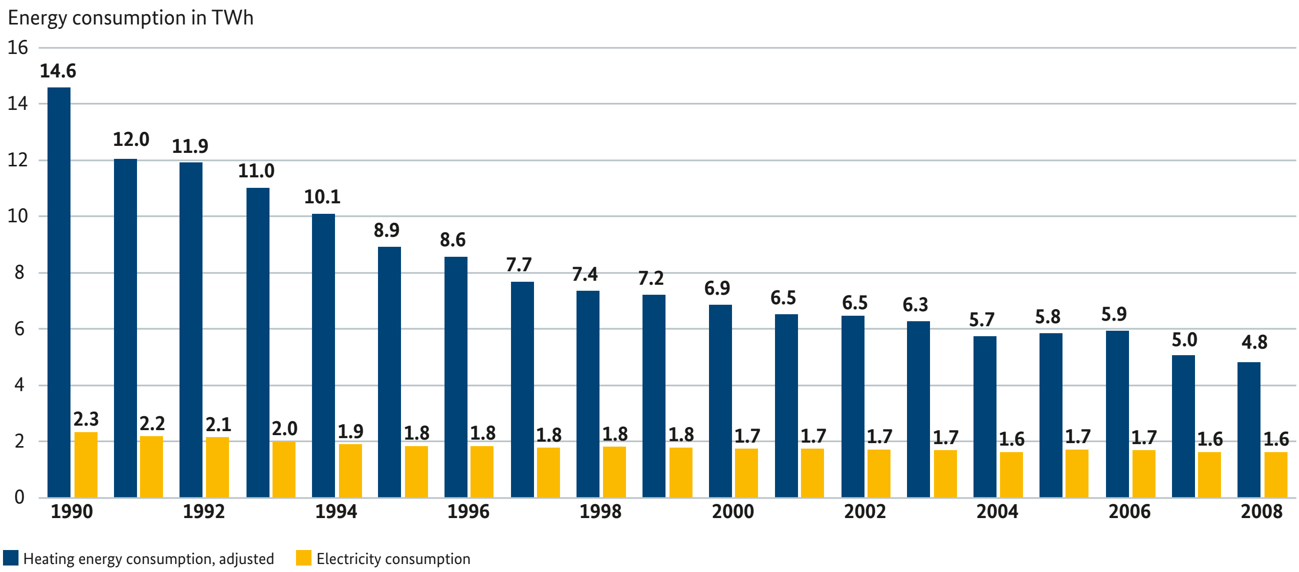
In recent years, efforts have been made under the energy-saving programme for federally-owned properties (volume: 120 m euros) to reduce final energy consumption for heating federally-owned properties. In 2011, the so-called "ministerial order on the Energy Saving Ordinance" introduced requirements for outperforming the applicable Energy Saving Ordinance in federally-owned buildings. This means that primary energy demand must remain at least 20 percent below the permissible primary energy demand of all new buildings and of existing buildings after modification, expansion or development. Irrespective of this, the energy-related quality of the building envelope (thermal insulation, windows) must be 30 percent better than the permissible level. Furthermore, the guidelines for the performance of federal-government construction tasks and the provisions regarding the implementation of an energy management system contained therein are a tool that can be used to control energy consumption of federally-owned buildings during operation.

Civilian and military properties of the **federal administration** have recorded an almost 70 percent reduction in heat consumption and an around 30 percent reduction in electricity consumption since 1990. The reduction is due to both the abandoning of properties (mainly by the Federal Armed Forces) and increased efficiency in the form of declining heat consumption per unit of space (**Fig. 27**).

Climate-adjusted absolute heat consumption of **military properties** fell to a similar degree by slightly more than 70 percent and absolute electricity consumption by around 40 percent. Electricity consumption per unit of space, however, increased by around 9 percent in recent years, whilst heat consumption per unit of space fell by around 19 percent during the same period.

Absolute heat consumption by **civilian properties of the federal administration** has declined by around 34 percent since 1990, whilst absolute electricity consumption increased by around 30 percent during the same period. Heat consumption per unit of space fell by 22 percent whilst electricity consumption per unit of space increased by around 15 percent.

Figure 27: Heat and electricity consumption by (civilian and military) properties of the direct federal administration from 1990 to 2008 (energy consumption of civilian properties extrapolated)



Source: BBSR 2012

7.1 Energy-efficient refurbishment timetable for federally-owned properties

The energy-efficient refurbishment timetable is to serve as a basis for exemplary energy-efficient refurbishment of the properties of the Institute for Federal Real Estate (BImA). The aims are a 20 percent reduction in heat demand by the year 2050 as well as an around 80 percent reduction in primary energy demand by the year 2050 (baseline year: 2010).

"Final energy" is used as the verification parameter for the "20 percent reduction in heat demand by the year 2050" target in line with the applicable technical rules of energy saving legislation. The energy-efficient refurbishment timetable therefore uses a holistic approach and considers all measures (optimising operation, modernising technical systems, renovating the building envelope, using renewable energy) designed to reduce final energy consumption.

The energy-efficient refurbishment timetable focuses on achieving these targets through economic measures. The use of renewable energy for heat supply is to be developed in an exemplary manner in this context. The option of applying section 7 (compensatory measures) in order to comply with the Renewable Energies Heat Act is to be used to the smallest extent possible.

7.2 Energy-efficient refurbishment timetables of the federal states for their properties

Energy-efficient refurbishment timetables can be effective tools for implementing an energy-efficient refurbishment concept for large building stocks. Especially if energy specifications are linked to long-term and stable investment planning, economically sensible solutions can be created that ensure further development of the building stock against the background of property use perspectives for the property sector.

The energy-efficient refurbishment timetables are designed to integrate activities already implemented by the federal states into the overall strategy. In the federal states of Baden-Württemberg, Brandenburg and Hesse, for instance, energy-efficient refurbishment timetables have already been set up for federal-state owned properties:

- The energy-efficient refurbishment timetable of Baden-Württemberg aims at meeting the federal state's energy targets by the year 2050, i.e. a 50 percent reduction in energy consumption – 80 percent energy from renewable sources – 90 percent reduction in greenhouse gas.

- Brandenburg's energy-efficient refurbishment timetable calls for compliance with the federal state's energy strategy by the year 2030 (23% final energy savings by the year 2030).

- The federal state of Hesse is implementing the target of climate-neutral federal-state administration by the year 2030 through its energy-efficient refurbishment timetable. The federal states of Berlin and North Rhine-Westphalia are currently in the process of having energy-efficient refurbishment timetables drafted for their buildings.

III. Measures and further options to increase energy efficiency and the share of renewable energy in the building stock

1. Existing measures

Germany boasts a wide range of tools for increasing energy efficiency and strengthening renewable energies on the heat market. The established instruments can be generally broken down in terms of providing support, demanding action, informing and researching. These existing instruments and their present design as well as their respective effects are considered in the reference scenario.

With the immediate actions under the **National Action Plan on Energy Efficiency (NAPE)** adopted by the Cabinet on 3 December 2014, additional immediate actions and longer-term work processes to boost energy efficiency were triggered in a number of sectors including the buildings sector. These measures have not yet been considered in the calculation of the reference scenario. However, the results of a scientific project in support of NAPE suggest that additional energy efficiency savings of 390 PJ to 460 PJ can be expected up to the year 2020 (forecast from 3 December 2014). Although buildings account for part of these forecast savings, NAPE does not clearly define the contents of the buildings sector.

1.1 Energy Saving Legislation and other regulatory law for buildings

Energy Saving Act (EnEG)/Energy Saving Ordinance (EnEV)

The Energy Saving Act (EnEG) and the Energy Saving Ordinance (EnEV) which is based on it are an important instrument of the Federal Government's energy efficiency policy. Continuous updating of the energy-saving requirements for buildings orientated towards the state of the art and economic efficiency is an important contribution towards energy savings. The revised Energy Saving Ordinance (EnEV 2014) came into effect on 1 May 2014.

Increasing primary energy requirements for new buildings by on average 25 percent beginning 1 January 2016 is a core element of these efforts. The new building standard of the Energy Saving Ordinance, which will be valid from 2016 on, transposes a key requirement of the EU's Energy Performance of Buildings Directive into German law and forms the basis for the National Action Plan on Energy Efficiency (NAPE) and the Federal Government's Climate Action Programme 2020. It is a step towards the nearly zero-energy building whose standard – i.e. the technically and economically feasible minimum requirements – will be introduced by the end of 2016 in line with the requirements of the Energy Saving Act in order to transpose the EU's Energy Performance of Buildings Directiveinto German law. Beginning in 2019, new public-sector buildings and beginning in 2021, all new buildings must be built as nearly zero-energy buildings.

Renewable Energies Heat Act (EEWärmeG)

The Renewable Energies Heat Act (EEWärmeG) has been in effect since 1 January 2009 and obliges owners to cover part of the heat demand of new buildings from renewable energy. In view of its exemplary function, the public sector is obliged to use renewable energy also in full-scale renovation projects for its building stock. The law is expected to help raise the share of renewable energy in energy consumption for heating and cooling to 14 percent by the year 2020.

Under the Renewable Energies Heat Act, owners are free to decide which form of renewable energy is to be used whilst respecting certain minimum requirements. The law also permits certain alternative measures instead of using renewable energy, so that the obligations under the law can, for instance, also be fulfilled by better energy savings.

Heating Cost Ordinance

The Heating Cost Ordinance is part of energy saving legislation and regulates the metering, distribution and accounting of heating costs and hot water between tenants and landlords. The introduction of the Heating Cost Ordinance has contributed towards an average reduction in energy consumption of around 15 percent. Efforts are currently underway to examine the extent to which updating and upgrading the rules for accounting and/or user information, whilst fulfilling the requirement of economic efficiency, can make a reasonable contribution towards energy savings above and beyond this level.

EU ecodesign/EU label – increasing energy efficiency of products

Efficient technologies which also influence power consumption in buildings are becoming increasingly common. This is reflected, for instance, by sales figures for lighting systems. According to estimates from the 2013 forecast, the effect of the EU's new requirements regarding ecodesign (2009/125/EC) and energy consumption labelling (2010/30/EU) deserve special mention. Energy consumption labels for products support the market penetration of efficient products. The label has turned out to be an effective consumer information tool. These two instruments are combined within the scope of the EU's top-runner strategy. The ecodesign, for instance, with its staged increase in minimum requirements fosters the gradual displacement from the market of products with relatively high energy consumption, and energy consumption labels for products support the market penetration of efficient products. These two tools in tandem create incentives for manufacturers to develop correspondingly innovative, energy-efficient technology and to make energy consumption transparent for consumers.

In order to strengthen energy efficiency even further, the Federal Government supports the introduction of demanding requirements for the respective product groups. At the same time, it must be ensured that the requirements are designed in a technology-neutral manner and that they are ecologically sensible and economically reasonable. This will enable a further reduction in energy demand.

Tenancy law, in particular, rent increase option after modernisation

The right to increase rents after modernisation (section 559 of the German Civil Code (BGB)) is an important economic precondition for energy-saving modernisation of existing leasehold property. A revision of the option to increase rent after modernisation must ensure that housing remains affordable on the one hand and that incentives are not reduced on the other.

1.2 Financial incentives

Financial incentives generate momentum for implementing energy efficiency measures and/or the increased use of renewable energy.

CO_2 building renovation programme

The CO_2 building renovation programme is a central promotional instrument for energy saving and climate protection in the buildings sector. Funds from the CO_2 building renovation programme are used to finance promotional programmes of KfW for energy-efficient building and renovation. Funds are available for new buildings and comprehensive renovation with the aim of achieving the KfW Efficiency House standard as well as energy-efficient individual measures in existing buildings. The promotional standards of these programmes go significantly beyond the requirements of energy saving legislation. The CO_2 building renovation programme also provides special promotional rates for best practice projects (for instance, via model projects). The Federal Government uses the promotional lever which is available in this respect in order to speed up the dissemination of efficient and innovative projects, such as the KfW energy-efficient buildings 40 and 55.

Since 2006, the CO_2 building renovation programme has triggered an investment volume of 209 bn euros that was used in close to 4 million flats and more than 2,200 council houses and municipal buildings, already resulting in CO_2 emission savings of close to 8 million tonnes per annum (as per 2015). In 2015, the Federal Government increased the volume of promotional funds to 2 bn euros. Energy-saving renovation and the energy efficient construction of new commercial non-residential buildings have been supported and subsidised since 1 July 2015. Funds under this programme are available to all **commercial businesses**, freelance professionals and contractors. Since 1 October 2015, **municipalities, municipal companies and social institutions** have been eligible for support via KfW for the construction of new, particularly energy efficient buildings. Existing rehabilitation support and promotional measures have also been improved.

"Renewable energy" Market Incentive Programme

The Market Incentive Programme is a central instrument designed to promote renewable energy in the heat area. Since 2009, the support programme has been anchored in section 13 of the Renewable Energies Heat Act which provides for support for renewable energy for heating and cooling. The programme contributes towards increasing the share of renewable energy in the heat sector to 14 percent by the year 2020 and is additionally making an important contribution towards achievement of the goal of a virtually climate-neutral building stock by 2050. The Market Incentive Programme promotes, for instance, solar panel installations, biomass plants, heat pumps, deep geothermal energy plants, heat grids fed from renewable energy as well as large heat storage systems for renewable energy. The amended Market Incentive Programme came into effect on 1 April 2015 and sets forth new and improved conditions for support.

The Market Incentive Programme supports particularly innovative projects, so-called solar houses. The key feature of a **solar house** are the solar panels on the roof which are ideally facing south. The solar panels collect solar heat and direct it into a central buffer storage. At least 50 percent of gross energy demand for heating and hot water in a solar house should be covered from solar radiation energy (solar thermal energy or photovoltaics). In contrast to this, **efficiency plus houses** rely on electric heating. A large PV installation and, increasingly, a battery storage unit are used to achieve maximum possible energy autonomy (up to 30 percent without and up to 60 percent with a battery).

"Energy Efficiency" Market Incentive Programme

The "Energy Efficiency" Incentive Programme replaces the tax support scheme for energy-efficiency building renovation measures that was originally planned in the National Action Plan on Energy Efficiency (NAPE). The support volume totals 165 m euros per annum. The programme supports:

- the introduction to market of innovative fuel cell heating systems,
- the installation of ventilation systems in conjunction with measures for the building envelope in order to avoid damage to the building (for instance, mould),

- the replacement of inefficient heating systems with efficient ones; this includes measures to optimise the heating system (heating and heat distribution) which address the entire efficiency potential of the heating system, as well as a quality, efficiency and outreach initiative.

1.3 Energy tax and electricity tax

The ecological tax reform from 1999 raised energy tax rates and introduced an electricity tax. The last stage was implemented in 2003.

1.4 Tax deductibility of craftsmen's bills

Owner-occupants and tenants can deduct 20 percent of the labour costs – maximum of 1,200 euros – of craftsmen's bills from their income tax bill (section 35a (3) of the Income Tax Act (EStG)) unless other public funds were received. Landlords can treat the costs of energy-saving renovation measures as maintenance costs and thereby reduce their tax bill, often by the full amount of such costs.

1.5 Information and outreach

The energy balance of a large share of residential and non-residential buildings in Germany is poor by today's standards. In order to change this, and to trigger investment in the energy efficiency of buildings, the Federal Government relies on information and outreach as core elements of its energy efficiency policy. The aim is to provide owners with reliable information regarding the energy-related condition and renovation potential of their properties.

The **on-site consulting** programme addresses owners of residential buildings. An energy consultant first analyses the property and then prepares a detailed energy consultancy report. Support and promotional programmes as well as the specific options available to the owner are considered. The **energy consulting for SMEs** programme supports renovation concepts for commercial buildings of small and medium-sized enterprises. Support includes the energy consulting costs and assistance during implementation.

The **list of energy efficiency experts** which the German Energy Agency maintains for the Federal Government serves as a quality assurance tool for funded energy consulting services as part of "on-site consulting" or "energy consulting for SMEs" as well as the KfW programmes for the energy-efficient building. The Federal Agency for Energy Efficiency additionally maintains a **public supplier list** for energy services, energy audits and energy efficiency measures. The **energy consulting units of the consumer advice centres** focus on the different interests of private households. An expert conducts so-called **energy checks** in the household in order to identify energy saving possibilities.

The **energy passport** for buildings enables tenants or buyers to consider the energy-specific condition of the building in their decisions. Pursuant to the Energy Saving Ordinance, the energy passport must be presented to prospective buyers, tenants and/or lessees whenever a property is rented out, sold or leased.

The Federal Government is planning to introduce a **national heating label** for old boilers in 2016. The new efficiency label is to inform consumers about the efficiency status of their heating boilers and in this context to provide more in-depth information regarding consulting services and possible subsidies or support programmes. The measure is designed to motivate consumers to replace old heating boilers. Starting in 2016, the label will be introduced initially on a voluntary basis and as of 2017 will become compulsory and must be issued by the official heating inspector. In addition to this, a voluntary **heating check** will be offered to consumers as a means of identifying the efficiency of their entire heating system.

The Federal Government supports and promotes the creation of **energy efficiency networks in municipalities** in order to utilise the energy saving potential that exists there. In a manner comparable to the on-site consulting service for private home owners, **energy consulting services for municipalities** will also be offered for municipal buildings and sewage treatment plants.

In order to motivate households and commercial users to save energy, a decision was made to introduce the **"energy-saving meters" pilot programme** as part of NAPE. Energy-saving meters measure the energy consumption of appliances and installations and additionally identify options for saving energy.

1.6 Energy research

The "Energy in buildings and neighbourhoods" research network

Energy research is a strategic element of energy policy and contributes towards the successful implementation of the energy transition through the medium to long-term development of technological innovation. The basis is the Federal Government's 6th energy research programme that focuses on industry-driven trans-disciplinary projects with research institutes and their practical application. The "energy in buildings and neighbourhoods" research network bundles research initiatives with building relevance in order to quickly transpose innovative technologies and concepts into practical use:

The Energy-Optimised Building (EnOB) research initiative

The "Energy-Optimised Building" research initiative is orientated towards the "Building of the future" as a model. The initiative focuses on the construction of energy-optimised, sustainable, functional, comfortable and architecturally valuable buildings at reasonable investment and operating costs. The support measures aim to foster further technological development in order to boost the efficiency of technical systems in buildings and to integrate renewable energy, taking life cycle analyses and the protection of resources into consideration. Besides the use of innovative components, optimising energy use during operation through low-investment measures is another important focus. This is supplemented by grid-friendly buildings in the urban context where sensible integration as an energy sink, source or storage system into local energy supply systems can be tested.

The EnEff:Stadt (energy-efficient city) research initiative

The "EnEff:Stadt – Forschung für die energieeffiziente Stadt" (research for the energy-efficient city) initiative addresses local innovative overall solutions for more energy efficiency and better integration of renewable energy at neighbourhood level. It aims to speed up the necessary processes in urban energy supply structures through integral planning and the implementation of pilot projects for large-scale energy efficiency.

The EnEff:Wärme (energy-efficient heat) research initiative

The "EnEff:Wärme" (energy-efficient heat) research initiative encompasses measures for energy-efficient and solar thermal power generation (low-temperature solar thermal energy, combined heat/cold generation) as well as heat and cold grids in densely populated urban areas. Its aim is to optimise load-near supply structures through the use of innovative components as well as planning and operating methods from an energy, economic and ecological perspective.

2. Injecting new momentum – a discussion of new proposals for methods to boost energy efficiency and to develop renewable energy in the buildings sector

The Federal Government's energy efficiency policy continues to focus on voluntariness, economic efficiency of measures, technology-openness and a well-balanced mix of existing, upgraded and new instruments in the form of politically and socially accepted incentive systems, requirements and outreach measures. All stakeholders must consider the energy-efficient renovation of the building stock to be an opportunity if this is to be successful. This means that trust must be created and cooperation between the different stakeholders fostered in order to enhance the quality of housing and living for citizens, to reduce dependence on fossil fuels and thus to enhance supply security in a joint effort. This is the reason why this topic was also addressed in a separate working group of the Alliance for Affordable Living and Building.

The results of the reference scenario show that the measures already established are a major step towards achieving the energy policy target of a virtually climate-neutral building stock, i.e. reducing primary energy demand by around 80 percent against the level of 2008.

NAPE has already developed the key points of this Energy Efficiency Strategy for Buildings. These key points will be described below in more detail. The measures address a wide range of stakeholders and thereby make an important contribution towards target achievement. The NAPE measures already adopted in 2014 must be considered in addition to the reference scenario. These include the upgrading and expansion of the CO_2 Building Renovation Programme, the continuation of the market incentive programme for renewable energy on the heat market, the energy efficiency label for old heating installations (supplemented by the heating check) and the promotion of cross-sectional technologies.

The Energy Efficiency Strategy for Buildings also contains proposals for the further development of existing actions in order to reduce final energy consumption in buildings and to speed up the use of renewable energy. With regard to development efforts, the Federal Government is focusing on measures to increase the effectiveness of the actions. The strategy also identifies further possible fields of action where these fundamentals should be first discussed with stakeholders. The measures identified in the Energy Efficiency Strategy for Buildings should be regarded as the basis for more in-depth debate and could be addressed within the scope of discussion processes. The proposals include technology-open and target-group specific approaches for individual buildings.

The proposals can be generally broken down into the categories of providing support, demanding action and conducting research:

- The **"strengthen information and consulting services as well as creating new incentives"** field of action aims at eliminating information deficits among building users and craftsmen and to provide target-group specific assistance during the renovation process. This is the purpose of the measures designed to establish a voluntary standardised building-specific renovation roadmap, to further develop and expand energy consulting/information offers and to establish regional renovation networks.

- Attractive and continuous **promotion and continuation of financial incentives** are to be fostered through investment support for ambitious building renovation and new building concepts, the promotional concept titled "renewable energies in low-temperature heat grids showcase" as well as additional investment support for the energy-saving renovation of cities and neighbourhoods as part of urban development.

- The further development of **regulatory law** aims to ensure long-term and continuous implementation.

- **Continuation of research and innovation** is a prerequisite for a diverse mix of technologies and services in the buildings sector. Targeted measures to promote technology and market launch as well as accelerated transfer to practical use are therefore vital. The promotional initiative on "Innovative Projects for a virtually Climate-neutral Building Stock 2050" is a first step in this direction.

All the proposals and actions will be implemented within the scope of the applicable budgets of the respective ministries in charge.

2.1 Establishing the building-specific renovation roadmap

The majority of renovation measures in buildings are not carried out as a comprehensive full-scale project. Building owners often lack the necessary capital, and they are often unaware of the opportunities resulting from a sensible combination of repair, modernisation and renovation measures. Instead, building owners often carry out (partial) rehabilitation projects because they shy away from the complexity of full-scale renovation and the sometimes lacking reliability of consulting, planning or construction work.

This is where the voluntary building-specific renovation roadmap comes into play which offers building owners a reliable strategy for an energy-efficient renovation programme for their buildings spanning a period of several years. Besides purely energy-related issues, the determination of the renovation concept is to focus on the specific options for the building owner and the building and to identify possible funding and/or support offers.

This measure focuses on both building owners and energy consultants because their task is to develop the building-specific renovation roadmap. Standardised methods for preparing renovation roadmaps are designed to enable them to translate the building-specific consulting service into a format that the building owner can understand and handle because an understandable description of the effects of the individual measures on energy efficiency and their economic efficiency will strengthen building owner's willingness to invest.

The technical and energy-specific key points for the renovation roadmap can be highlighted as follows.

- Energy-specific parameters are determined for the individual parts of the building which must be fulfilled for the overall target to be achieved.

- A technically sensible sequence is proposed for the individual measures. The individual renovation measures are adapted to each other and in their entirety make up a coordinated renovation strategy.

- The interfaces between the individual renovation phases and work packages are described so that a high quality level is ensured despite different execution times. The renovation roadmap remains relevant even after a change in ownership and documents the measures already completed as well as the measures yet to be carried out.

Implementation

In the long term, the building-specific renovation roadmap is to be applied to residential and non-residential buildings and will thereby become an integrated, long-term guide to energy transition in buildings. The methodological basis of the renovation roadmap for residential buildings is currently being developed. The renovation roadmap for non-residential building will be developed immediately after the roadmap for residential buildings has been introduced. The coming years will then require suitable campaigns to transfer the building renovation roadmap to and integrate it into other building renovation instruments. The renovation roadmap has the potential to bundle and coordinate many of the existing and future tools. The success of this tool will strongly depend on the degree of acceptance of the energy consulting service. Before its introduction, the practical suitability of the concept will be analysed in a joint effort by several energy consultants.

2.2 Further development and expansion of the energy consulting service

The targeted provision and in-process communication of energy efficiency expertise through energy consulting is another important component for the energy transition in the building stock. Although various information and consultancy offers are already available to building owners and users, these offers still require better coordination. The aim is to create a holistic, stringently phased information and consulting system that meets with the specific needs and options of owners of residential and non-residential buildings. The development of a building-specific renovation roadmap is a key element of this effort.

Implementation

The further development of the energy consulting service includes, first and foremost, the following tasks:

- Increasing transparency and the effectiveness of energy consulting.

- Improving penetration and dissemination of quality standards of the Federal Government's promotional and support programmes, for instance, of the list of energy efficiency experts.

- A more active approach means that building owners who are undecided or insufficiently informed about efficiency potential can be approached and motivated to implement energy efficiency measures.

- The development of a stringent, quality-assured and long-term energy consulting and information offering is linked to an expansion of consulting services. This measure must also aim to achieve nation-wide availability of the service.

- Anchoring and dissemination of quality standards with the involvement of the federal states and regional stakeholders. The extent to which networking of different stakeholders can be helpful is also examined in this context.

- Examination of the possibility to establish regional renovation networks.

2.3 Public funding for investment in ambitious building renovation and new building projects

In recent years, the Federal Government's existing promotional and support programmes for building renovation and new building projects as well as renewable energy have already supported comprehensive investment and thereby contributed substantially towards both energy efficiency and the share of renewable energy in final energy consumption. In view of their high promotional amounts and their large-scale effects, the CO_2 Building Renovation Programme and the Market Incentive Programme are particularly important in this respect. However, the scenarios show that the renovation momentum triggered by the promotional and support programmes must be increased further in order to be able to achieve a virtually climate-neutral building stock by 2050. This calls for the determined further development of the existing instruments.

Implementation

Several fields of action exist for the further development and improvement of the existing promotional and support instruments.

- Strengthening the combination of efficiency and renewable energy in energy-saving renovation projects in buildings through closer integration of the existing promotional instruments, for instance, by giving special consideration to package solutions that combine efficiency measures with the installation of new systems to generate heat from renewable sources.
- Further development of the "Efficiency House Plus" standard for all building types also with a view to renewable energy and including a trial phase as part of model projects.
- Further development of the system of promoting and supporting individual measures by creating a support level for particularly innovative efficiency measures aimed at highly ambitious efficiency targets far above the requirements of regulatory law.
- Strengthening the coupling of the heat and electricity sectors by upgrading promotional and support measures for heat storage systems as well as IT interfaces enabling bidirectional data communications with grid operators whilst respecting the efficiency targets on the heat market for the operation of heat generating systems.

Continuation of the promotional and support programmes according to NAPE is an important prerequisite for the implementation of the measures.

2.4 Public funding for energy-efficient urban and neighbourhood renovation

An analysis of the building stock must address not only energy, but also climate protection aspects in view of its strategic horizon up until the year 2050.

The aim is to promote investment in measures as part of energy-saving urban and neighbourhood renovation, municipal climate protection or urban development support concepts so that these measures can also be applied in practice.

The Federal Government already supports the **development of suitable concepts** in the field of energy-saving urban and neighbourhood renovation through suitable instruments, including, for instance, the following three:

- The *National Climate Initiative* supports the development of municipal climate protection concepts at urban level, of heat plans as well as municipal climate protection managers who have to push ahead with the implementation of the concepts previously developed. Climate protection concepts address all aspects (such as mobility, industry and commerce) relevant for climate protection and therefore go beyond the mere buildings sector.
- The *"Energy efficient urban refurbishment" KfW programme* provides grants to support the development of integrated concepts for energy efficient neighbourhood renovation as well as the initiation of a renovation management system. Renovation management also supports the implementation of the measures previously developed as part of the concepts. Support will be granted in future for a term of typically three years with a renewal option for a five-year term. Low-interest loans as well as future redemption grants will be provided to support energy-saving supply systems for neighbourhoods (heat and in future also cold and water supply as well as sewage disposal).
- Within the scope of urban development investment support, integrated and multidisciplinary concepts are a precondition for support and the basis for bundling measures and programmes. In the field of energy-saving renovation, these include, for instance, the KfW programmes and the "Renewable energy" Market Incentive Programme. Urban development support contributes towards achieving the aims of socially, economically and ecologically balanced urban development and urban

renewal policy. It generally serves to strengthen city centres in their urban function, also with a view to the interests of built heritage, to create sustainable urban structures in areas particularly affected by a serious loss of urban functions, to eliminate social imbalance and to strengthen small and medium-sized cities in urban areas in their function as public service centres.

Implementation

The implementation rate of the energy-related measures outlined is to be increased. The Federal Government, the federal states and the municipalities already offer a range of programmes for implementing energy-related measures. One positive side-effect of this measure is that the additional support is an incentive to develop concepts so that more stakeholders are encouraged to address the issue of energy-saving measures.

2.5 The "renewable energies in low-temperature heat grids" showcase

The provision of heat from renewable sources is particularly efficient if larger plants cover the demand of several users connected to a heat grid. This also enables the use of the potential of renewable heat from geothermal energy (including, for instance, large-scale heat pumps using geothermal heat via geothermal probe clusters or from the medium-depth geothermal range) as well as large-scale solar thermal plants. However, traditional district heating grids require relatively high flow temperatures of typically 80 to 120° Celsius which solar thermal and geothermal sources can provide to a limited extent only. Low-temperature heat grids, in contrast, only require flow temperatures of around 30 to 40° Celsius which can be effectively provided by renewable energy sources. Moreover, low-temperature heat grids also enable the effective use of seasonal large-scale heat storage systems because the heat stored in summer, for instance, as solar thermal energy or as excess electricity from renewable energy sources is still sufficient for operation during winter despite temperature losses. Loads can use the heat directly via heat exchangers from the piping system and in conjunction with low-temperature heating systems, or the heat can be increased to the level required in households using heat pumps. These concepts, also called "low-temperature heat grids" or "4th generation district heating", enable highly efficient solutions as well as far-reaching utilisation of existing geothermal and solar thermal potential also for cities and can thereby contribute significantly towards increasing the share of heat from renewable sources.

However, complete systems of this kind are still very rare in Germany. The main obstacles here are high lockup costs and long refinancing periods as well as the lack of experience with the development of such projects. Although some implementation examples of low-temperature heat grids exist as part of demonstration projects in the energy research area, incentives and input for practical implementation are so far lacking. This should be the subject matter of larger model projects which could pave the way for more wide-spread implementation. Funding of major pilot projects, for instance, as part of sponsoring competitions like those used within the scope of the "Showcases for intelligent grids – digital agenda for the energy transition" (Schaufenster intelligente Netze – Digitale Agenda für die Energiewende), is a good way of testing and demonstrating the viability of such innovative overall concepts even for wide-spread practical implementation.

Implementation

Development of a promotional concept titled "renewable energies in low-temperature heat grids showcase" in order to initiate, on the basis of model projects with a term of several years, the implementation of larger model projects that can be used to gather practical experience. Parallel evaluation of the measure should be carried out under aspects of technical and economic efficiency, sustainability and transferability to Germany's heat supply system in general, including scientific support within the scope of cooperation with energy researchers. The results of the evaluation will then serve as a basis for both optimisation of technologies and concepts and the further development of existing promotional and support schemes for heat grids, large-scale heat storages and low-temperature enabled heating systems.

2.6 Further development of energy saving legislation for buildings

The standards of the EnergySaving Act/Energy Saving Ordinance are key elements for achieving the Federal Government's energy efficiency and climate targets. The further development of the two sets of rules to form a harmonised system is an essential component when it comes to achieving the goal of a virtually climate-neutral building stock. The completed expert appraisal regarding harmonisation of the Renewable Energies Heat Act (EEWärmeG) and the Energy Saving Act (EnEG)/Energy Saving Ordinance (EnEV) identifies the options for structural re-design of the Energy Saving Ordinance and the Renewable Energies Heat Act. The expert appraisal addresses overlaps at interfaces as well as simplification options, especially with a view to improved integration of renewable energy into heat supply for buildings and more effective enforcement. It also outlines possible approaches for bundling the Renewable Energies Heat Act and the Energy Saving Act/Energy Saving Ordinance in one document.

Energy-saving legislation will retain its important steering effect. This will also require continuous further development in a manner that also considers future developments of the state of the art and economic efficiency.

The target scenarios calculated by the supporting research on the Energy Efficiency Strategy for Buildings suggest that the energy efficiency level of the envelope of renovated existing buildings must be increased by 20 to 40 percent against the current state of the art by the year 2030. Depending on the particular scenario, this will require a share of new heat generating systems installed each year of 50 to 70 percent. Today, however, they account for only around 15 percent of the entire boiler market. Pursuant to the EU's Energy Performance of Buildings Directive and the Energy Saving Act, nearly zero-energy building requirements will apply to new buildings of the public sector as of 2019 and to all new buildings as of 2021.

This altogether translates into the framework for the further development of energy saving legislation up until 2030.

- Pursuant to the Energy-saving Law, the nearly-zero energy building standard – i.e. the minimum requirements for new buildings which are technically and economically feasible – will be introduced by the end of 2016 in order to transpose the provisions of the EU's Energy Performance of Buildings Directive.

- The energy-related requirements for buildings and technical equipment as well as the requirements regarding the use of renewable energies are continuously being examined and, if economically sensible, adapted as required.

- The conditions under which an obligation to adhere to energy-saving quality standards in voluntary building renovation projects by building owners arises as a result of a particular condition – for instance, replacement or modification of individual or all parts of a building – will continue to apply. The Market Incentive Programme will continue to support the use of renewable energy for heating existing buildings.

- Current energy saving legislation sets forth standards for the primary energy demand of the building as a whole, for the energy efficiency of the building envelope and for the use of renewable energy. The requirement parameters and values will be adapted against the background of the European requirements.

- The exemptions of certain areas from existing obligations to replace boilers will be examined in order to increase the effectiveness of the regulations as well as the still low replacement rate of outdated and inefficient heating systems. The expansion of the replacement obligation to include further systems and components (for instance, windows, recirculation pumps) will be additionally examined whilst at the same time respecting the requirement to ensure economic efficiency.

- In the case of non-residential buildings, specific requirements for individual systems, such as lighting, air conditioning or control systems, are under scrutiny.

- Plans exist to expand the scope and to improve the degree of implementation of the inspection obligation for technical systems (air conditioning units, expansion to include ventilation systems) in non-residential buildings.

- Any further development of energy saving legislation should aim to simplify and improve enforcement.

Implementation

The aim of the further development of energy saving legislation is a harmonised regulatory system of energy requirements for new and existing buildings as well as the use of renewable energies for heating. The completed expert appraisal regarding harmonisation of the Renewable Energies Heat Act (EEWärmeG) and the Energy Saving Act (EnEG)/Energy Saving Ordinance (EnEV) identifies the options for structural re-design of the Energy Saving Ordinance and the Renewable Energies Heat Act. This will be discussed in more detail with the federal states. In this context, it is vital to leave sufficient freedom for investment promotion measures for building renovation and new construction projects.

2.7 Targeted support for research and innovation, faster transfer to practice

In order to achieve targets in the buildings sector, the energy demand of buildings must be significantly reduced and renewable energies must be developed and integrated further into the heat supply regime by the year 2050. What is needed most here are affordable, highly efficient technologies and energy innovation. Some of these are not yet available or technically not mature. Others may exist, but their implementation is economically not possible. Furthermore, completely new technologies and concepts will probably be needed. Research and innovation are therefore key elements of the energy transition in the building stock.

With a view to supporting the energy transition in buildings, energy research will tackle new challenges in the years to come. Besides technology development, the focus will increasingly be on system optimisation and a faster transfer of results to practical application. In order to address this development, the "energy in buildings and neighbourhoods" research network and the National Platform – City of the Future" were established with the task of providing consulting services for the development of complex promotional and support strategies.

The growing complexity of innovation processes and the increasing importance of system contexts when it comes to optimising the energy demand of buildings call for programmatic cooperation in research support systems. The necessary technological breakthrough can only be achieved through the use of synergies and by bundling forces.

Implementation

- A new research initiative titled "Innovative projects for a virtually climate-neutral building stock 2050" (Innovative Vorhaben klimaneutraler Gebäudebestand 2050) is launched in order to support the Energy Efficiency Strategy for Buildings and the aspects discussed earlier in this document. The measure aims to show how innovations which are already available today but not yet very widespread can significantly reduce primary energy consumption in buildings. Targeted implementation calls for support and promotional schemes which encompass both innovative projects and competitions. Different target groups are to be addressed, including, for instance, industry, the housing sector, private owners/builders as groups, research institutes and multipliers. The measure is part of the "Energy in buildings and neighbourhoods" research network. The new initiative thus sensibly supplements existing promotional activities and closes the gap between research support and broad assistance for energy innovation in buildings.

- As part of energy research, the Federal Government will launch a cross-departmental research initiative on "solar building/energy-efficient building" in 2016. The measure will be designed as a modular programme in order to adequately consider the different aspects of energy-optimised building.

- System solutions also facilitate planning/design and installation and can help to save costs with energy saving technologies. The advantage of modular systems is that different combinations of components can be chosen depending on their specific form and function. Standardisation of such systems can yield economic benefits with several manufacturers competing for standardised components.

2.8 Next steps

The measures described in chapter 2 along with the measures additionally adopted as part of NAPE are an important contribution towards the aim of a virtually climate-neutral building stock by the year 2050. The Energy Efficiency Strategy for Buildings will have to be dynamically adapted in light of the savings achieved with these measures. The discussion of further options will also be triggered to these ends. Some of these options will be outlined below.

The actions and processes mentioned above are just a selection. The experts additionally submitted a number of more far-reaching proposals. If it is found in future, especially as part of the monitoring exercise, that it is not possible to close the gap to achieving the 80-percent target, the existing and other additionally proposed actions will have to be assessed, developed further and re-adjusted, when necessary. This also includes the examination of tax incentive instruments.

Since the Energy Efficiency Strategy for Buildings forms an integral part of the energy transition as a whole, actions should be well-considered. European plans and approaches must also be considered: The European Commission, for instance, has announced that it will propose amendments and restated versions of all directives with energy efficiency relevance in 2015/2016. At the same time, the question of the EU's overarching energy efficiency target for 2030 has not yet been finally answered at European level, nor is it clear how the implementation of the EU target is to take place during the decade from 2020 to 2030 within the scope of the new governance approach for European energy policy. Moreover, the European Commission is developing a cross-sector strategy for the heat market which will encompass both the demand and the generation ends and which will be published by the end of 2015 as a "Communication on an EU strategy for heating and cooling". The results of these different processes at European level will have to be considered as part of the forthcoming national debate and a possible re-orientation of Germany's efficiency policy.

Energy-related aspects of tenancy law

The boundary conditions laid down in tenancy law influence the willingness of landlords to invest and of tenants to accept energy efficiency driven renovation projects in existing buildings. There are two points where tenancy law could be modernised to this effect: the distribution of rent level surveys differentiated according to energy aspects in as far as energy-related factors are found to be a relevant feature of housing quality on the housing market and the further development of the system of increasing rent in response to modernisation projects.

Within the scope of the further revision of tenancy law, the Federal Government examines, for instance, the requirements for arm's-length reference rent in the rent index as well as the possibility of increasing rent after modernisation. This examination will include, for instance, the question as to whether energy-relevant fit-out and properties can be given more consideration in a rent index. This work is supported by experts. The outline is to be available by the end of 2015 with a ministerial draft expected in 2016.

Energy-saving and therefore climate-friendly modernisation of rented building stock requires incentives for landlords to invest and renovation measures to be accepted by tenants. For landlords, this is the case if rents can be increased in conjunction with modernisation measures, whilst tenants will benefit from energy-saving renovation if the related cost savings due to lower energy demand are at least as high as the increase in rent (rent neutrality). If full rent neutrality cannot be achieved, or if other costs have increased, an important prerequisite for modernisation projects to be accepted by tenants is that living space in general continues to be affordable.

The Federal Government is therefore determined to implement the obligations under the coalition agreement regarding revised provisions for rent increases after modernisation, including the hardship clause, under the above-mentioned general conditions. Revised provisions for rent increases after modernisation are designed to protect tenants against excessive financial burdens. At the same time, it must be ensured that housing remains affordable also under aspects of climate and energy policy and that tenancy law still offers incentives for energy-saving modernisation measures. The Federal Ministry of Justice and Consumer Protection is developing relevant outlines to be considered in a corresponding draft bill.

Energy-related aspects in social law

Nation-wide energy-saving renovation, especially of residential buildings, is a challenge for both energy policy as well as society in general. The provision of affordable housing has always been one of the key challenges of housing policy. Incidental costs, especially in the case of poorly insulated buildings with outdated heating systems, have already become a kind of "second rent". Low-income households are hit particularly hard and are especially concerned about rising rents due to renovation measures.

The gross rents (excluding heating costs) of many flats which have undergone energy-saving renovation are higher than the maximum rents qualifying for housing allowance, so that welfare recipients are often not entitled to such flats whilst recipients of housing allowance cannot afford them.

The Federal Government and the federal states are therefore examining the possibility of adding a climate component to housing allowances. The energy-specific building quality could, for instance, be considered in the form of differentiated maximum housing allowance sums. The Federal Ministry of Labour and Social Affairs is conducting a research project to this effect with the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety as a member of the steering group. The results of the research project are expected by the end of 2016.

Furthermore, the Federal Government is also examining the possibility to amend Volumes II and XII of the Social Security Code. The purpose of this is to determine the minimum subsistence needs for housing and heating as part of basic cover for jobseekers pursuant to Volume II of the Social Security Code (SBG II) and of social assistance pursuant to Volume XII of the Social Security Code (SBG XII) on the basis of an overall concept (gross rent including heating costs).

Additional market activation

Market-orientated models have become increasingly important in the debate on boosting energy efficiency in recent years. This debate is especially driven by the EU's Energy Efficiency Directive which was adopted at the end of 2012. Article 7 of this Directive provides for the introduction of such an instrument as one transposition option. Against this background, the Federal Ministry of Economics and Technology and the Federal Ministry of Finance have commissioned expert studies at an early stage for more detailed analyses, including a study by the Fraunhofer Institute for Systems and Innovation Research ISI, the Öko-Institut e.V. and Ecofys ("Cost-to-benefit analysis of the introduction of market-orientated instruments for the implementation of final energy savings in Germany" – 2012 (Kosten-Nutzen-Analyse der Einführung marktorientierter Instrumente zur Realisierung von Endenergieeinsparungen in Deutschland – 2012)) and a study by the Wuppertal Institute and Ecofys ("Design and assessment of a market-based and budget-independent obligation approach for carbon reduction on the heat market" – 2013 (Ausgestaltung und Bewertung eines marktbasierten und haushaltsunabhängigen Verpflichtungsansatzes zur CO_2-Minderung im Wärmemarkt – 2013)).

Models of this kind obligate certain stakeholder groups to achieve a specific amount of energy or carbon savings (saving target) and/or to increase the share of renewable energy within a certain period. The stakeholders can then generally fulfil this requirement in different ways, depending on the specific design of the instrument, for instance, by initiating measures on the part of other stakeholders (such as customers) or by buying standardised saving titles (i.e. so.-called "white certificates") from third parties. Another option is payment of defined compensatory sums, for instance, into a saving fund. This measure could contribute towards a stronger market for energy efficiency and renewable energy in the buildings sector.

Although the Federal Government opted for a different approach in its transposition of Article 7 of the EU's Energy Efficiency Directive, it nevertheless continues to examine the extent to which such a system could help to achieve the target of a virtually climate-neutral building stock. The pros and cons should be weighed in a discussion process, also with a view to the cost of living and distribution effects. The different concrete implementation options must also be considered for this purpose. Experience from other EU Member States shows that the specific design has a crucial impact on applications and the measures implemented and therefore ultimately on saving volumes and the necessary costs.

Digitisation in the buildings sector

The developments in digitisation could make an important contribution towards the implementation of the Energy Efficiency Strategy for Buildings. These include technical progress, better consideration and control of energy efficiency measures and the use of renewable energy during the planning, design and construction phase as well as digital applications for building use. The key prerequisite for this are user acceptance as well as data protection and data security.

Smart home

A host of applications for further data interfaces are conceivable on the basis of building automation systems, connecting individual components and uses in a building to each other. This also includes external control techniques. A group of different buildings on a property, in a neighbourhood or urban district can communicate by digital means, for instance, as part of integrated power supply management for a complete property. Smart control of power supply for a quarter or larger user groups, for instance, opens up energy saving potential. Digitisation can also lead to improved and easier control and management of the coupling of the electricity and heat sectors.

Savings can be achieved through targeted control, for instance, of the heating or air conditioning system of individual buildings or flats as a function of user presence or based on use profiles.

Further studies are still needed in order to identify suitable applications and enable comparability of the resultant savings potential of smart technologies.

Digitisation of building data during the operation and design/planning process

During the earliest possible stage of the design and planning phase, new developments in digitisation can prepare important decisions for improving energy efficiency of buildings and using renewable energy. The fundamental architectural decisions have often already been made at the time specialist planners become involved. Adjustments are then either difficult and costly or require major changes in plans and design. After completion of plans and design and after construction and/or renovation it would then be possible to link automated building operation to the digitised planning and design data that is then available so that the building's operation processes would be optimised with a view to energy demand.

Building Information Modelling (BIM) is a tool that generates digitised building data for use in the subsequent operation of the building. All specialist disciplines (architecture, technical building system, structural design, energy consultants and executing contractors) contribute their respective plans and designs to the overall planning and design process.

3. Outlook

The proposals and actions presented in this document will boost energy efficiency further and increase the use of renewable energies. Whether the goal of a virtually climate-neutral building stock can be achieved by the year 2050 will depend on the development of the general conditions of the energy sector and the further concretisation of the previously mentioned measures. The Energy Efficiency Strategy for Buildings must provide investors with sufficient planning security, but in view of the uncertainties that result from a horizon extending up to 2050, it must also be sufficiently flexible in order to respond to new technical developments and challenges. The Energy Efficiency Strategy for Buildings is hence understood to be a "learning" strategy that should be developed further as needed and on the basis of new results and changed overall conditions.

The earlier the relevant decisions are made, the more time will be available for their implementation and the greater are possible efficiency gains. However, any actions must be well-considered so that the Energy Efficiency Strategy for Buildings fits into the overall picture. The European Commission, for instance, has announced that it will propose amendments and restated versions of all directives with energy efficiency relevance in 2015/2016. At the same time, the question of the EU's overarching energy efficiency target for 2030 has not yet been finally answered at European level, nor is it clear how the implementation of the EU target is to take place during the decade from 2020 to 2030 within the scope of the new governance approach for European energy policy. Moreover, the European Commission is developing a cross-sector strategy for the heat market which will encompass both the demand and the generation ends and which will be published by the end of 2015 as a "Communication on an EU strategy for heating and cooling". The results of these different processes at European level will have to be considered as part of the forthcoming national debate and a possible re-orientation of Germany's efficiency policy.

IV. Communication and next steps

With the “Energy Transition Platform for Buildings”, the Federal Government brings together relevant stakeholders from business and industry, civil society and the scientific community along with representatives of the federal states to discuss issues related to the energy transition in the buildings sector.

With the adoption of the Energy Efficiency Strategy for Buildings and the decision for the fundamental orientation of the energy transition in the buildings sector, the platform will increasingly focus on implementation. To these ends, the Federal Government will set up a made-to-measure working structure for the platform in order to ensure stakeholder involvement. We will pay special attention to the activities of the energy transition platform for energy in this context.

Besides the platform, several working groups have already been established on selected topics, such as support and promotional measures, legal framework, financing models or energy consulting. This division of labour resulting from the platform process was found to be generally valuable and will be maintained.

A precondition for the necessary future-orientated decisions are active communication processes involving all stakeholders because they must see energy-efficient renovation of the building stock as an opportunity to be successful. Trust must hence be created and cooperation between the different stakeholders fostered. To this effect, the **Federal Government** will **initiate** a discussion process that will also include public consultation regarding the action options identified in the efficiency strategy.

The energy transition in the buildings sector will require involvement and participation by the federal states if it is to succeed. The joint central and federal state government working group was set up in spring for this purpose. After the Energy Efficiency Strategy for Buildings has been adopted by the Cabinet, constructive work with the federal states will continue.

The Federal Government considers it important that the process of implementing the Energy Efficiency Strategy for Buildings be harmonised with the other initiatives for implementing the energy concept, such as the National Action Plan on Energy Efficiency, the Electricity Market Law, the Climate Action Programme, the “Alliance for Affordable Living and Building” as well as the “Research Network – Energy in Buildings and Neighbourhoods”.

V. Monitoring

Support for the implementation of the Energy Efficiency Strategy for Buildings calls for the evaluation of the measures and instruments which are new, which are already in the process of implementation and which have already been implemented. Processes are already in place for certain measures and instruments. Promotional and support programmes, for instance, are being undergoing permanent evaluation, and a process is in place for the ongoing exchange of experience regarding the Renewable Energy Heat Act. The evaluation of the Energy Efficiency Strategy for Buildings will build on this. However, the energy transition in the buildings sector requires a comprehensive analysis in addition to these evaluations of individual aspects. The Energy Efficiency Strategy for Buildings is therefore an integral part of the "energy of the future" monitoring process. This monitoring process analyses the target achievement process and the state of the implementation process with a view to the energy transition. To these ends, the Federal Government adopts a report on the state of the energy transition each year.

The expert commission accompanying the monitoring process will additionally perform an independent assessment and unbiased monitoring of the Energy Efficiency Strategy for Buildings.

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