Building Market Brief

Germany

Climate-KIC is supported by the EIT, a body of the European Union

Climate Innovation Experience
Edition

Building Market Brief
Germany

Prelude

In light of the necessary global transformation towards a low-carbon economy, the building sector is facing dramatic changes and dire need for disruptive innovations in the years to come. These changes come with risks as well as opportunities. A solid and regional specific understanding is needed to minimize the first and maximize the second when designing, investing in or implementing low-carbon solutions.

Global greenhouse gas emissions from the building sector have globally more than doubled since 1970. In Europe buildings are responsible for 40% of the energy consumption and 36% of the emissions. As such, a low-carbon transformation of the building sector, (deep) refurbishment of the existing building stock and a revitalization of the sector are key components of the EU Roadmap 2050.

With this European perspective in mind, one of the major barriers curtailing large scale investments into low-carbon technologies in the building sector is the lack of cross-country comparable market data. Such an overview would enable inventors, low-carbon technology suppliers and other key stakeholder to exchange know-how and transfer solutions across borders. As the building sector is commonly described as one of the most fractured and regionally colored industries - with very specific habits, traditions and stakeholder setups - this is often impossible.

It is exactly this gap of understanding and data availability that the Building Market Brief series addresses. On a limited number of pages, the condensed essence of a countries' building sector and its spirit is summed up and quantified with indicators aligned across countries. The series of reports provides a reliable basis for low-carbon innovation, investments and adoption, by offering a pan-European market understanding and providing comparable insights of the sector. It aims at documenting a holistic understanding, taken from multiple perspectives, market experts, models and statistical data. This information contributes to enable optimization, integration and scaling. We endeavor a sustained, collective effort to channel investments and behavior in a manner necessary to realize this low-carbon future of the building sector.

Therefore, we would like to address low-carbon innovation suppliers and entrepreneurs that look for suiting markets for their ideas or inspiration for their developments, but also investors and policy makers who would benefit from a better pan-EU overview, allowing for benchmarking and cross-country experience exchange.

I am confident that the information and insights provided by the Building Market Brief series contribute to the transformation into a low-carbon economy as one of the key challenges of this century.

York Ostermeyer
Editor in chief

Acronyms list:

2DS: 2-Degrees Scenario
APEE: Energy Efficiency Incentive Programme
BMWi: The Federal Ministry for Economic Affairs and Energy
BSM: Building Stock Model
CAP: Climate Action Programme
CBRP: CO_2 Buildings Rehabilitation Program
Destatis: Federal Statistical Office (Statistisches Bundesamt)
DH: District Heating
DWD: German Meteorological Office (Deutscher Wetterdienst)
EEWärmeG: Renewable Energies Heat Act
EMF: European Mortgage Federation
EnEG: The Energy Saving Act (Energieeinsparungsgesetz)
EnEV: Energy Saving Ordinance (Energieeinsparverordnung)
EnVKG: Energy Consumption Labeling Act (Energieverbrauchskennzeichnungs-Gesetz)
EPBD: Energy Performance Building Directive
EU(28): European Union
EUROSTAT: European Statistical Office
GDP: Gross Domestic Product
GHG: Greenhouse Gases
HDD: Heating Degree Days
HVAC: Heating, Ventilation, and Air Conditioning.
INDC: Intended Nationally Defined Contribution(s)
KWh: Kilo Watt Hours
LCA: Life Cycle Assessment
MAP: Market Stimulation Program
MDB: Multi-Dwelling Building(s)
MEPS: Minimum Energy Performance Standard
NEEAP: National Energy Efficiency Action Plan
nZEB: nearly Zero Energy Building(s)
R&D: Research & Development
RES: Renewable Energy Sources
RS: Reference Scenario
SDB: Single-Dwelling Building(s)
SME: Small and medium-sized enterprises
t CO_2eq.: Tonne CO_2 equivalent
TJ: Terajoule
UN: United Nations

How to use this report
How to read it and meta structure

This report is meant to provide an intuitive and reliable entry point for assessing the character of the construction sector in the addressed country. It is not necessarily meant to be read from the beginning to the end but rather to be used as an encyclopedia of facts and figures with links to complementary data sources if one wants to get more detailed information on a certain aspect. The structure of the report in independent subchapters enables the readers to start reading at any point depending on their needs and interests. Condensed information is provided from as many perspectives and sources as possible. This might lead to conflicting statements from different sources hopefully helping to communicate the complexity of the market rather than provide streamlined insights. This report is part of a series, one for each country. All reports follow a similar methodology, making all indicators listed comparable between countries. Even if not familiar with a certain indicator the knowledge on one market can therefore be used by the reader to put other markets into perspective. The structure of the reports also allows direct comparison. The readers will find the same indicator on the same page at roughly the same position in every report if it was available for the respective country.

This report is divided into three main chapters according to the methodology followed: **Chapter A**, a literature-based approach; **Chapter B**, a survey-based approach; and **Chapter C** a model-based approach. This structure is complemented by an executive summary and indicator factsheets in the beginning of each report.

Each of the chapters is divided into subsequent subchapters or sections addressing specific topic condensed in a 2-pager format. The main body of the text aims to highlight the most relevant information from the graphs and contextualize the data by explaining relevant frame conditions. For this purpose, the graphs and figure trends are listed side by side with absolute numbers in most cases. This aims to allow an easy perception of the development of a sector as well as to put trends into an absolute perspective, comparing relevance between countries. Specially highlighted numbers are also listed in the factsheet at the beginning of the report where they are sided with numbers form different fields to provide market characterization indicators.

The graphs in the report follow a color code. The color therefore indicates what kind of data is visualized in the graph, making the reading of the report as intuitive as possible.

The chapter's content is complemented by market expert comments and additional sources of information such as reports and data bases in the side bar of each page. The comments refer to opinions voiced by experts as a direct reaction to the report as well as in complementary workshops and interviews and are listed to provide a holistic view of the market as possible. Great care was taken to quote a wide array of opinions.

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©Cristina Gottardi, www.unsplash.com

Publisher
CUES Foundation.
E-mail: info@cuesanalytics.com
Web: www.cuesanalytics.eu

Partners

wbcsd
RICS
eit Climate-KIC

World Business Council for Sustainable Development (WBCSD)
Royal Institution of Chartered Surveyors (RICS)
Knowledge and Innovation Community on Climate (Climate-KIC)

Aknowledgements:
Hans-Jürgen Cramer, Sven Mönnig, Jens Kerstan, Oliver Scheifinger, Dirk Loennecker, Ingo Gabriel, Etienne Cadestine, Eckhart Hertzsch, Antje Holdefleiss, Oliver Scheifinger, Mathias Wohlfahrt, Christian Brand, Philipp Bouteiler, Sven Martens, Anke Unverzagt, Ingrid Vogler, Sybren Steensma, Michael Klippel, Elise Vonk, Katrin Hauser, Roland Hunziker, Delphine Garin, Matthew Watkins, Daniel Zimmer; Richard Barker, Peter Graham, Pierre Touya, Ian Hamilton, Paul Ruyssevelt, Stefan Wiesendanger, Zeno Winkels, Construction21.

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FSC FOREST STEWARDSHIP COUNCIL

Building Market Briefs

ISBN 978-90-827279-2-0, 1st Edition, 2018

This document is funded by the Building Technology Accelerator (BTA) flagship, within the Knowledge and Innovation Community on Climate (Climate-KIC) funded by the European Institute for Technology (EIT) under the Horizon 2020 framework of the European Union.

This report should be cited as:
Ostermeyer, Y.; Camarasa, C.; Saraf, S.; Naegli, C.;Jakob, M.; Von Geibler, J.; Bienge, K.; Hennes, L.: “Building Market Brief Germany”, ISBN 978-90-827279-2-0

Content

Executive summary

Economic framework conditions

The Federal Republic of Germany is a country in central-western Europe with a population of 81.2 million (2015), or roughly 16% of the EU population. The nominal GDP of the country in 2015 was €3,033 billion, and it grew at an average annual growth rate of 2.8% from 2005-15. In the same period its GDP per capita increased from 27,889 €/capita (2005) to 37,351 €/capita (2015) and the disposable income per capita grew at an average annual growth rate of +2.2%. Germany has a services-oriented economy: 68.9% of the Gross Value Added in 2015 is contributed by the tertiary sector, followed by industry & manufacturing (28%) and agriculture (1%) (Section A1).

The monthly consumption expenditure per household grew by +12% in from 2005-15, while that spent on housing and energy grew by +9.9% in the same period. This is representing roughly a quarter of the total household expenditure (24%) in 2015 with a slight trend downwards.

The construction sector of Germany accounts for over 4% of the German GDP. In 2015 roughly 2.6% of the German GDP, totalling €69.43 billion was spent on building construction expenditure. Since 2005 the **total investments in building construction increased** at an average annual rate of +2.1% per year (Section A5).

Between 2005 and 2015 Germany has shown a **remarkable increase in the proportion of one-person households**. They stood at 37% in 2005 and grew to 41% in 2015. Two-persons household remained more or less where they were in 2005 (from 34.1% to 34.4%) (Section A1).

In the cleantech sphere, Germany secured the 8th rank in t´he Global Cleantech Innovation Index 2017. This was a one-point jump in the rank from 2014. Germany showed high level of innovation outputs, being a leader in environmental patents and in the renewable energy sector. A rough 2.3% of total private equity investments (€150.6 million) in the year 2016 were made in energy & environment companies (Section A1).

The structure of the building sector in Germany

The majority of the German building stock (5,413 million m²) is in the residential sector which constitutes about 69% of the total floor area amounting to 3,467 million m² in 2015. The share of non-residential buildings is 31% of the total area which is a normal share compared to other countries. Roughly 39% of the total non-residential floor area is occupied by offices.

About 60% of the residential floor area consists of single-dwelling buildings (stand-alone or in row houses). The residential floor area is also predominately privately owned (with a share of 53%) and 46% of the dwellings are owner-occupied. The social housing sector accounts for about 5% (Sections A2 and A6).

Over 54% of the German residential dwellings were constructed before the 1970's and approximately 63% before 1976-1979 with the introduction of the first EnEG was introduced, establishing building codes for housing.

In Germany, the building codes are implemented through federal legislations determined by the Energy Saving Act (Energieeinsparungsgesetz, EnEG) and the Energy Saving Ordinance (Energieeinsparverordnung, EnEV). The codes have evolved over time, became more stringent and cover wider energy usages (from building components to HVAC and lighting). The current requirements require primary energy consumption of new buildings to be about 45 kWh/m² along with a partial use obligation for renewable energy. Building codes are set for new buildings as well as for the renovation of existing buildings (Sections A2 and A4).

Policy framework and other demand side drivers

Gradual increase of average temperatures has been observed worldwide with Germany being no exception. This increase in the annual mean temperature has also resulted in a decrease of Heating Degree Days (HDD). These have decreased by 15.5% (2009) since 1980. Therefore, there is a potential of substantial reduction in heating energy demands in the country and a risk of increasing cooling energy needs (Section A2).

The building sector has for a long time been on the agenda for Germany's energy strategy and standards as well as financing mechanisms are in place. In 2009, the EnEV was tightened to include a primary energy demand reduction for new buildings by 30% and a reduction of thermal insulation losses (i.e. average U-value reduction by 15%). Additionally, the energy certificate was redesigned as well, including its mandatory issuance for each building transaction. In 2017, such certification or labelling was also introduced for heating systems older than 15 years, to increase the exchange rate of old systems (EnVKG, 2015).

The KfW Energy-efficient Construction Programme, a scheme from the German state bank KfW, was introduced in 2009. Houses which met conditions to be a KfW Energy Efficient House could receive funding in the form of low-interest loans. Financing is provided to a maximum of €100,000 per building, to a maximum of 100% of the eligible costs. In 2014, 230,000 buildings have been renovated and 110,000 new buildings (about 45% of all new buildings) have been built under this scheme. In the past years, additional funding was made available also for non-residential buildings, increasing the renovation program by €2 million per year. Additionally, since the year 2000, the market stimulation program (MAP) exists, supporting as of today the exchange of up to 1.8 million fossil heating systems with renewable heating systems. In 2015 this program was renewed and amended by the stimulation program APEE, providing €165 million for the next three years to improve energy efficiency of heating and ventilation systems.

All these efforts are overshadowed by the currently booming economy in the construction sector in Germany in which steeply increasing prices and lack of labour dominate the state of play (Section A4).

State intervention has obstructed housing construction. Measures like the increased funding for social housing schemes seem proving insufficient and hardly having a significant effect, while the new rental cap ("Mietpreisbremse") may prove to be a brake on investment (Section A6).

According to experts interviewed for this study, the housing demand, derived energy demand, and related carbon emissions, will be driven by the creation of new residential space, the refurbishment rate, and upgrading of existing space (Section A1). Considering the current trends, a net addition of 6% to the floor area by 2050 is expected. The increase in floor area is mainly driven by an increasing demand for floor area per person. The latter is mainly explained by the decrease of the average number of persons per dwelling due to a continuous trend towards smaller household sizes as well as the current shortage of residential space in general. The need for refurbishment of the existing stock is expected to be a key driver for change until 2050 (Section C4).

Demand side energy, carbon and market trends

Although population and floor area are expected to grow, final energy demand for heating, hot water, and ventilation (including ambient heat) is expected to be 22.7% lower than present values in 2050under current and decided policies (what is called in this report the Reference Scenario1). With more stringent policies and regulations (the 2-Degrees Scenario2), the reduction would reach more than 37.1% by 2050 (Section C3).

The main drivers for this reduction are the government efforts to encourage the refurbishment of building envelopes. With building codes already securing a very high level of energy efficiency for new buildings the main challenge will be to incentivize owners to upgrade existing possibilities. According to experts, German policy has so far enforced only less demanding refurbishment measures (Sections A4 and C3).

The support of more demanding refurbishment measures will also lead to a shift towards more efficient building technologies and low emission heating system. Heat pumps and district heating based on renewable energy sources are expected to reduce the demand for fossil fuels that will be no longer attractive e.g. due to higher prices and taxes on fossil fuels. With natural gas being an extremely established and accepted energy carrier in Germany this will form a mayor challenge. Power to gas is seen by many experts as one of the most feasible ways forward (Sections B7 and C3).

From the market perspective, this transformation of the building stock will translate into an increasing demand for more efficient buildings but especially for envelope related measures and renewable energy (Section A6). Hot summers and weather extremes have increased awareness of climate change in Germany, however market experts see no impact on decision making as the construction sector is booming and not receptive to climate related concerns. For several German cities (e.g. Munich and Frankfurt) experts see the risk of an economic bubble (Section B2).

Despite a tradition of high efforts in energy efficiency and many German policy makers liking to see Germany as first mover, experts consider that in comparison with other countries, Germany has lost its place among the pioneers in this sector. Having a legacy in near zero carbon buildings ("Passivehouse") as lighthouses for energy efficiency, and having been a forerunner of decentral photovoltaic electricity production, Germany is now falling behind in trends like pre-fabrication, heat pumps, smart grids and digitalization. The economy weakens the governmental support programs, and a trend to increasingly complex standards hinders the uptake of low carbon solutions. The market is currently focussed on what is most profitable rather than what is needed, resulting in severe shortage of affordable residential space and refurbishment becoming a niche.

From the market perspective, this transformation will have an important impact on the market volumes for energy sales and low-carbon technologies.

According to calculations with the building stock model (BSM), the total market volume of the energy- and GHG-related building market amounts to €110 billion per year in 2018. More than 60% of this market volume comes from energy sales (€68 billion per year), even though electricity sales for household appliances are not included (Section C.5). This volume is expected to slightly increase in the short term (mainly coming from an increase in energy prices).

The building envelope market (€27.1 billion per year in 2018) and building technology market (€14.4 billion per year) are expected to strongly increase in the short term, especially in the 2DS as result of the early adoption of policies taking effect in 2020, deeper refurbishment targets, and speeding up the phase out of fossil fuel heating systems (Section C5).

In the long term, the overall market volumes decrease compared with present values. A reduction of the energy demand in the building sector in both scenarios leads to a decreased market volume in energy sales (-11.2% in the RS and up to -15.6% in the 2DS compared to 2018), which cannot be offset by the shift to higher price energy carriers anymore. However, the market volumes for building technologies and the building envelope are projected to remain stable or slightly increase until 2050 compared to 2030 (Sections C5, C6 and C7).

The supply side: construction sector and technology providers

Most of the interviewed suppliers and developers of building technologies in Germany, incl. architects, engineers, planners, consider that upgrading the envelope is the biggest opportunity for improving the energy performance of existing buildings, and in case of new buildings, the choice of a low carbon energy carrier for heating. Decentral energy generation is seen as an important complementation in both cases, a situation strengthened by the German energy standard that makes a share of renewable mandatory in many cases (Sections B2 and B3).

In Germany, architects are key decision makers in construction and planning processes. The architects often influence the design process including the (pre-)selection of technologies and the communication with the specialized engineers. The increasing complexity of the legal standards of the German construction law in the recent decade has strengthened the position of specialized engineers. Especially in larger projects and despite being legally responsible the architect is seen to be less and less able to design systemic solutions with synergies between technical systems and meet standards as well as cost expectations. As a result of this and labour shortage, costs have been steeply increasing in the past years (Section B4).

The current economy and the booming construction sector currently dominate all other arguments in Germany. Economic and environmental aspects are equally often named as drivers and barriers for aspiring to or not to low carbon solutions (Section B5).

From the perspective of supply-side stakeholders, the existing economic mechanisms make energy efficiency not paying off quick enough and correspondingly ask for higher governmental support via tax incentives or subsidy schemes. There is an agreement among experts that especially in the refurbishment sector Germany will not succeed without strict and mandatory refurbishment standards (Section B7).

Conclusion and outlook

Germany is facing a deadlock situation steaming from its economic success. The realization of governmental low-carbon transition strategies heavily depends on the refurbishment of residential buildings. This however, is a less attractive segment for construction companies and planners due to its complexity and associated risks. Many market actors focus on other segments such as new buildings and disregard the opportunities in the refurbishment market.

Migration, a long-term challenge of affordable housing, and a trend of migration from countryside into cities, increases the need for residential space, especially for middle- and low-income groups in urban areas. This is expected to drive the refurbishment markets. The refurbishment solutions are expected to support a less carbon-intensive energy infrastructure, which include Power to gas solutions, smart grids, and reduced energy consumption based on improved building envelopes. There is urgent need for simplified planning and buildings solutions that allow the faster and cheaper construction of high-quality envelopes with substantially less labor – either in refurbishment or by substituting existing buildings with new ones.

A

Market overview

A

Aim

Chapter A intends to provide an overview of the country's building market, its frame conditions, trends and market mechanisms for the demand of low carbon products and solutions. It does this by providing a brief introduction of the country´s economy and society as well as a characterization of the building stock and influencing climate factors. Energy and climate goals of the country are also synthesized, which include grid mix, emission factors and implication of climate goals. This is followed by an overview of the current framework of standards and support measures. Investments and employment in the construction sector are finally depicted.

This chapter is based on an extensive literature study. The sources cover a wide range including European statistical data, the respective countries own statistical office, national and international public reports, scientific publications and market information such as prices and sales volumes. The main contribution is, therefore, collecting and summarizing this information, though readily available present in a fragmented manner. All data sources are clearly marked to allow the reader accessing more detailed information as needed. The complete list of sources can be found in the annex of the report.

A1 Introduction
Germany's economy and society

USEFUL READING:

OECD 2016. OECD Economic Surveys GERMANY.
www.oecd.org

Deutsche Bundesbank 2016. Outlook for the German economy – *macroeconomic projections for 2016 and 2017 and an outlook for 2018.*
www.bundesbank.de

With a population of 81.2 million (2015), Germany is the most populous country in the EU constituting roughly 16% of its entire population. It is also the largest economy in the EU, with a GDP of € 3,033 billion (nominal terms) and is a founding member of both the EU and the Eurozone. The country has seen its nominal GDP grow at an annual average rate of 2.83% (2005–15), whilst GDP per capita evolved from 27,889 €/capita in 2005 to 37,351 €/capita by 2015. During the same period, the population decreased at an annual average rate of 0.16%, whilst disposable incomes per capita increased at a rate of 2.24%.[1].

A1.1 – ***Trends in Germany's GDP, disposable incomes and population.***
German GDP is expected to grow anchored by a robust domestic demand, rising household incomes and export growth. This may further impact private investment, consumption as well as the housing sector.

Sources:
EUROSTAT

Notes:
GDP index depicted in the graph is in current €.

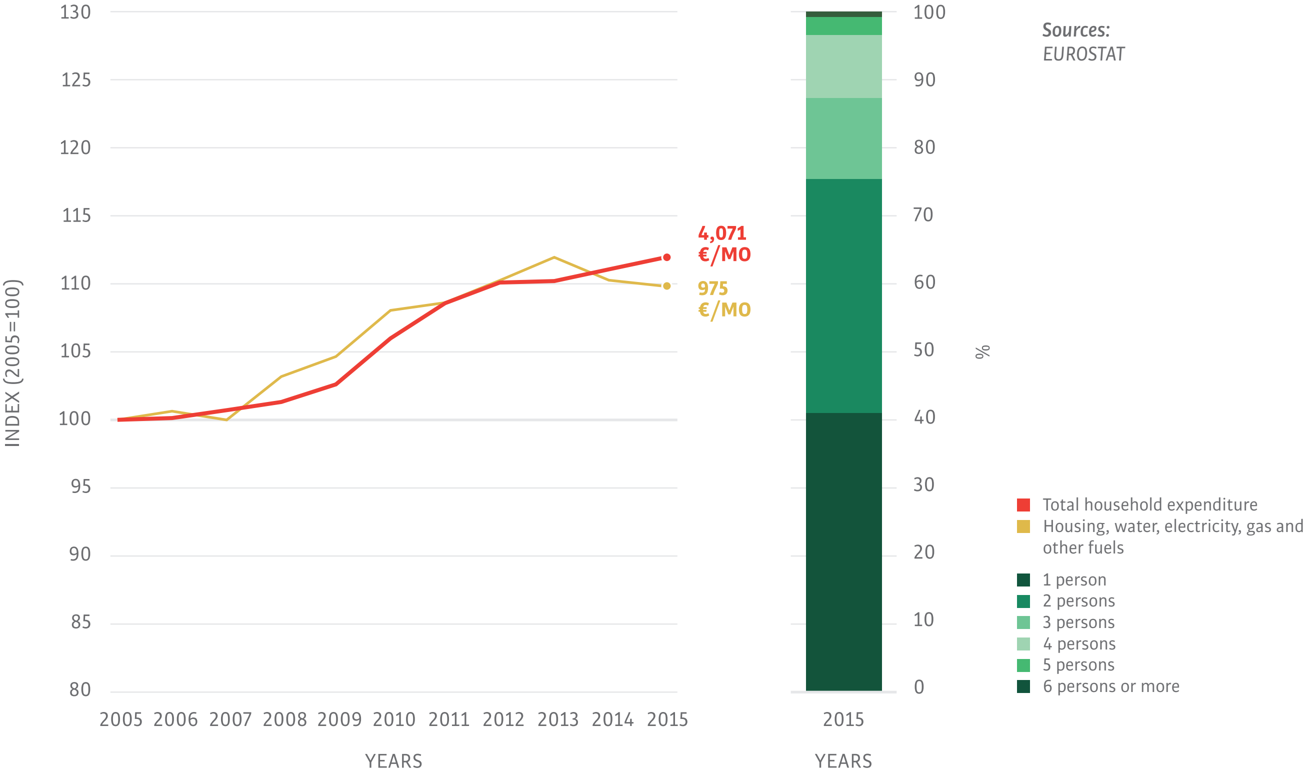
Germany is a major global trading member, with exports comprising 46.9% of GDP (2015), and the country has the largest trade surplus amongst the EU member states, totalling around € 248,195 million (2015)[2]. Germany contributes 20.8% to intra-EU28 trade[3] and 18.8% to extra-EU28 trade[4], the largest contribution amongst the EU28. The services sector adds major value to German economy (68.9% of the total value added in 2015), followed by the industry (26%) and manufacturing (23%) sectors[5]. Nearly 31% of the German services sector is occupied by SMEs, which constitute 99.95% of the total companies, contributing 52% to the economic output and employing roughly 68% of the working population[6]. About 2.92% (2015) of GDP is spent on R&D, compared to the EU28 average of 2.0%.[7]. Due to efforts in innovative development and entrepreneurship, Germany is grouped amongst the 'Innovation Leaders' in the EU28 countries (European Innovation Scoreboard 2017), with an above average innovation score[8].

In the cleantech sphere, Germany secured the 8th position rank in the Global Cleantech Innovation Index 2017[9], a one-point jump in rank from 2014. Germany showed a high level of innovation output as a leader in environmental patents and the renewable energy sector. The established industry and manufacturing sectors aid the development of innovations and their application to markets. Germany has consistently ranked higher in the EY renewable energy country attractiveness index[10]. Some 2.3% of total private equity investments (€ 150.6 million) in 2016 were made in German energy and environment companies[11].

Monthly household consumption expenditure grew by 12.0% from 2005 to 2015, whilst expenditure on housing and energy grew by 9.9%. This represents an annual average increase of 1.1% and 1.0%, respectively. As a proportion of total consumption, housing and energy expenditure showed a marginal decrease, from 24.4% to 24.0%, attributed to higher energy efficiency and resultant savings[12 13].

A1.2 – *German households witnessed a gradual increase in 1 person households. In 2015, 75.4% of households were 1 and 2 persons strong.*

The total household expenditure is roughly 50.68% of the GDP, while that on housing and fuel a 12.14% of the GDP. Despite the decrease in population, the number of households increased due to the formation of more one person households.



Sources:
EUROSTAT

Between 2005 and 2015, Germany has shown a remarkable increase in the proportion of one-person households, which stood at 37% in 2005 but grew to 41% in 2015, whilst two-person households remained more or less at the position they occupied in 2005 (moving from 34.1% to 34.4%). The total of one and two-person households thus comes to a total of 75.4% of all households. This changing family structures is going to shape consumption patterns and the future demand for housing.

A2

Building stock
Building characteristics and influencing climate factors

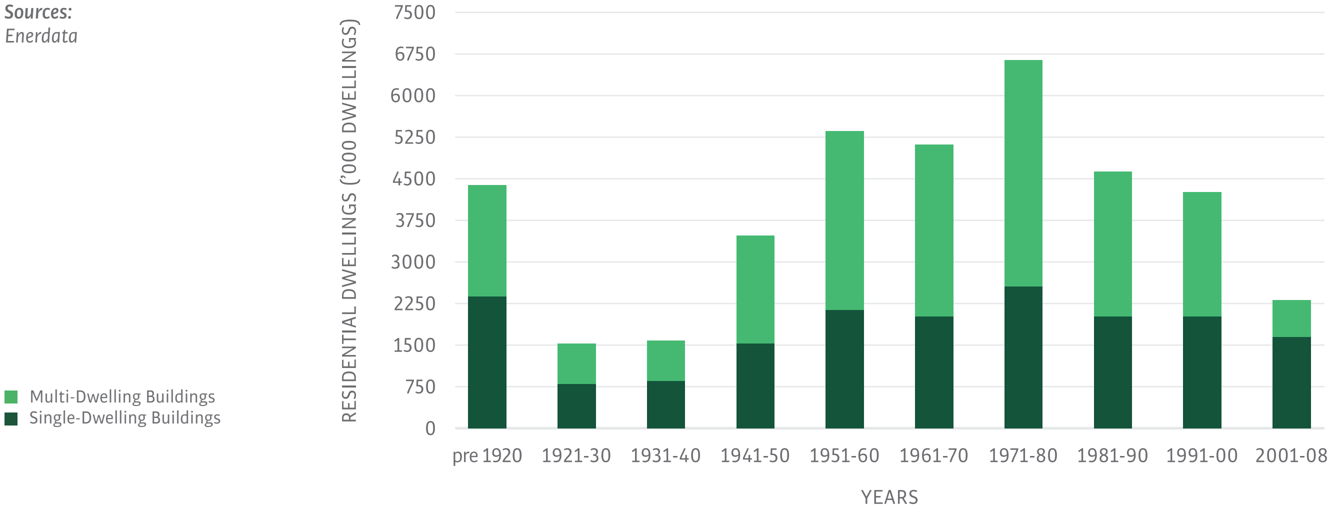
USEFUL READING:

Allen & Overy 2017. Current trends in the German real estate market Overview for institutional investors.
www.allenovery.com

Over 54% of German residential dwellings were constructed before the 1970s, and approximately 63% before 1976–79, when the first Energy Saving Act (EnEG) was introduced to establish building codes for housing.[14]. The construction of new housing has been declining since. Price developments have been influenced by recent events surrounding immigration to the country and the shortfall in housing supply relative to the demand, particularly in large German cities. The average living area per capita was 53 m²/capita in 2008, slightly decreasing thereafter to 45 m²/capita. The economic recovery of Germany since the recession, leading to higher purchasing power, an increase in population, and urbanisation, have increased the demand for scare housing space[15].

A2.1 – ***Trends in residential building space.***
Due to recent influx of immigrants housing demand is expected to increase in pockets of Germany.

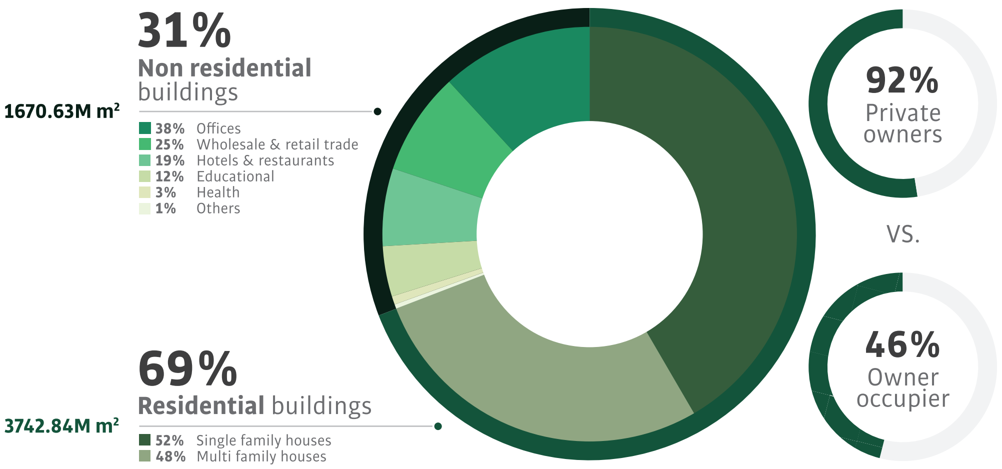
Sources: *Enerdata*



In Germany, the residential housing accounts for 69% of the total floor area of 5,413 million m², whilst non-residential comprises 31% of the total. Of the residential dwellings, 30% are single-dwelling types, whilst the remaining are multi-dwelling. In the non-residential sector, 39% of the space is occupied by offices, followed by wholesale and retail trade institutions (25%) and hotels and restaurants (19%)[16 17].

A2.2 – ***Breakdown of the building stock.***

Sources: *EU Building Observatory, Entranze, Destatis, CUES Analysis*



Germany is characterised by very low rates of owner-occupied residential space amongst the developed countries. Only **46% of residential dwellings are owner-occupied, whilst the remaining 54% are rented by private tenants**. Additionally, with the comparatively high rates of immigration and urbanisation in very recent years, the demand for low-cost housing has increased.

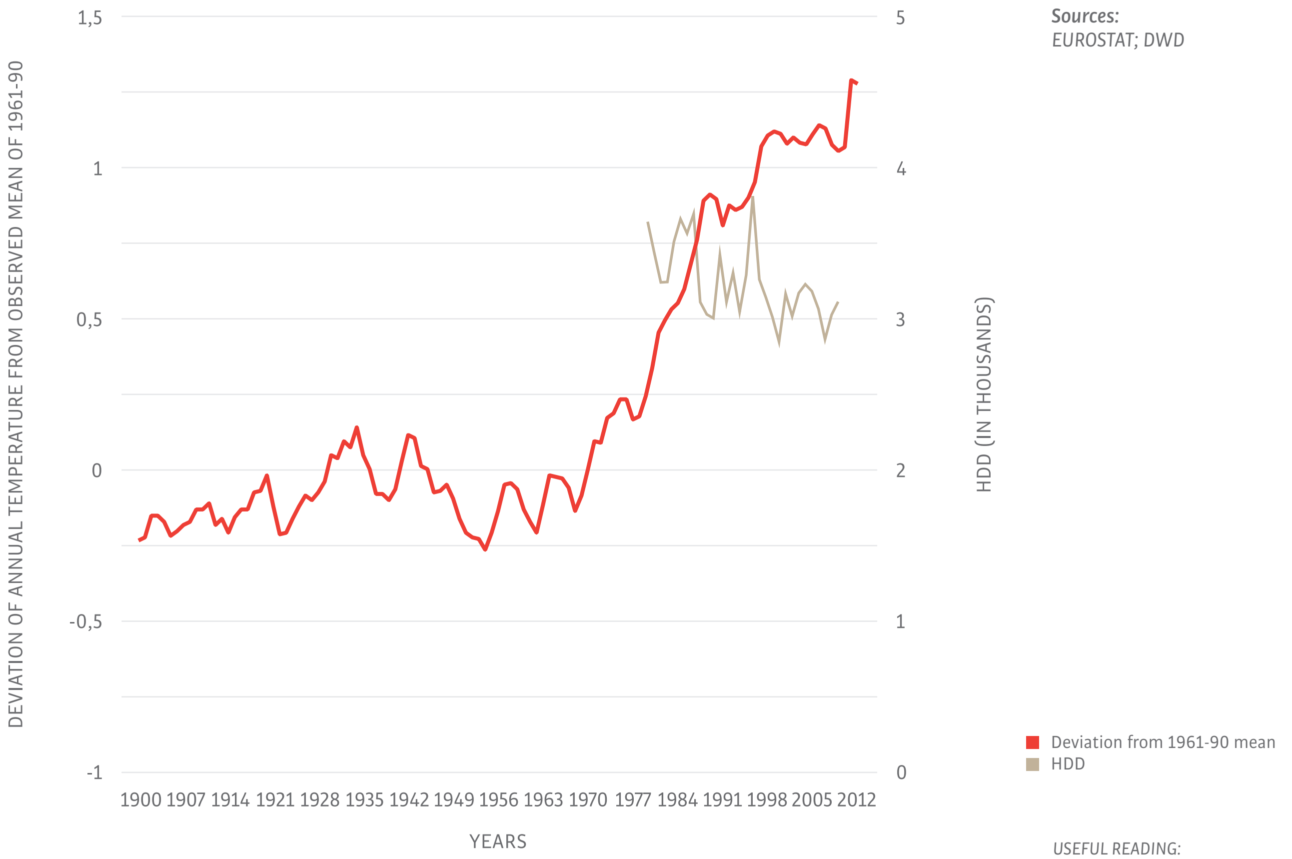
Along with changes in socio-economic conditions, climate change phenomena will also shape how the German building stock evolves and impacts energy needs and demands. The gradual warming of temperatures has been observed worldwide, with Germany being no exception. This increase in the annual mean temperature has also resulted in a decrease in HDD's[18] Therefore, a potentially substantial reduction in heating energy demand in the country will give way to an increase in cooling energy needs.

NOTE

(HDD) is an indicators to quantify the heat energy demand for a building. It is the number of degrees that a day's average temperature is below a base temperature, below which buildings need to be heated.

A2.3– *A period of constant warming.*

Substantially reduced heating demands due to increasingly warmer mean temperatures.



Sources:
EUROSTAT; DWD

As a result of climate trends, the German building stock will likely need to withstand prolonged heat-waves in the summer, increased rain, and stronger storms. These weather phenomena could pose a threat to the structural safety of buildings, the liveability of occupants, and energy needs. Therefore, building planning and development will need to be organised to account for climate-related uncertainties.

USEFUL READING:

BPIE 2014. Renovation strategies of selected EU countries. Buildings Performance Institute Europe, Brussels.
www.bpie.eu

BPIE 2011. Europe's buildings under the microscope. Buildings Performance Institute Europe, Brussels.
www.bpie.eu

A3 Energy, emissions, and climate goals

Introduction to the energy mix, emissions profiles, and the implications of climate goals

Germany's total gross inland energy consumption decreased at an average annual rate of 0.77% from 2005 to 2015. The energy mix of the country is dominated by fossil fuels, and the government's intent to phase out nuclear power by 2022 is well reflected in the annual average decrease of nuclear energy by 5.16% from 2005 to 2015[19]. During the same period, the share of renewable energy in gross total energy consumption rose from 6.7% to 14.6%[20]. The low-carbon transition of the German economy has been collectively termed Energiewende[21].

A3.1 – *A decade since 2005, Germany's total gross inland energy consumption decreased by -8.11%.*
Introduction to the energy mix, emission profiles and implications of climate goals.

Sources:
EUROSTAT

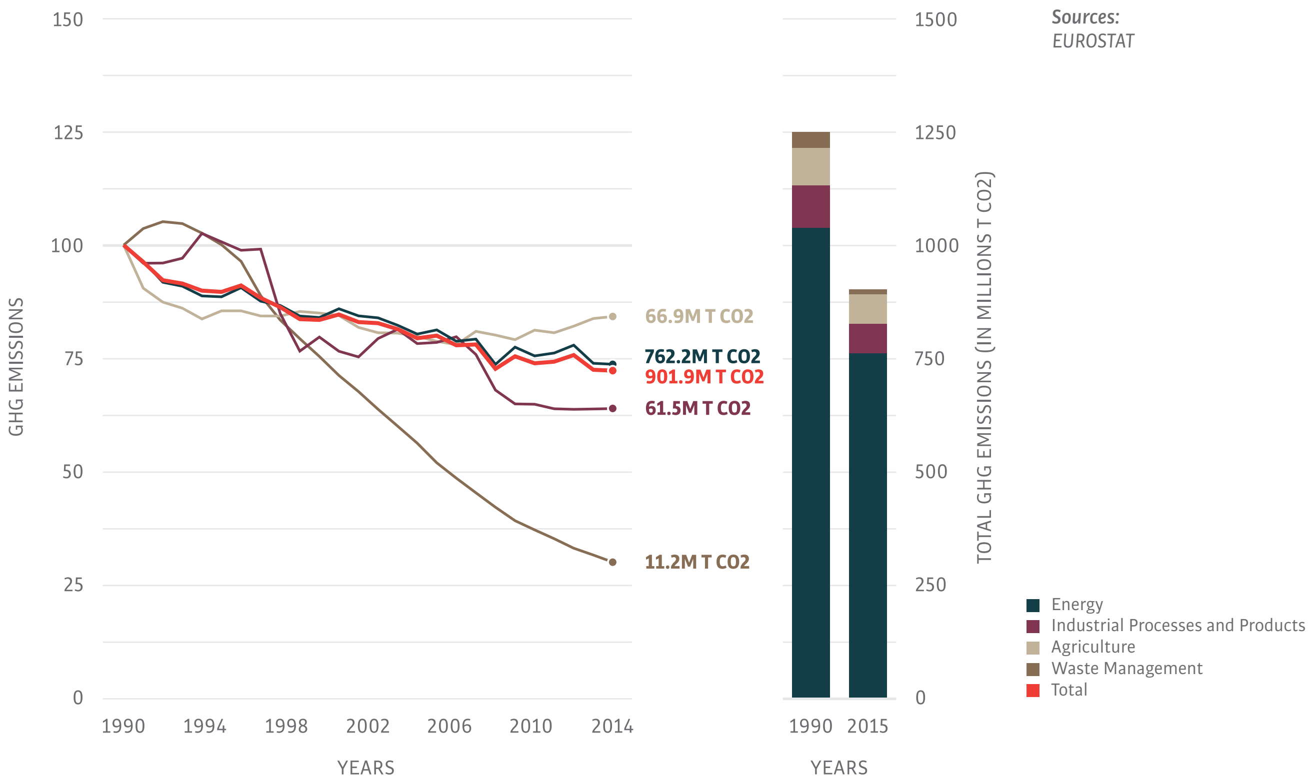
For German households, the energy mix is dominated by gas (37.1%), followed by petroleum products (22%) and electricity.[22]. The residential electricity demand equalled approximately 128.7 TWh in 2015 (25% of total electricity generation).[23]. The electricity mix is dominated by coal (42.1%), followed by renewables (29%) and nuclear (14.2%)[24], so that the resulting emissions factor for electricity consumed is 0.624 kg CO_2eq./kWh, or 0.706 kg CO_2eq./kWh using an LCA approach[25]. The average electricity price for medium-sized households was around 0.29-0.30 €/kWh$_{electr}$ and that for mid-sized industry was 0.08 €/kWh$_{electr}$[26].

German residential energy consumption was around 2.2 million TJ in 2015, or 25% of total energy consumption[27]. Space heating consumed the dominant share of energy usage (68.2%), whilst gas was the pre-dominant fuel (43.8%) followed by petroleum products (28.4%) and renewables and waste (13.9%)[28]. The share of renewable energy in heating and cooling in Germany was 12.9% (2015), up from 6.8% in 2005[29]. The average resulting emissions factor is 0.111 kg CO_2eq./kWh$_{heat}$, with heat energy prices ranging between 0.065 and 0.07 €/kWh$_{heat}$[30].

Of these emissions, those attributable to buildings were 121 Mt CO_2 equivalent in 2015 (13.5% of total emissions). Since 1990, building sector emissions fell by 38.7% at an average annual rate of 1.5%[31].

A3.2 – *Since 1990, German total direct CO_2 emissions decreased by 27.9% while building sector emissions reduced by 38.75%.*

Under the Energiewende Germany aims for a 80% to 95% reduction in emissions by 2050 compared to 1990 levels. German emission per capita was 11.41 t CO_2eq/capital and the total emissions were 901.9 Mt CO_2 eq.in 2015.



Sources:
EUROSTAT

In the period from 1990 to 2015, the residential building space to be heated increased by 21% (from 3,022.6 to 3,667.7 million m²) and the German population increased by 29.5% (from 62.7 to 81.2 million). However, overall emissions actually declined during this time.

Germany fulfilled its Kyoto Protocol (1997) commitment by reducing the total GHG emissions by 25.9% by 2012, compared to 1990 levels, surpassing the 21% which was originally pledged[32]. The country then set an even more ambitious target for 2020 (under the Energy Concept/Energiewende) of 40% emission reduction, compared to the EU's 20%, and a further emissions reduction of 80–95% by 2050. To do so, the share of renewables in power consumption is targeted to increase to 40–45% by 2025, 55–60% by 2035, and more than 80% by 2050. A targeted increase in energy efficiency of 25% by 2050 (compared to 2008 levels) is also planned[33]. These targets are more ambitious than the INDC submitted by the EU to the UN[34]. In 2016, the government agreed on its Climate Action Plan 2050, which intends to bolster efforts to meet the various targets[35]. The largest share of potential CO_2 reductions specified is expected to come through energy renovations in buildings[36].

USEFUL READING:

INDC of EU and its member states
www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf

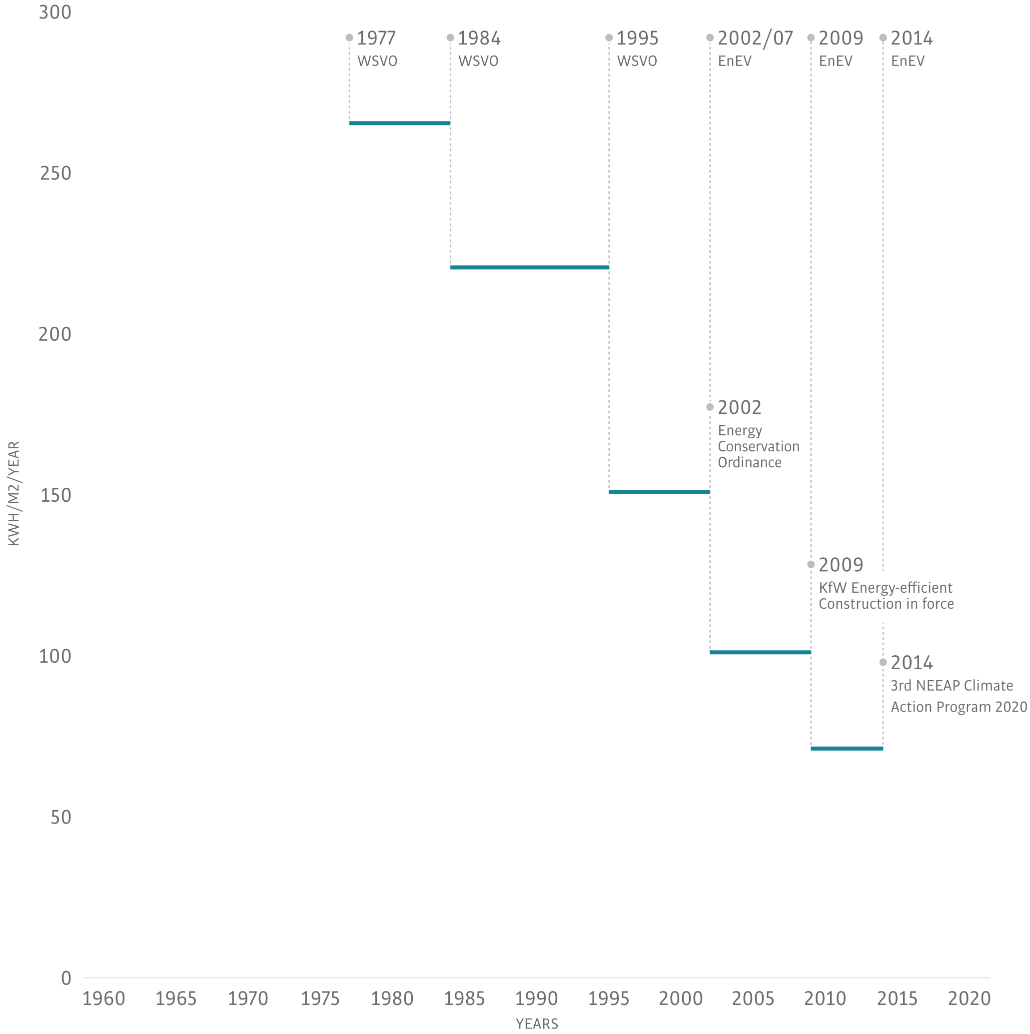
A4 Policy framework
Building sector norms and a legal framework

Germany announced its Energy Concept in 2010, which aims at a 20% reduction in primary energy consumption by 2020 and a 50% reduction by 2050 (compared to 2008 levels), building on regulations such as the renewable heat act (EEWärmeG, 2009)[37]. In 2011, the Energy Concept, named Energiewende, was developed to transform the entire national energy system. By late 2014, the German Federal Ministry for Economic Affairs and Energy (BMWi) presented the National Energy Efficiency Action Plan (NEEAP, BMWi 2014)[38] to deal with the deviation of the actually achieved energy savings from the targets laid out in the Energy Concept. Together, policy programs such as the Climate Action Programme 2020 (CAP2020, BMUB 2014) and the Climate Action Plan 2050 (CAP2050) are intended to result in energy efficiency and emissions reduction measures in all energy demand sectors.

For the building sector, the general strategy foresaw a 20% heat demand reduction by 2020, as well as a primary energy demand reduction of 80% by 2050 (both compared to 2008 levels), amongst other targets. Specific measures were related to stringent building codes (e.g., new buildings to be climate neutral from 2020 onward), targeting 2% of buildings to be refurbished per year and therefore linking higher energy efficiency standards to climate relevant ones[39].

***A4.1** – Progression of building standards and their limits on space heating demand [kWh/m² a] in Switzerland (new construction).* *Building standards have been increasingly getting stringent for space heating. The heating limits for refurbishment is usually 1.5 times that of a similar new building.*

Sources:
Cues Analysis



Building Codes and Standards

In Germany, building codes are implemented through federal legislation determined by the Energy Saving Act (Energieeinsparungsgesetz, EnEG) and the Energy Saving Ordinance (Energieeinsparverordnung, EnEV). The codes have evolved over time, becoming more stringent and covering a wider range of energy usages from building components to HVAC and lighting. The current requirements necessitate the primary energy consumption of new buildings to be about 45 kWh/m² along with an obligation to partially use renewable energy[40]. Building codes apply to new buildings as well as to the renovation of existing ones.

Whilst the EnEG specifies the general legal framework, the EnEV defines numerical, minimum energy performance requirements for buildings (including such for heating, ventilation, HVAC, and water boilers). In 2002, the EnEV was split into two separate ordinances, one pertaining to thermal insulation and heating systems and one to accommodate EU directives as well as the standards set by the German Standardisation Institute (DIN). In 2009, the EnEV was tightened to include a reduction in primary energy demand for new buildings by 30% and a reduction of thermal insulation losses (i.e., average U-value reduction) by 15%. Additionally, the energy certificate was redesigned as well, including its mandatory issuance for each building transaction. In 2017, such certification or labelling was also introduced for heating systems older than 15 years so as to increase the replacement rate of old systems (EnVKG, 2015)[41 42 43].

USEFUL READING:

INDC of EU and its member states ***www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf***

Financial Support Measures

In Germany, governmental funding is available for building renovations in the interest of increased energy efficiency. Since 2001, when the CO_2 Buildings Rehabilitation Program (CBRP) came into force, low-interest loans and grants to households for refurbishment measures have been available, organised by the Bank for Reconstruction (KfW), through which home owners, housing companies, and other building owners can apply for financial products.

After the implementation of the CBRP, the KfW Energy efficient Construction Programme was introduced in 2009. Houses which met the conditions of a KfW Energy Efficient House could receive funding in the form of low-interest loans. Financing is provided to a maximum of € 100,000 per building or to a maximum of 100% of the eligible costs[44]. In 2014, 230,000 buildings were renovated and 110,000 new buildings (around 45% of all new buildings) built under this scheme[45]. In the past few years, additional funding was additionally made available also for non-residential buildings, increasing the renovation programme by € 200 Mio million € EUR per year.

Furthermore, since the year 2000, the Mmarket Sstimulation Pprogram (MAP)[46] has supported, the exchange of up to 1.8 million fossil heating systems with renewable heating systems. In 2015, this programme was renewed and amended by the energy efficiency incentive programme APEE, providing € 165 million for the next three years to improve the energy efficiency of heating and ventilation systems[47].

USEFUL READING:

IEA/AFD 2008. Promoting energy efficiency investments Case studies in the residential sector.
www.iea.org

Notes:
A KfW Energy Efficient House 70 has an annual consume of only 70% of the primary energy of a similar normal house and so on.

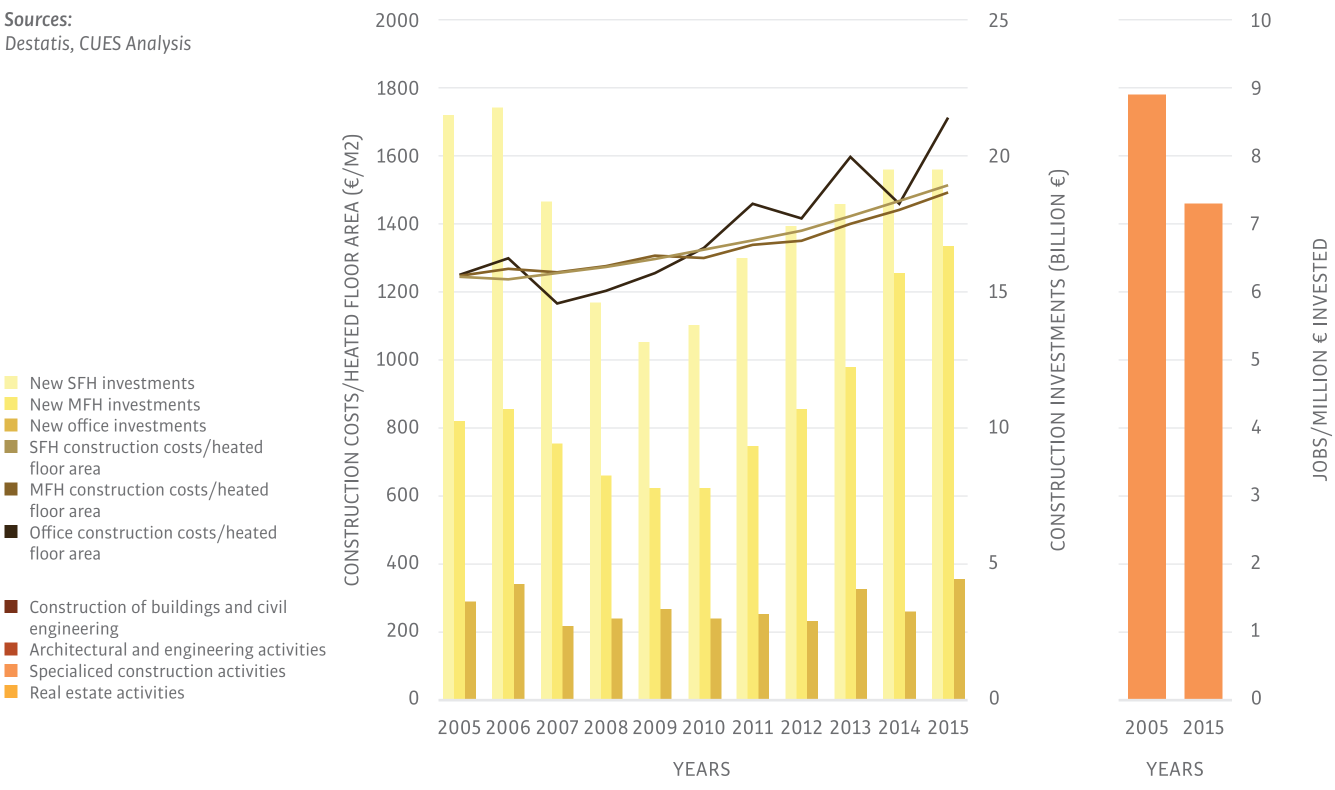
A5

Investment and employment
Construction costs and jobs in the building sector

The construction sector accounts for over 4.6% of Germany's GDP. In 2015, roughly 2.6% of Germany's GDP, totalling € 69.43 billion, was spent on building construction. Of this, some 82.5% was spent on the construction of new buildings, whilst the remaining money went to repair and maintenance related work. Since 2005, total investment in building construction has increased at an average annual rate of 1.89%. Beside its apparent economic significance, the building construction sector of the economy impacts employment as well. In 2015, for every million euro that was thus invested, around 7.3 jobs linked to construction of buildings were created[48 49].

A5.1 – ***Total construction investments by type of development (€ bilion) , along with jobs attributed to construction related investment.***
The total employment contribution by construction and ancillary sectors linked to it was 9% in 2015.

Sources:
Destatis, CUES Analysis



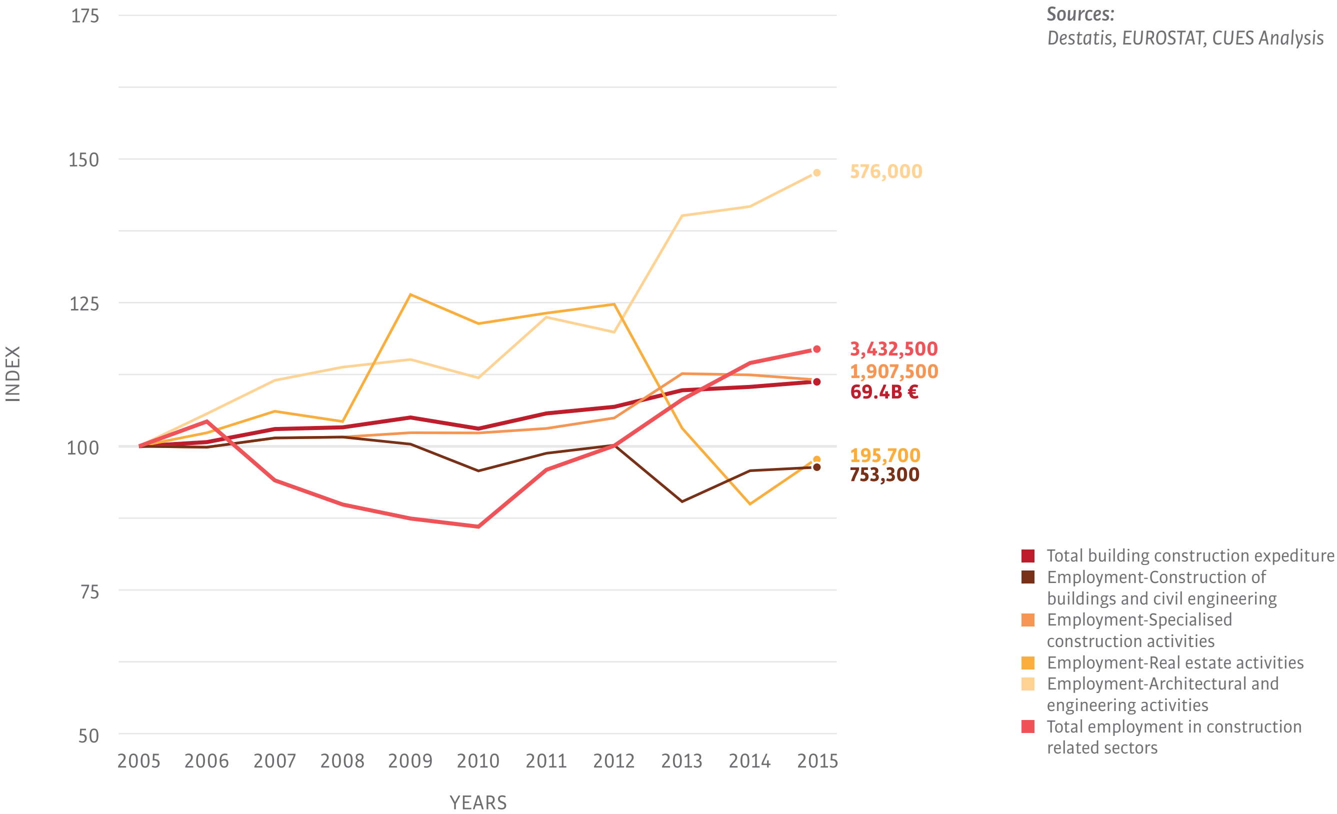
Investment into building construction is driven by an increase in population and the average net floor area per person. It is also a result of the trend toward smaller households and a general demand for more personal space. Since 2005, the proportion of building investment in single and multi-dwelling buildings has varied, with a gradual increase visible in the proportion of money invested in multi-dwelling buildings. In 2015, 54% of construction costs could be attributed to single-dwelling building development, and the remaining to multi-dwelling. Investment increased at an average annual growth rate of 5.8% in multi-dwelling buildings from 2005 to 2015[50]. In terms of building constructions costs on a per-heated-floor-area basis, office construction costs are the highest amongst all the categories.

Germany has approximately 40 million residential dwellings, and many of these require refurbishment for the country to meet its ambitious targets of energy efficiency. The annual refurbishment rate for building façade insulation was just 0.8% between 2005 and 2008, and the annual rate for roof insulation was 1.3%.[51].

Of the 39 million total employees in Germany in 2015, roughly 8.7% of employment was attributed directly to the construction sector (including building construction) or sectors which are linked to main construction activity. In 2015, for all enterprise sizes, the hourly labour costs were € 26.3 in construction, € 32 in real estate activities, and € 40.3 in professional, scientific, and technical activities (which includes architecture and engineering services). The cost of labour and materials in construction is roughly divided into 55% labour costs and 45% material costs.

***A5.2** – Index of employment and investment (2005=100).*

Increase in total construction investments, is paralleled by a similar trend in total employment related to construction.



Sources:
Destatis, EUROSTAT, CUES Analysis

In 2015, 66% of the German population was of a working age (15–64),[52] and sectors such as manufacturing, construction, trade and repair of motor vehicles, and health and social work activities employed roughly 46% of the employed population[53]. Gradual growth was witnessed in employment in the construction sector and the ancillary sectors that depend directly or indirectly on construction activity, including architectural and engineering services and real estate activities. Between 2005 and 2015, whilst total construction expenditure jumped by 18.1%, total employment in construction and its ancillary sectors jumped by 12%. Of the latter increase, employment in architectural and engineering activities (a +51% increase since 2005) witnessed the most pronounced change.

The building construction sector is thus an important German economic sector, and the changing trends in business, lifestyle, and demographics, along with the development of the building stock, should therefore be closely monitored. To transition the existing stock toward a low-carbon path would require not only specialised skills but also targeted investment.

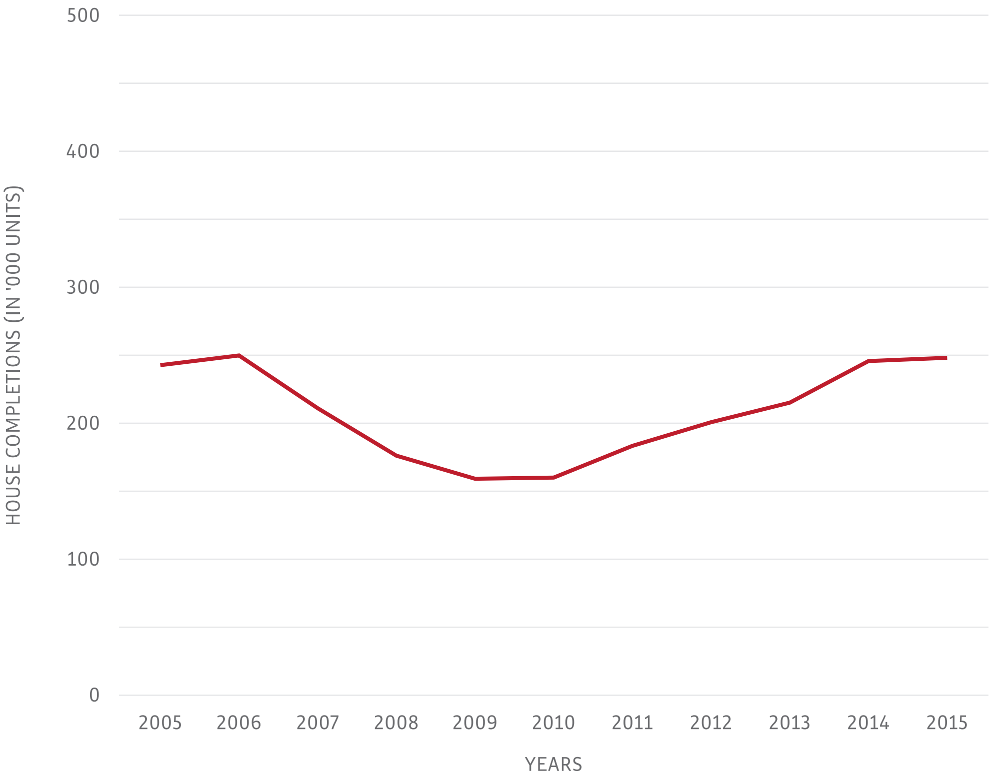
A6 Demand, supply, and affordability
Housing market conditions

Germany has enjoyed a well-developed rental housing sector, and it is the only EU country with an almost even split between renters and owner-occupiers, for in 2015, only 51.9% of German households were owner-occupied.[54].

Unlike much of the rest of Europe, housing prices in Germany did not drop following the financial crisis. During the 2000s, housing prices were relatively stable in Germany, and new housing output matched household growth. Since 2010, housing prices in Germany displayed a clear upward trend, driven by fundamental factors, low interest rates, and a lack of investment alternatives. According to the German Bundesbank, housing prices in German cities rose by an average of 5.25% in 2014 after having increased by 7.25% in 2013[55]. These price increases were particularly true for apartments in urban real estate markets. The German Bundesbank considers that there is no overall over-valuation of residential property but that in major cities, prices for apartments are overvalued by 10–20%[56].

A6.1 – *House completions in Germany*

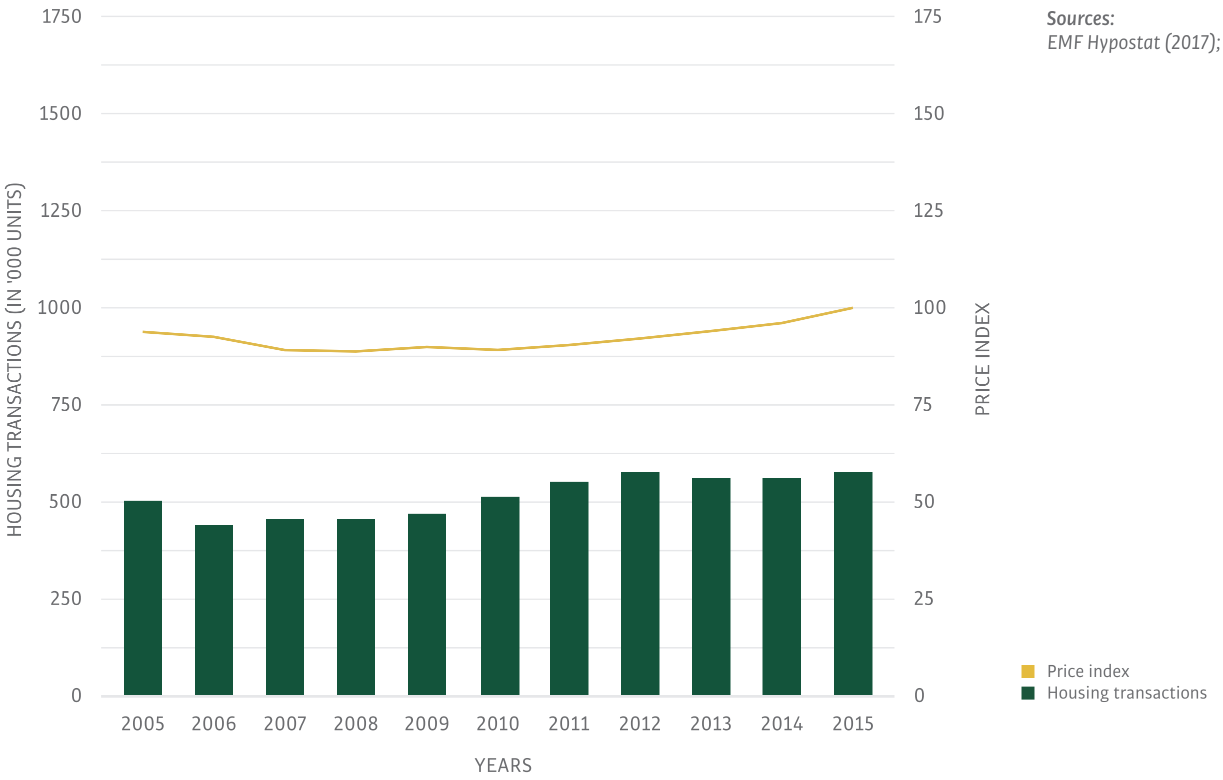
Sources:
European Central Bank



The current rise in prices in Germany can be explained to a large extent by the trend in supply and demand. Demand for residential properties remains high, although current housing market trends show considerable regional disparities. In metropolitan areas, for example, there is strong demand-side pressure, whilst in other areas such as rural locations, the population is decreasing, resulting in a costly structural vacancy in the housing stock[57].

Since 2010, a higher influx of workers from Southern and Eastern Europe and the more recent stream of refugees has resulted in strong population growth and an increased demand for housing. In 2015 alone, net migration exceeded 1.1 million. As most immigrants head to Germany's dynamic growth centres, shortages have been developing in the urban housing market, as have a strong rise in purchase prices and rents, whilst the housing space per capita is decreasing.

A6.2 – *Number of transactions and housing price variations in Germany*



Sources:
EMF Hypostat (2017); EUROSTAT

The supply side has been slow to respond to the sustained population growth witnessed since 2012. However, new-build activity has recently increased significantly, with annual housing completions totalling almost 280,000 last year, having risen by 35% between 2011 and 2015. During the same period, building permits increased by over 37% to more than 310,000. However, with an estimated demand of 300,000 to 400,000 housing units annually, the strained situation in the German housing market will persist for some time. The building of new affordable housing units in Germany is challenged by the increase in construction costs, mainly due to higher soundproofing, fire, and energy efficiency standards. GdW, the Federal Union of German Housing and Real Estate Associations, estimates that average construction costs for new dwellings have increased by 47% between 2004–05 and 2012–13.

State intervention has also thwarted housing construction, and measures such as the increased funding for social housing schemes are proving insufficient and failing to have a significant effect, whilst the new rental cap ('Mietpreisbremse') may prove to act as a brake on investment. By contrast, little is being done to increase the amount of building land or to create affordable housing. The federal government is promoting energy renovation measures in existing buildings as well as energy standards regarding newly constructed buildings[58]. evertheless, the responsibility for social housing policies lies at the level of the federal states, and strategies implemented at the regional and local levels differ significantly across Germany. Overall, the social housing stock is decreasing, from 2,570,600 in 2002 to 1,538,700 in 2012[59]. In recent years, policy has shifted toward supporting people directly through housing benefits, with housing allowances and the payment of housing and heating costs available to social benefit recipients[60]. In 2013, the government provided housing allowances or the housing and heating costs payment to 4.8 million households, spending € 17 billion on housing costs. About 12% of households in the country are recipients of housing assistance.

A7

The retrofit challenge
Status of building refurbishment

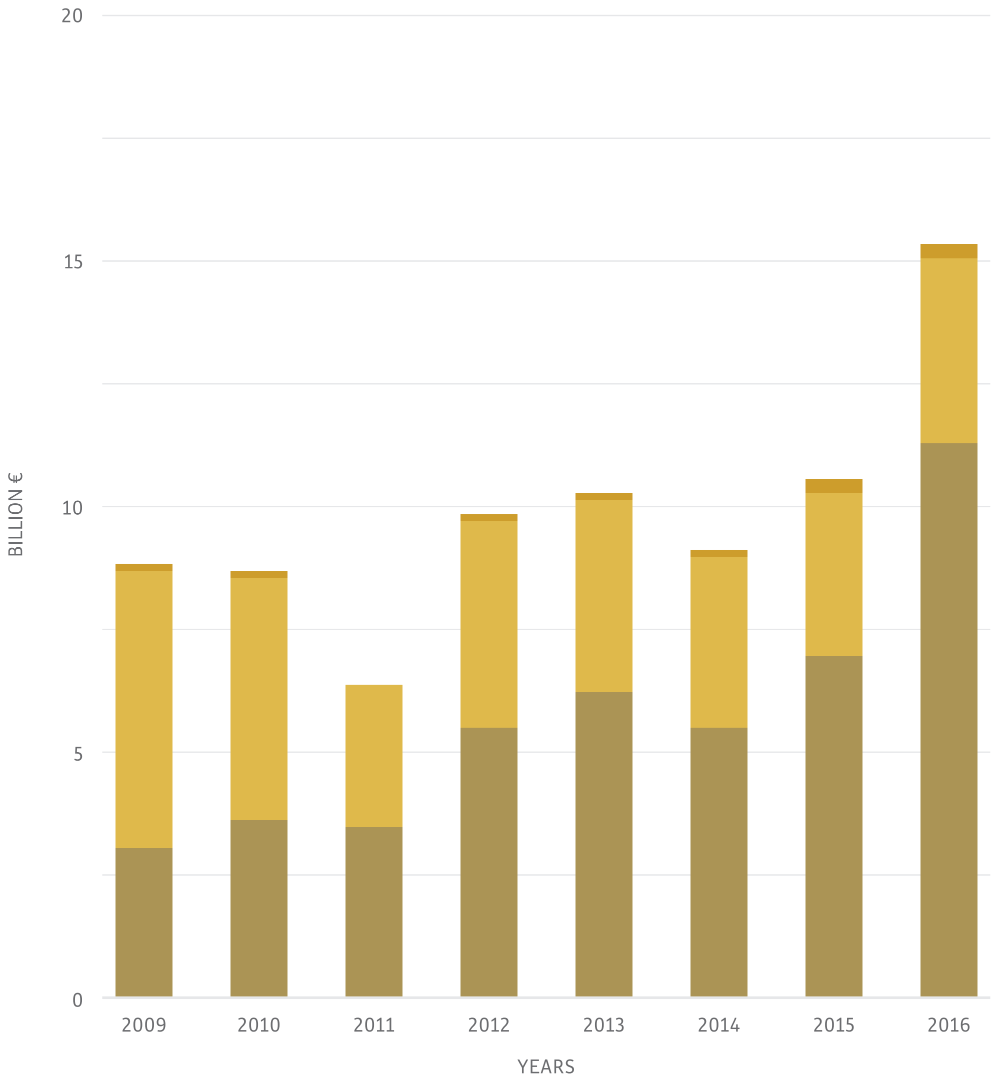
Notes:

In order to make these programmes more effective, KfW has established the Effizienzhaus (EH) scheme, which categorises buildings according to their primary energy demand and heat losses due to transmission. Building owners can apply for grants or soft loans, which are provided via their local commercial banks (not directly from KfW). The better the EH category achieved, the better the funding conditions. Eligible buildings must fit into one of the six EH classes after refurbishment: EH 115, EH 100, EH 85, EH 70 or EH 55. New buildings are divided into EH 70, EH 55, EH 40. For both, new and existing buildings, the number indicates the building's maximum allowed primary energy demand in comparison to a new building built to meet Germany's MEPS. For example, a refurbished EH 70-certified building demands only 70% of the primary energy of a comparable new building. Moreover, there are maximum values for heat getting lost due to transmission for each category. For instance, an EH 70 home may not lose more than 85% of transmission heat to that of a comparable new home. The minimum performance standards for new homes are stipulated in Germany's EnEV.

Since the introduction of the Energiewende, Germany has made substantial efforts to increase the energy efficiency of its building stock. Buildings account for approximately 35% of energy consumption and thus have important energy savings potential[61]. Through the 2050 Energy Concept, the federal government has set a target of reducing the primary energy demand of buildings by 80% by 2050, compared to 2008 levels[62]. Recognising the additional progress needed, the government has thus aimed to double the rate of energy-saving modernisation from 1% to 2% per year, with the EnEG and EnEV introduced to implement these goals[63].

Increasing the rate of retrofits extremely important, as roughly 63% of Germany's buildings were built before 1979, at which point the first Thermal Insulation Ordinance for buildings came into effect. Since then, Germany has tightened the minimum energy performance standards (MEPS) for new buildings several times, and new residential buildings today are allowed to use 75% less energy than they were 35 years ago. The MEPS will need to be further strengthened to meet the nearly-zero energy standard for all new buildings from 2021, as required by the EnEG.

A7.1 – *KfW funding for energy efficiency construction and refurbishment programmes (bn. EUR).*



Sources:
KfW Annual Reports (2011 to 2016)

- Energy efficient refurbishment grants
- Energy efficient refurbishment loans
- Energy efficient construction

The key components of German Energy Efficiency Strategy for Buildings are as follows: 1) MEPS for buildings, 2) a roadmap enumerating short- and long-term goals, and 3) financial incentives and preferential loans to exceed MEPS in new buildings and to trigger refurbishment, facilitated by the government-owned development bank KfW Bankengruppe.

Lack of capital was identified as one of the main challenges preventing homeowners from upgrading their properties. The KfW-supported Energy Efficient Refurbishment and Construction Programmes are the most well-known measures to address this issue. They were launched in 2009 but were built on similar programmes that had operated since 1996. The schemes offer grants and soft loans to support energy efficiency work during the general refurbishment of existing buildings and to encourage energy efficiency standards in new buildings which are higher than the legally required minimum. The loan conditions are highly preferential, with a tenure of up to 30 years and an initial grace period. Interest rates can be as low as 1%, depending on market rates, and are then reduced using the government's budget support.

The schemes are open to all building owners including private individuals, housing enterprises, housing cooperatives, real estate agents, municipalities, and local community associations. They are intended to be technology neutral; the key criteria for measures are cost-efficiency and reductions in energy consumption. However, energy savings have to be verified by an approved energy assessor before funding can be drawn from KfW.

The Energy Efficient Refurbishment and Construction Programmes support both single measures (wall insulation, loft insulation, floor insulation, window replacement or refurbishment, installation of ventilation, replacement of heating systems, etc.) and a series of multi-measure packages.

During the period from 2006 to 2016, 4.6 million dwellings were either refurbished or constructed as energy-efficient by design[64]. No surveys record the level of public familiarity with the programmes; however, the entire budget is consumed each year, which may suggest that familiarity is high.

B

Market mechanisms, barriers and drivers

Aim

The chapter 'Market Mechanisms, Barriers and Drivers' provides stakeholders' perspective on residential building projects in Germany. The aim of this chapter is to support the conception of business strategies and policy measures to foster energy efficiency and low carbon solutions.

Based on a survey covering the whole value chain and a series of experts' interviews, this chapter aims to capture the stakeholders' perspective on low carbon building concepts and solutions, covering both the construction of new buildings and the retrofit of existing ones. Special attention is put on those aspects considered as most critical for in the uptake of respective technologies, particularly the decision-making process.

B

Methodology

The data gathered in this chapter was obtained via an online survey and in-depth market expert interviews.

The results from the online survey were collected from June 2018 to September 2018 and covered stakeholders along the complete value chain of the building. A stratified sample of a total of 21 groups were approached, providing a differentiated view of the market. The study is centered around concrete past projects of the respondents. The survey results are used to quantify findings when a statistically relevant response rate is available.

The content and topic of the survey is based on exploratory interviews and findings from a literature review study. Sources used are listed in the reference section of this report. Questions and answer options were tested in a pilot phase. Every survey question offered a pre-selection of choices as well as 'other' and 'I don't know / can't judge' options.

The in-depth experts' interviews to market experts were conducted between August and September 2018. The experts were selected to cover the complete value chain of the construction sector in the respective country (i.e. planning, technology and material suppliers, construction and installation, use, end of life and overarching), as well as projects types (new built and refurbishment) and project scales (small and large typologies of buildings), where applicable. The results from these interviews are presented and clearly marked after the survey results, to complement this information. These statements may, in rare occasions, conflict the results from the survey.

The level of agreement among the interviewees on the statements in the main text is ranked in the following stages:

- **Very high**: virtually all experts that feel confident to comment on the statement agree.
- **High**: nearly all experts agree at least to a certain degree.
- **Medium**: there is a trend among the experts to back up the statement, but a notable number are not convinced, though they don't disagree.
- **Low**: some experts emphasize the statement but there is no consensus among the experts, some experts might even disagree

B1 Value chain & life cycle of the building
Defining the scope and rationale

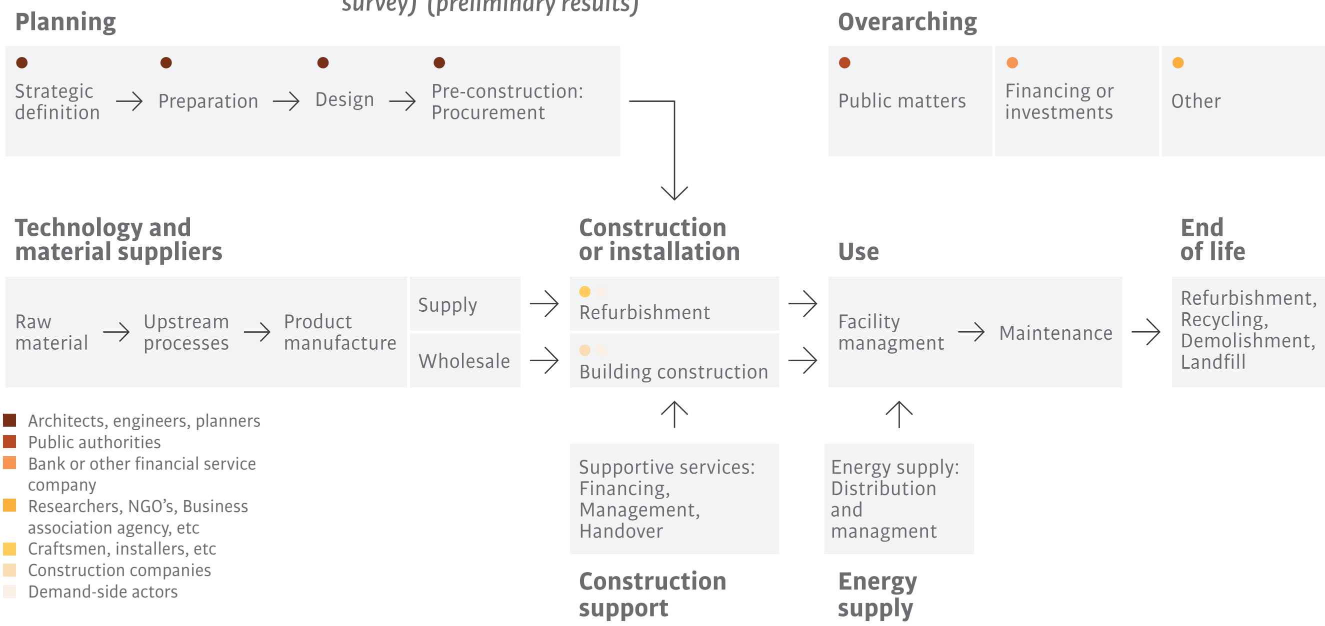
USEFUL LINKS:

www.make-it-in-germany.com
www.ec.europa.eu

The value chain refers to all stakeholders from the raw material, material and technology production, installation usage and deconstruction professions. To provide a comprehensive understanding of stakeholders' view, this study covers groups along the whole building value chain in Germany, entailing more than 20 stakeholder groups. To properly contextualize the market structure the exact number and size of enterprises is listed below for the main stakeholder groups in Germany.

Figure B1.1.1 visualizes the structure and main phases in the building value chain that were used as basis for the survey and structure of the following subchapters. From the table B1.1.2 below, it becomes apparent the majority of companies and also of the professionals of the main sectors of the building value chain in Germany are small and medium sized companies up to 50 employees.

***B1.1.1** – **German** characterization of the residential building value chain (the "universe" of the survey) (preliminary results)*



Sources:
NACE Rev. 2, Eurostat

(preliminary results)

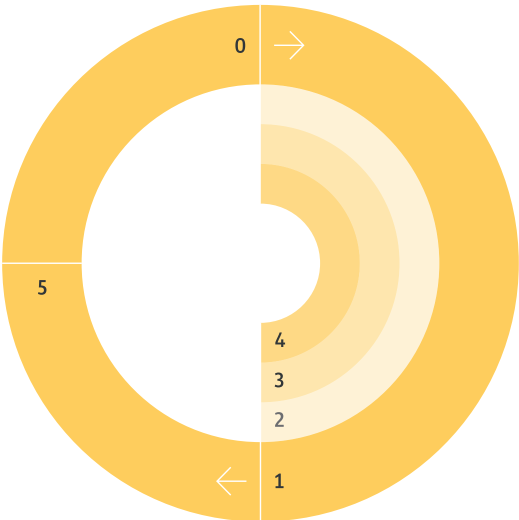
***B1.1.2** – Number of enterprises and employees for planning and construction activities in **Germany**.*

		Total	0 to 9	10 to 19	20 to 49	50 to 249	250 or +
Number of enterprises	**Construction of buildings**	**25,308**	**17,707**	**4,852**	**1,975**	**721**	**53**
	Development of building projects	3,795	3,233	428	101	33	-
	Construction of residential and non-residential buildings	21,513	14,474	4,424	1,874	688	53
	Specialised construction activities	**299 142**	**256,707**	**32,488**	**7,886**	**1,951**	**110**
	Demolition and site preparation	6,133	4,983	882	193	-	-
	Electrical, plumbing and other construction installation activities	116,177	96,320	14,543	4,089	1,153	72
	Building completion and finishing	126,821	115,057	9,407	2,014	329	14
	Other specialised construction activities	50,011	40,347	7,656	1,590	-	-
Number of employees	**Construction of buildings**	**276,122**	**57,376**	**66,641**	**59,663**	**64,490**	**27,952**
	Development of building projects	22,484	10,837	5,732	3,001	2,914	-
	Construction of residential and non-residential buildings	253,638	46,539	60,909	56,662	61,576	27,952
	Specialised construction activities	**1,419,804**	**538,909**	**423,094**	**232,514**	**162,911**	**62,376**
	Demolition and site preparation	36,836	11,972	10,772	5,825	-	-
	Electrical, plumbing and other construction installation activities	663,811	210,383	191,405	122,394	98,147	41,482
	Building completion and finishing	434,519	222,225	123,407	57,800	24,765	6,322
	Other specialised construction activities	284,638	94,329	97,510	46,495	-	-

The building life cycle refers to the prospect of a building over the course of its entire life - encompassing the design, construction, operation, maintenance, modification and eventual demolition and waste treatment. To characterize what measures have taken place during the complete building's cycle in Germany, the building typologies are differentiated between small (one family home, row houses, small multi-dwelling building, etc.) and large projects (large multi-dwelling buildings) and types of projects are differentiated between new building activities, light modification of an existing building (overhaul, partial retrofit, refurbishment) and in-depth modifications of an existing building (deep comprehensive retrofit).

Figure B1.2 depicts the buildings life cycle, starting with planning/ construction phase (0), followed by a usage/ maintenance phase (1), continued by repair (2), interrupted by different intensities of light (3) and deep refurbishment (4), and eventually ending with deconstruction (5).

B1.2 – *Type of projects over the life cycle of the building.* ***(Germany)*** *(preliminary results)*



Phase 0
Construction

Phase 1
Usage and maintenance

Phase 2
Repairs

Phase 3
Light/partial refurbishment

Phase 4
Deep/comprenhensive refurbishment

Phase 5
Deconstruction

The statements and findings of this chapter are accordingly aggegated into the following project types a) to f):

	SMALL BUILDING	LARGE BUILDING
Construction of a new building	a)	b)
Overhaul or partial retrofit or refurbishment project	c)	d)
Comprehensive retrofit project	e)	f)

All questions in the survey are related to a concrete project that the respondent or interviewee worked on. This is to ensure receive concrete and specific answers.

economy of Germany is based on the construction activity of new buildings, especially those of larger sizes, being economically most attractive. The other activities, such as refurbishment and smaller construction projects suffer from the consequences of what all interviewees describe as a severe shortage of skills especially in skilled labour on construction sites, resulting in high costs increases for related activities as well as delays.

USEFUL READING:

https://www.hamburg.de/contentblob/9773386/4d60113359dc73d6fd10ef128636ce89/data/d-gutachten.pdf

https://www.hamburg.de/contentblob/7084354/06e5a3dc78194f06127edb1af5ec75c6/data/pdf-f-b-vortrag-kraemer-8-nd-ph-konferenz-09-2016.pdf

MARKET EXPERT COMMENT

'The study shows that there is no correlation between the energy efficiency standard and the construction costs. This is good news for Hamburg. It means that our climate targets and affordable buildings are not exclusive to each other. We now need to find to real reasons behind the cost increases and then build homes in Hamburg so that energy costs as well as rents remains affordable'.
– Jens Kerstan
Senator for Environment and Energy, Hamburg as comment to the InWis Baukosten Studie (see useful readings)

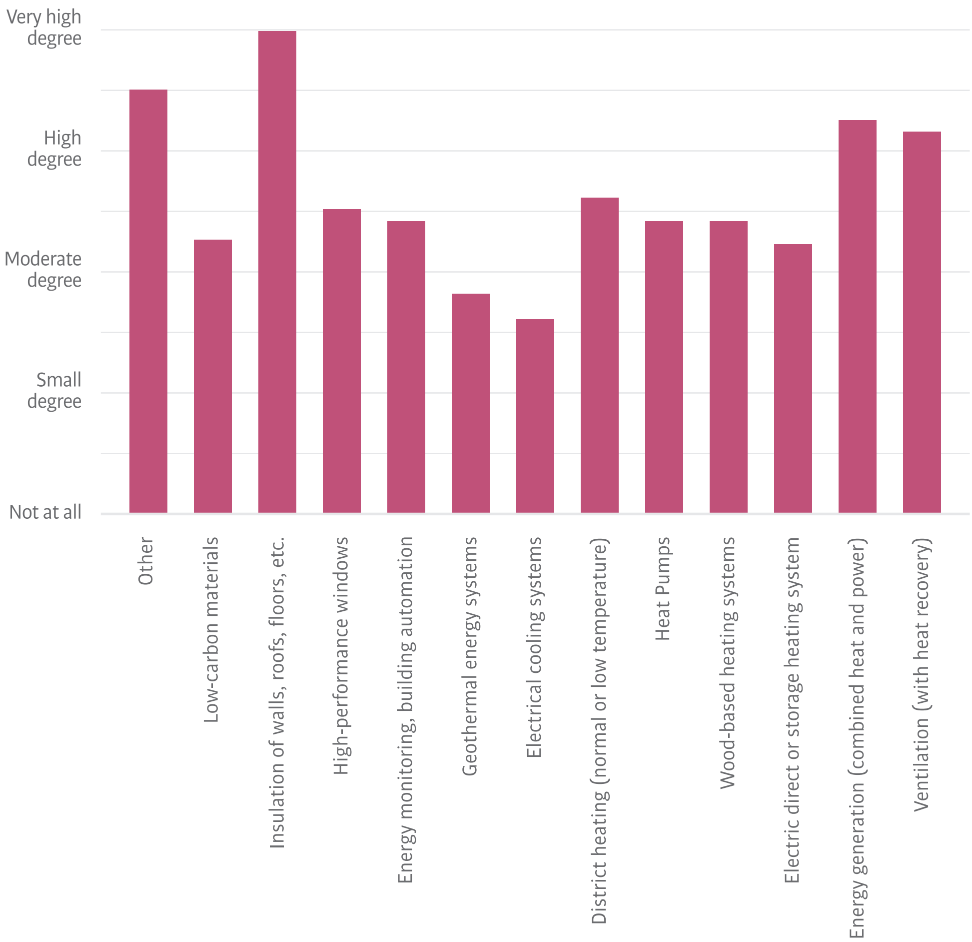
B2 ***Technology competences*** *Familiarity with technology groups*

Competences related to implementation of technologies differ significantly in different markets. It is important to identify the level of knowledge towards different solutions a market has in order to design education programs when necessary. Hence, the following section assesses the level of competence and familiarity of stakeholders involved in planning and construction projects to different energy efficiency and low carbon technology groups.

Survey respondents from the groups of planners, constructors and facility managers/maintenance were asked ***'How familiar are you with the following technologies?'*** They were then provided with a pre-selected list of technologies and the options ***'worked with it once; worked with it several times, part of day to day business, no experience'*** on all technologies. Answering was not mandatory. The respondents could also add technologies they felt highly relevant in a free entry field. The final responses are listed in figure B2.1, indicating the average familiarity of respondents with the listed technologies. Interviewees were asked the same question and given the opportunity to contextualize and comment.

'Insulation of walls, roofs, floors, etc.' has the highest level of familiarity among the respondents in Germany (Figure B2.1). The technology with the least level of familiarity among the respondents is 'Electrical cooling systems'. This is closely followed by 'Geothermal energy systems'.

B2.1 – *Familiarity level with low carbon and energy efficiency technologies in* ***Germany****. (preliminary results)*



MARKET EXPERT COMMENT

'Business models are generally lagging behind the development of the construction sector in Germany. We will need bolder partnerships than just the occasional ESCO SME if we want to be successful. Façade refurbishment leasing, circular economy ideas, and prefabricated refurbishment approaches are currently all evolving in countries around Germany and not within.
There is a need to establish these innovation in Germany as these are crucial to get us out of the spiral of increasing construction costs and lack of labour and residential space.'.

There is a **high** agreement among interviewees that the general level of craftsmanship competence in Germany is high in comparison with many other countries. Especially the craft culture and the education system are named as reasons for this. There is a medium agreement that the average competence among constructors and craftsmen is dropping due to unskilled labour substituting skilled labour mainly due to lack of trainees.

There is a **very high** agreement that the time invested in professional training has been dropping in the past years.

There is a **high** agreement among interviewees that the competences related to technologies are increasingly monopolized by specialized engineers and specialized craftsmen. There is a medium agreement that this leads to conflicting statements in designing systemic solutions and that this is resulting in a perceived low technology competence despite mainly the systemic competence being missing.

There is a **high** agreement that there is a general lack of systemic competence related to the contribution of single technologies to the overall carbon performance of buildings. There is a medium agreement that the architects that should field this understanding is not sufficiently providing this competence.

There is a **medium** agreement that the planning competences for low carbon technologies is generally higher than the installation competence especially in larger projects. There is a high agreement among interviewees that the maintenance and management competence of technologies is lower than the planning and installation competence.

There is a **medium** agreement that the general competence in planning low carbon buildings is stagnating or even decreasing. The main reason being fielded is the increasing complexity of solutions and standards and the education falling behind. There is a high agreement among interviewees that there is low competence in the market regarding the life cycle performance of technologies.

MARKET EXPERT COMMENTS

'Low carbon materials are still not focus of industry development, but cost reduction, and therefore research projects that are focusing on carbon reduction a niche in Germany, despite labels like DGNB including Life Cycle Assessment that includes the materials. A main reason for this is that the carbon performance of materials is invisible. Its not even that lower carbon alternatives are more expensive often even cheaper. They are just not requested. On this, policy makers need to act'.
- Dr.-Ing Sven Mönnig
Head of New Buiness, Construction Materials, BASF

'The housing associations we work with need energy cost security most of all. For many the safest way forward has been become an energy supplier themselves. Recent verdicts however found the tax handling of these providers as independent subsidiaries not valid and such energy suppliers now need to be truly independent. This is changing the whole game again and solution providers are sorely needed.'
– Hans Jürgen Cramer
Owner 3C-PreCon, former CEO Vattenfall Germany

B3

State of play
Measures implemented in the building stock

MARKET EXPERT COMMENTS

'When not being the result of a change of ownership most overhauls start at the top – with a leaking roof. Then energy measures are added to the anyway costs for repairing the damage. Looking at is this way would indicate the value of roofers to inform their clients about the potential to also think about energy efficiency measures rather than lock in the energy condition of the roof by simply renewing the roof covering. Even governmental subsidies via the KfW are in place. It's really often an information issue'.
- Oliver Scheifinger
Partner, tafkaoo architects

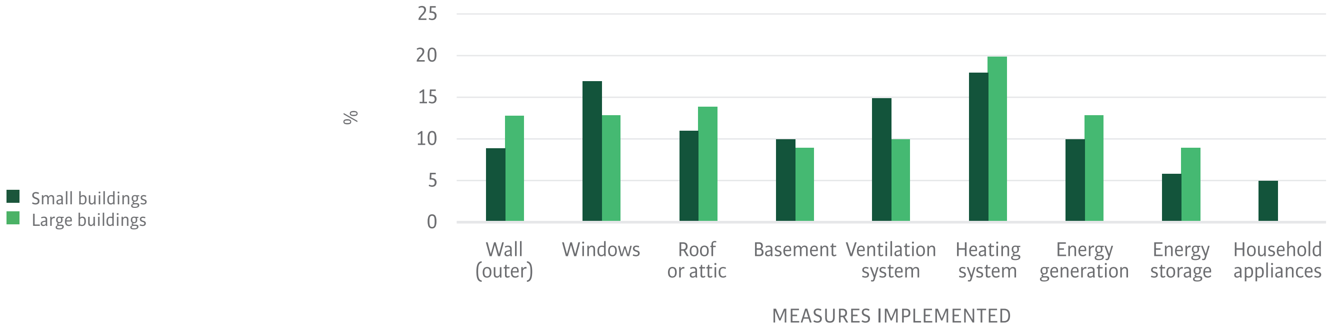
'Germany has an extensive natural gas grid. I see no feasible option for an energy transition that does not make use of this asset in some way. Private household are hesitating to move away from what they know. The know-how and labour capacity for this technology is in place'.

In most European countries, the state of the building stock is mostly unknown due to limited monitoring of past and present retrofit measures. This section characterizes the measures that have been implemented in the residential buildings in Germany for different project types. The results in B3.1 and B3.2 are based on the survey results. These have been complimented by insights from in-depth stakeholder interviews.

To gather this information, survey respondents were asked ***'What measures were implemented in your latest project?'*** The respondent was provided with a table with 9 different elements covering all building components which they had to choose from. Then had to indicate what was the type of measure. The answer options were: ***'Maintenance (including repair)', 'Upgrade of existing elements or systems (incl. insulation and control)' and 'New element or systems'.*** Additionally, to these answer options, they were provided the option of 'I don't know' and 'Other'. Interviewees were asked the same question and given the opportunity to contextualize and comment.

Results from the survey show that the type of measure does not vary substantially depending on the size of the building in Germany. As can be depicted in B3.1, for 'overhaul, partial retrofit or refurbishment projects' in small buildings, 'Heating systems' (18%) are the most often implemented measures. The same as in large buildings When it comes to the least frequent implemented measures it is 'household appliances', again for small (5%) and for large buildings (0%).

B3.1 – *Measures implemented in (c) overhaul or partial retrofit or refurbishment project in small building and (d) overhaul or partial retrofit or refurbishment project in large buildings in* **Germany**. *(preliminary results)*

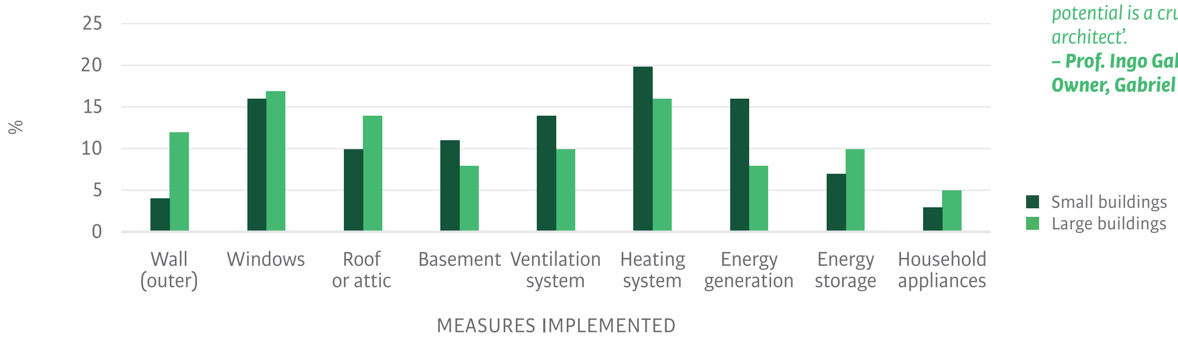


For overhaul, partial retrofit or refurbishment measures, there is a **high** level of agreement among the interviewees that the most common overhaul and partial retrofit in the German building stock is related to decentral energy generation in the form of PV especially on private one family homes and envelope related measures. Especially uninsulated roofs are insulated and windows or only the glazing is upgraded. Outside insulation and the filling of cavity spaces are less common and mainly applied where this is easily.

There is a **very high** agreement among the interviewees that heating system exchange is almost exclusively conducted as the result of the original system reaching the end of its life or failing and that there is very few changes towards a different energy carrier in these incidents.

Again, in comprehensive retrofit projects, measures don't vary that much if it's a small or large buildings. As can be depicted in figure B3.2, the most often implemented measure in small buildings is 'Heating systems' (20%). In large buildings, however, it is 'Windows' (17%), though closely followed by 'Heating systems' (16%). In small buildings; 'Wall' (4%) and 'Household appliances' (3%) are seldomly identified as common measures. Whereas, 'Windows' (17%) and 'Heating systems' (16%) are quite common. Followed by 'Roof (pitched / flat) or attic ' (14%) and 'Wall (outer)' (12%).

***B3.2** – Measures implemented in (e) comprehensive retrofit project in small building, (f) comprehensive retrofit projects of large building in **Germany**. (preliminary results)*



In comprehensive projects, there is a **high** agreement among the interviewees that deep refurbishment/ comprehensive retrofit are centred around upgrading or exchanging the envelope of the building to current standard as well as modify the room composition to better suit the future usage. The heating system, while being upgraded and sometimes complemented with a renewable energy source almost always stays based on the previous energy carrier.

There is a **very high** agreement that, while decentral energy, especially PV, scaled massively on private homes in the past 10 years, electrical storage is still very much a niche, mainly for cost reasons.

There is a **very high** agreement that controlled ventilation systems are nearly always a component in deep refurbishments, especially in large buildings where they are a crucial asset to safeguard against mould. This is explained by the legal situation in which the owner of the property can almost never hold tenants responsible for such damages.

There is a **very high** agreement that policy is continuously leading to appliances, especially lighting, being exchanged with more energy efficient versions in all types of buildings.

MARKET EXPERT COMMENT

'The highest potential in deep refurbishment is in the windows. Not energetically but also in improving the architectural qualities. Railings can be taken out, windows be enlarged, and the daylight factor be brought up to current standards and lifestyle.
If this is not done, an energetic refurbishment can turn a decent home into a dark cave.
Communicating this risk and potential is a crucial task of the architect'.
– Prof. Ingo Gabriel
Owner, Gabriel Architekten

MARKET EXPERT COMMENT

'Large PV systems for commercial clients is a booming business in Germany. It is more complicated for larger projects though than it is for one family homes that just put some m² of PV on their roof.
Uncertainties with grid tariff development currently still limit the solutions that can be provided. Small ESCOs are filling this space left by the big market players that have a hard time adjusting to the changing energy paradigm.
PV will continue to be one of the main drivers of the energy transition in Germany'.
– Etienne Cadestine
Managing Director and Owner, Longevity Partners

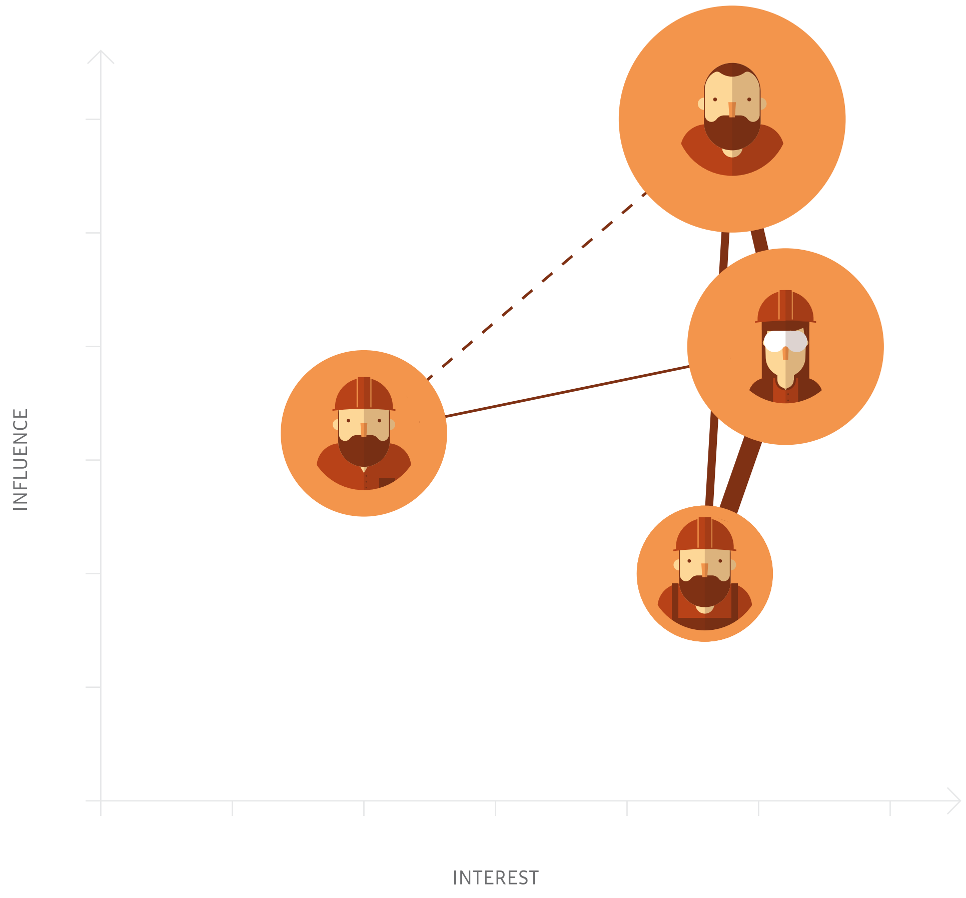
B4 Deep-dive into stakeholder's interaction
The technology selection

The stakeholder setup in the building sector is considered to be complex and fragmented. Furthermore, it varies across project types, phases or even decisions. This section assesses the level of power and interaction of the stakeholders involved in the technology selection for residential building projects in Germany.

Referred to their latest project, survey respondents were asked **'What was your level of interest in the energy-efficiency and low-carbon strategy in your project?'**. And **'How much did you communicate with the stakeholders about the energy-efficiency or low-carbon strategy in your project?'** Followed by **'What was the level of influence of the following stakeholders in the energy-efficiency and low-carbon strategy in your project?'** This was complimented by **'What was your level of interest in the technology selection in your project?'** And, **'How much did you communicate with the following stakeholders about the technology selection in your project?'**. Finally, **'What was the level of influence of the following stakeholders on the technology selection in your last project?'**. In doing so, respondents were provided with a scale 0-5. Results are illustrated in figure B4.1 below. Interviewees were asked the same question and given the opportunity to contextualize and comment.

When it comes to the decision related to the what technology will be implemented in the project, 'Home owners' are perceived to have the highest level of influence as well as interest, closely followed by the engineer. Main communication streams go through engineers, which provides them with a critical role in this decision.

B4.1 – *Stakeholder interaction regarding the technology selection in* ***Germany***. *(preliminary results)*



MARKET EXPERT COMMENTS

'Planning is complex because the number of regulation dramatically increased. On top of this we face differing regulations in different states - as if fire would burn different in one state than in its neighbour state...one should focus more on reaching performance targets than follow regulations on a technology level - not blindly focus on insulation thickness but strive for a great overall result'.
- Prof. Dr.-Ing Eckhart Hertzsch CEO, Joanes Foundation

'Especially the DGNB label that ambitious projects and development in Germany aim for requires an early involvement of specialized experts. When done right, this cannot only improve the quality of the projects but also reduce costs. Even more so when you consider later costs in the use phase or consider co-benefits'.

For new construction, there is a **high** agreement among the interviewees that the architect is the central figure in the process leading to the decision of technology selection and com-position in new building construction. The architect's role in Germany covers the design process, almost always covering at least the preselection of technologies and the communication with the specialized engineers.

There is a **very high** agreement among the interviewees that the architect is the central communication channel of the client to the engineers and craftsmen in small and medium sized projects. In larger projects of professional clients there is often a specialized architect working for the client, dealing with the design architect that is not part of the client's company.

There is a **high** agreement among the interviewees of the increasing trend of general con-tractors in Germany that try to address the increasing complexity of building processes by having all professions in house and standardizing communication and technical solutions.

There is a **very high** agreement among the interviewees that the role of specialized engineers has dramatically increased in the past years because of increasing complex technologies but especially much more complex legal framework and standards. There is a moderate agreement that this leads to the point that the architect often is not able any more to understand the applied technologies to the level of depth necessary to design sound systemic solutions/ building concepts especially in large projects.

In overhaul and retrofit, there is a **high** agreement among the interviewees that the role of the architect is significantly weaker in single component interventions than in systemic interventions. The Client is in many cases communication through and engineer or directly with the other stakeholders that in these cases also have significantly increased influence on the technology selection.

There is a **very high** agreement that the influence of online media, marketing, social networks and peer pressure is high in this type of projects with private clients.

In comprehensive retrofit projects, there is a **high** level of agreement among the interviewees that the legal framework in Germany makes deep refurbishment processes are very similar to new building projects.

There is a **high** level of agreement among the interviewees that the role of the architect is even stronger in deep refurbishment than in new building construction as every project has a high degree of individuality and generalized solutions a difficult to apply.

There is a **very high** level of agreement among the interviewees that there is a massive shortage of architects specializing in deep refurbishment.

MARKET EXPERT COMMENTS

'There is a significant potential in requiring trade and repair businesses to inform clients on energy efficiency synergies to measures they are offering.
These companies are the backbone of the German construction sector and the direct and trusted contact to private houseowners on issues where an architect is often perceived to be too lofty'.
– Oliver Scheifinger
Partner, tafkaoo architects

'On the one hand we ask for more refurbishment on a European level end especially so in Germany– on the other hand no architecture faculty in a Germany University has a chair for energetic refurbishment. We need these people to achieve our energy efficiency and carbon targets'.
– Mathias Wohlfahrt
Managing Director, ProKlima

B5 Motivations and barriers behind projects
The demand-side's perspective

MARKET EXPERT COMMENTS

'The key challenge we face in almost all major cities now is the generation of affordable residential space. We in parallel need to upgrade our stock to keep up to current standards of comfort but the current lack of rental space makes this a strategic decision rather than one resulting from direct need. In most major cities you can rent out nearly anything. The current approaches of the government are only of limited help in this situation. Rather than more subsidies we need leaner improvement procedures and innovations that allow us to build cheaper and faster'.

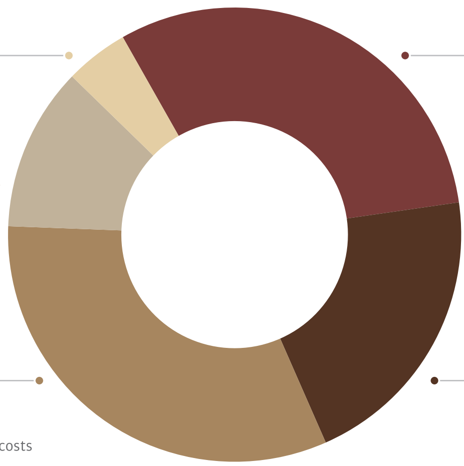
'There is an increasing risk of a bubble economy in the German building sector. Especially in Frankfurt and Munich. When the interest rates will be increased on day in the future we will see especially private owners that will not be able to cover their loans'.

Motivations behind projects differ significantly depending on the project type, the building typology and the demand-side's perspective. The following section describes Germany's stakeholders' motivations behind projects as well as hindering factors in pursuing 'higher' performing buildings, meaning, even more performance energy-efficient or low-carbon technologies or solutions.

Survey respondents were asked ***'What were the main motivations for your project?'*** They were then provided with a pre-selected list of arguments structured into ***environmental, technical, economic, social and legal*** clusters as well as the option to select ***'Other'***, and ***'I don't know'***. This question allowed participants to choose more than one answer option. Thus, the percentage of answers is calculated on the basis of the total number of options selected. The final responses have been classified according to stakeholder group, namely private owners (NPOs) and professional organizations (POs). Main motivations have been listed in figure B5.1, indicating in each case the % of responses that were selected for that answer. Interviewees were asked the same question and given the opportunity to contextualize and comment.

Main motivations for private (NPO) and professional organizations (PO) are economic and environmental. In the case of professional owners, this is followed by technical-related matters. For both stakeholder groups legal matters are of least importance.

***B5.1** – Main motivations behind projects in **Germany**. Characterized by ownership types. (preliminary results)*



There is a **high level** of agreement among the interviewees that environmental reasons are almost never the driving factor of projects. Only lighthouse projects or those in which policy makers place special requirements are dominated by related motivations. There is a similarly high agreement that there is a trend towards environmental reasoning but that the actual influence of such points is actually decreasing.

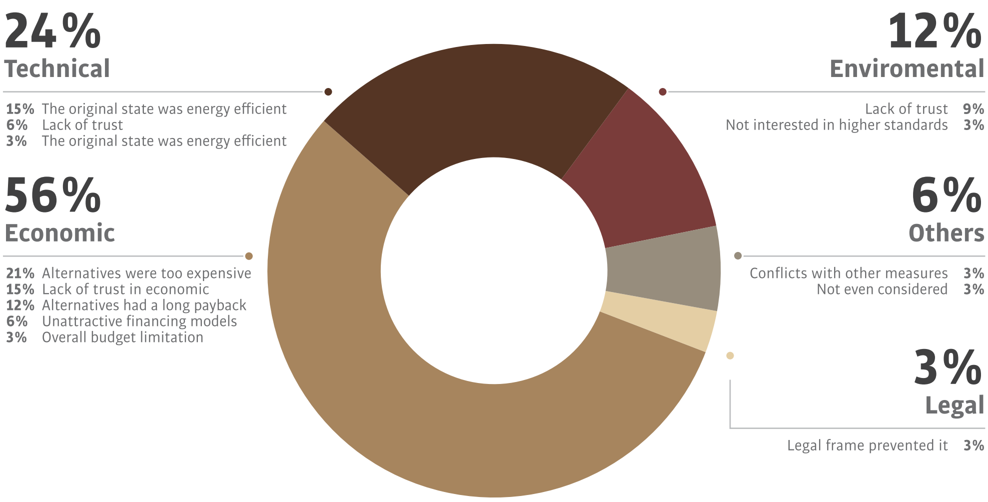
There is a **very high** level of agreement among the interviewees that the current economic situation with low interest rates is the key enabling and triggering condition for new construction and building activities. Especially private actors

There is a **very high** level of agreement among the interviewees that damages are the main motivation for refurbishment activities that are then added to the anyway repair measures. There is a similar agreement that change of ownership of privately-owned buildings is another key trigger of refurbishment, upgrading a property to current standards. There is a high level of agreement among interviewees that aesthetic and personal comfort are prioritized over increase energy efficiency in planning processes. There is a **very high** level of agreement that legal standards are a dominating influence on the extent of energy efficiency standards realized. There is a medium agreement among the interviewees that peer pressure is often behind the decisions of private building owners.

To identify what were the main barriers to not pursue higher performing technologies, Survey respondents were asked ***'What were the hindering factors for not implementing (even) more energy-efficient or low-carbon technologies in your project?'*** They were then provided with a pre-selected list of arguments structured into environmental, technical, economic, social and legal clusters as well as the option to select ***'Other'***, and ***'I don't know'*** The final responses have been classified according to stakeholder group, namely private owners or NPOs and Professional owners. Main barriers for not pursuing (even) more energy-efficient and/or low carbon technologies have been listed in figure B5.2. In each case it is indicated the % of responses that were selected for that answer. Interviewees were asked the same question and given the opportunity to contextualize and comment

Figure B5.2 indicates economic aspects is perceived to be by far the main barriers for not implementing 'higher' performing solutions for private as well as for professional owners. Technical aspects, again for both sides, are perceived as main barriers. The least hurdle is, in both cases again, in social-related matters.

***B5.2** – Main barrier for not implementing (even) more energy-efficient or low-carbon technologies in residential building projects in **Germany**. Characterized by ownership types.*
(preliminary results)



There is also a **high** agreement among the interviewees that the technical complexity of buildings makes it difficult to easily grasp the direct and indirect consequences of decisions. There is a similarly high agreement that conflicting advice is preventing especially private building owners from doing something out of the norm or ordinary.

MARKET EXPERT COMMENTS

'It currently is attractive for investors to refurbish energetically as they usually recover their (energetically relevant) investments after 9-10 years. After this the owner profits!! Therefore the rent should be reduced again to its former level after the costs are recovered...
in addition often very ambiguous refurbishment measures are implemented that do not really benefit the tenant. Sometimes the energy consumption does not even really change; but the tenant is asked to pay a higher rent (which then is also established for the future).
– Prof. Dr.-Ing Eckhart Hertzsch
CEO, Joanes Foundation

'While economic reasons play a key role in the main market, the upper market segment is not facing these constraints to that extent. In that segment the existing German infrastructure as well as the legal frame conditions and competences are limiting factors. I can only offer solutions that are enabled for example by the electrical grid or available internet infrastructure. In many case we do not only install charging stations for e-mobility but also have to upgrade public infrastructure to make this possible in the first place'.
– Christian Brand
Head of Housing Servcies, Imvest

B6

Promising approaches to reach carbon ambitions
General potential in new and existing buildings

MARKET EXPERT COMMENTS

'The current allocation of costs between energy infrastructure and the building is not
The buildings of the future need to be energy prosumers and the energy infrastructure need to enable this. This will result in higher investment in the energy infrastructure but because of the significantly lower carbon intensity of the resulting energy supply we will recover a lot more flexibility and freedom in designing user centred buildings. This will save overall costs as well as achieve our carbon targets. These kinds of innovations are what is needed'.
- Philipp Bouteiler
CEO, Berlin Tegel Projekt GmbH

'Ventilation is one of the key aspects we try to simplify as much as possible. Our clients often struggle with the maintenance schemes and ventilation related noise issues are often a problem. Solutions combining the best of all worlds are available, but they are expensive and complicated, leading to mistakes on site.
Yes, we need to build energy efficient, but we have to strive for simpler systems'.
- Sven Martens
Partner, GruppeOMP Architekten

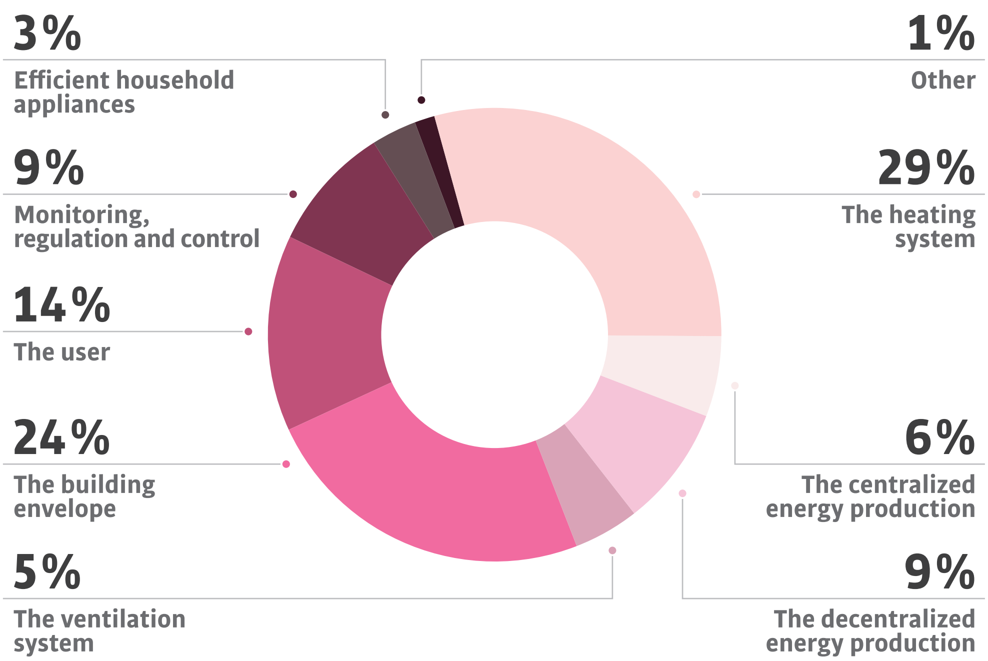
'Besides all the talk about energy efficiency we are missing a key point: how do we use the space we already have rather than building additional one, despite it being energy efficient. Germany has 13 mio. un-used former nurseries. Elderly living alone in large single-family homes and suffer from loneliness. The saving potential in re-thinking this issue dwarfs everything else'.
- Prof. Ingo Gabriel
Owner, Gabriel Architekten

Buildings are complex systems formed by an extensive range of elements and components. The carbon performance of a building is highly dependent on the nature and conception of these components. This section identifies what building concepts do market actors see as most favourable to reduce carbon emissions and achieve climate-protection goals in Germany. Results are presented for new built and refurbishment projects.

Survey respondents were asked ***'What technology or approach has the highest potential to contribute to reach ambitious climate-protection goals in Germany.'*** They were then provided with a preselection of 8 aspects as well as ***'Other', 'I don't know' and 'none' for both new buildings and refurbishment***. This question allowed participants to choose more than one answer option. Thus, percentage of answers was calculated on the basis of the total number of options selected. Interviewees were asked the same question and given the opportunity to contextualize and comment.

Heating systems (29%) and building envelope (24%) are perceived to have the highest potential in new buildings in Germany. This is followed by the user (14%), monitoring regulation and controls (9%) and decentralized energy production (9%).

B6.1 *– Technologies perceived to have the highest potential to contribute to reach to climate-protection goals in* ***Germany*** *for new buildings. (preliminary results)*

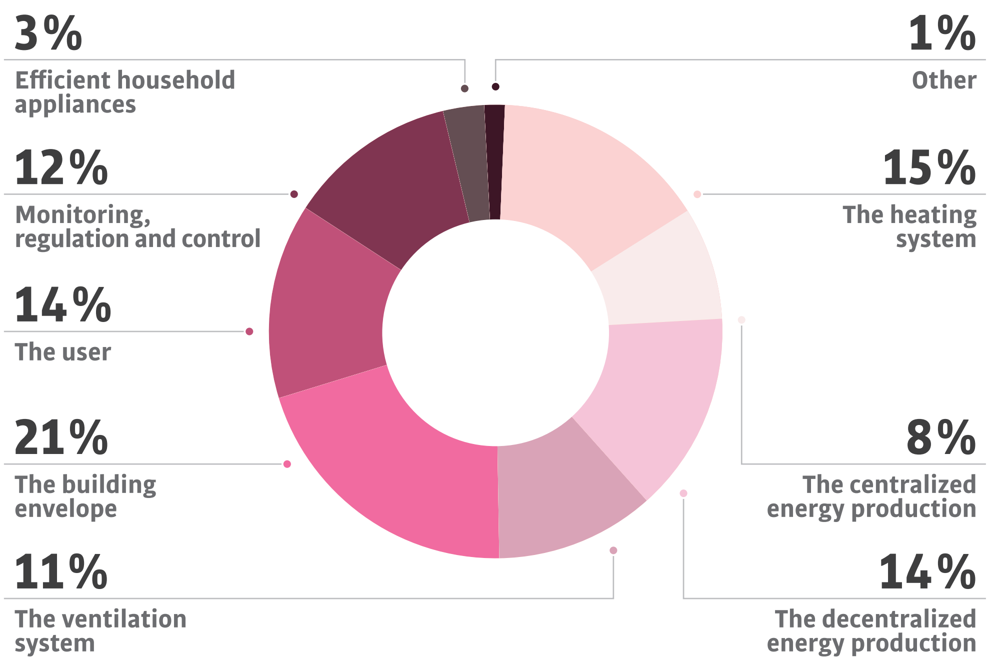


There is a **high** level of agreement among the interviewees that for new buildings the heating system and decentral energy generation play the key role in achieving a good carbon performance of small new buildings (a). For large new buildings (b) there is an equally high level of agreement that the heating system is the most crucial element.

There is a **very high** level of agreement among the interviewees that ventilation and the envelope are less of a variable in designing strategies and balancing measures for any new building (a) (b) as the current energy efficiency legislation makes controlled ventilation systems more or less mandatory especially in larger buildings and the legal framework already ensures a very high insulation standard.

When it comes to refurbishment projects, the building envelope (21%) is the considered to be the measure with the highest potential. Followed by the heating system (15%), the user (14%) and decentralized energy production (14%).

B6.2 – *Technologies perceived to have the highest potential to contribute to reach to clima-te-protection goals in* ***Germany*** *in refurbishment projects. (preliminary results)*



There is also a **very high** level of agreement among the interviewees that the envelope and decentral energy generation are the key elements in reducing the carbon emissions by refurbishment. Most interviewees argue that while addressing the envelope is often difficult, the co-benefit of addressing damages and value maintenance by improving the fabric of the building and the often-substantial effects by also increasing air tightness and comfort are making this a priority.

There is a **medium** level of agreement among the interviewees that user related behaviour, monitoring and smart home approaches are generally of high relevance for all buildings but a high level of agreement that the potential to activate the related behaviour change is low.

There is a **low** level of agreement on the potential of the existing national decarbonisation strategies, mainly via wind power with the problematic distribution especially from north to south being the most often raised and the necessary buffering capacity to make this valid being a close second.

MARKET EXPERT COMMENT

'Solution providers in the building sector, especially in refurbishment, in Germany should really stop competing with each other on the relevance of their respective product. They should rather focus together and offer optimized systemic solutions. Their arguing simply unsettles the market and such a market tends towards inaction.'.
– Hans Jürgen Cramer
Owner 3C-PreCon, former CEO Vattenfall Germany

B7

Drivers & barriers to reach carbon ambitions
Towards promising approaches

MARKET EXPERT COMMENT

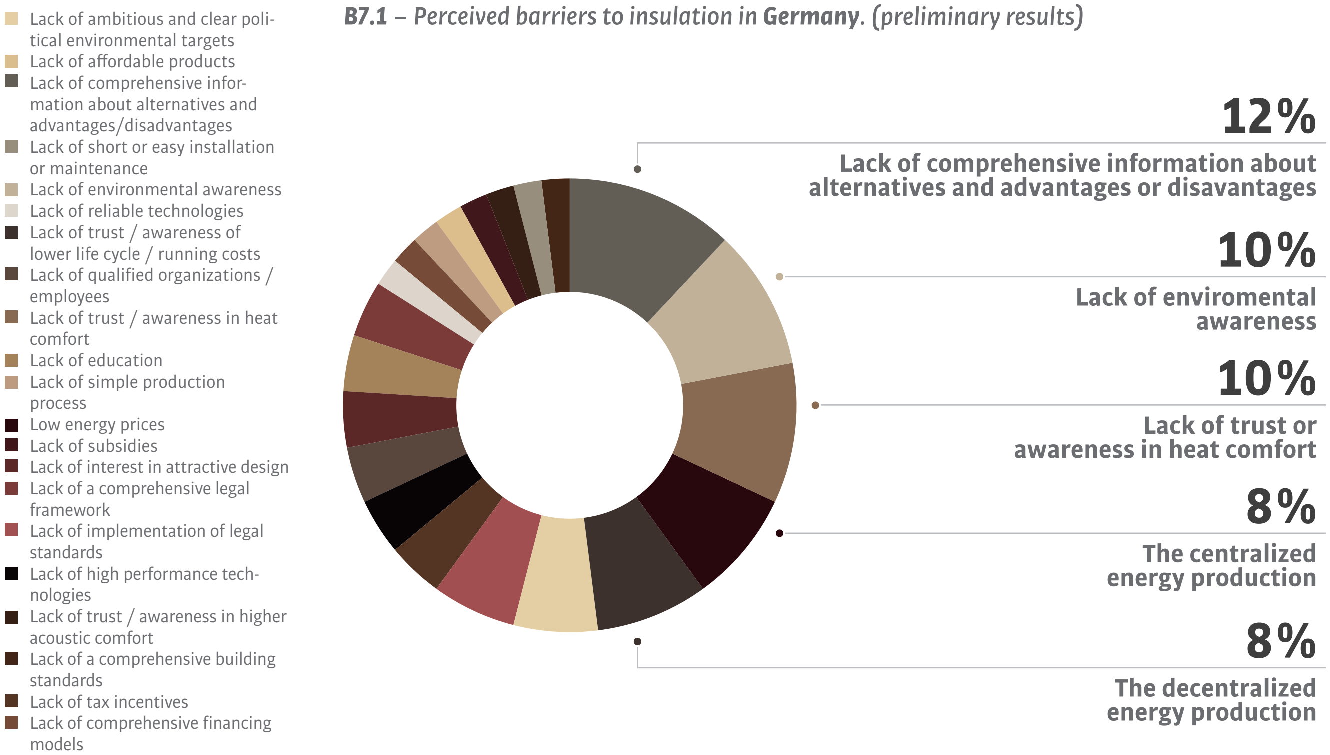
'Low carbon materials are still a niche in Germany, despite labels like DGNB including Life Cycle Assessment that includes the materials. A main reason for this is that the carbon performance of materials is invisible. Its not even that lower carbon alternatives are more expensive. They are just not requested'.
– Dr.-Ing Sven Mönnig
Head of New Buiness, Construction Materials, BASF

Many barriers hinder the uptake of energy efficient and low carbon solutions. These barriers are context specific and therefore vary considerably depending on the country, building type, stakeholder group or even on the specific technology. The following section describes stakeholders' perceived drivers and barriers to the technology that had been identified in previous section B6 as hosting the highest potential (in refurbishment projects). This is the building envelope in the case of Germany.

Survey respondents were asked to state for which specific technologies they are experts in. For one of those they were questioned on ***'What is the biggest barrier for the upscaling of this technology in Germany.'*** Figure B7.1 visualizes the results for insulation as a key component of the building envelope. Interviewees were asked the same question and given the opportunity to contextualize and comment.

For insulation in Germany, 'lack of comprehensive information about alternatives and advantages/disadvantages' (12%) is conceived to be one of the main barriers in the upscaling this technology. 'Lack of tax incentives' is one of the lowest rated barriers.

***B7.1** – Perceived barriers to insulation in **Germany**. (preliminary results)*



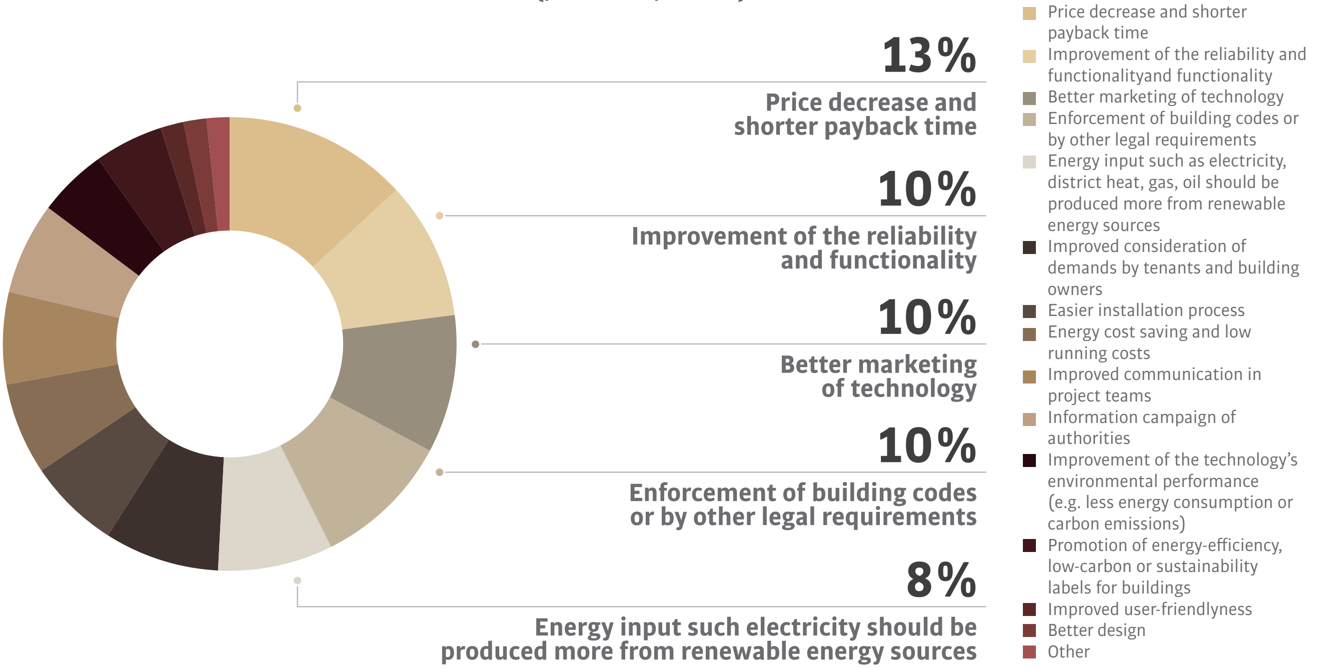
There is a **high** agreement among interviewees that the greatest barrier for envelope related technologies is the general lack of priority that energy efficiency has among private building owners. While professional building owners act on a cost-benefit basis, private building owners almost always prioritize other upgrades over the energetically relevant ones.

Drivers to low carbon solutions, the same as barriers, differ significantly depending on the building type, stakeholder group and even on the technology. Identifying stakeholders' market specific drivers and motivations is crucial in order to trace effective marketing campaigns and policy instruments to foster their uptake of low carbon energy solutions. The following section describes stakeholders' perceived drivers to insulation.

Survey respondents were asked what were ***'the most promising approach to support the market uptake of low carbon technologies.'*** Figure B7.2 visualizes the results for insulation as a key component of the building envelope. Interviewees were asked the same question and given the opportunity to contextualize and comment.

'Price decrease and shorter payback time' (13%) is the most common driver behind implementing insulation in residential building projects in Germany. On the other hand, 'Improved user-friendliness' (0%) is perceived as one of the less attractive drivers or incentives.

B7.2 – *Perceived drivers to insulation in* **Germany**. *(preliminary results)*



There is a **high** agreement among interviewees that the greatest potential for supporting the uptake of envelope-related is policy. This vision, however, is contradicting the survey results, as none of the technologies mentioned above conceives 'policy instruments' as an important driver in their implementation. This might be also interpreted as that policy is key for the envelope as a whole but not for the individual elements (insulation, high-performance windows and low-carbon materials).

MARKET EXPERT COMMENT

'Many decision makers would consider complementary energy efficiency options or low carbon alternatives if they were presented to them. In the current German Economy nobody needs to position himself with a future oriented solution. We need to work with the construction industry to use the current economy more as a chance also for implementing energy efficiency'.

C

Market volumes and economics

Aim

The chapter 'Market Volumes and Policy Scenarios' provides data on the current state of the building stock's GHG emissions as well as annual market volumes in the short, medium and long terms for two scenarios.

The first section of this chapter presents structural and GHG related data on the building stock (section C.1). The data on the building stock is collected from statistical sources, standards and norms. Market experts via interviews and dedicated imputation techniques complement this information. Based on the collected data, a synthetic building inventory of 10,000 representative buildings is generated. This inventory adopts a parametric variation approach with the building stock model (BSM).

In addition to the description of the current building stock, this chapter describes the market volumes for a Reference Scenario (RS) and a 2 Degrees Scenario (2DS). The Reference Scenario reflects current and decided energy and climate policy instruments and some moderate reinforcements that could be expected with good faith (similar to the EU reference scenario). Both European and national policies are considered. The 2 Degrees Scenario is designed to achieve ambitious climate change mitigation goals. The <2°C goal of the Paris Agreement of 2015 serves as a guideline. National peculiarities and implementation approaches that typically could be expected are reflected in the scenario definition (section C.2).

In both scenarios, the effects of an increase in energy efficiency and the share of renewable energy resources are considered. The resulting market volumes are listed for different technology groups. The aim is to provide realistic market volumes for different market segments.

All data sources are clearly marked to allow the reader to access more detailed information as needed. The complete list of sources can be found in the annex of the report. Key sources are listed as links in the side bar.

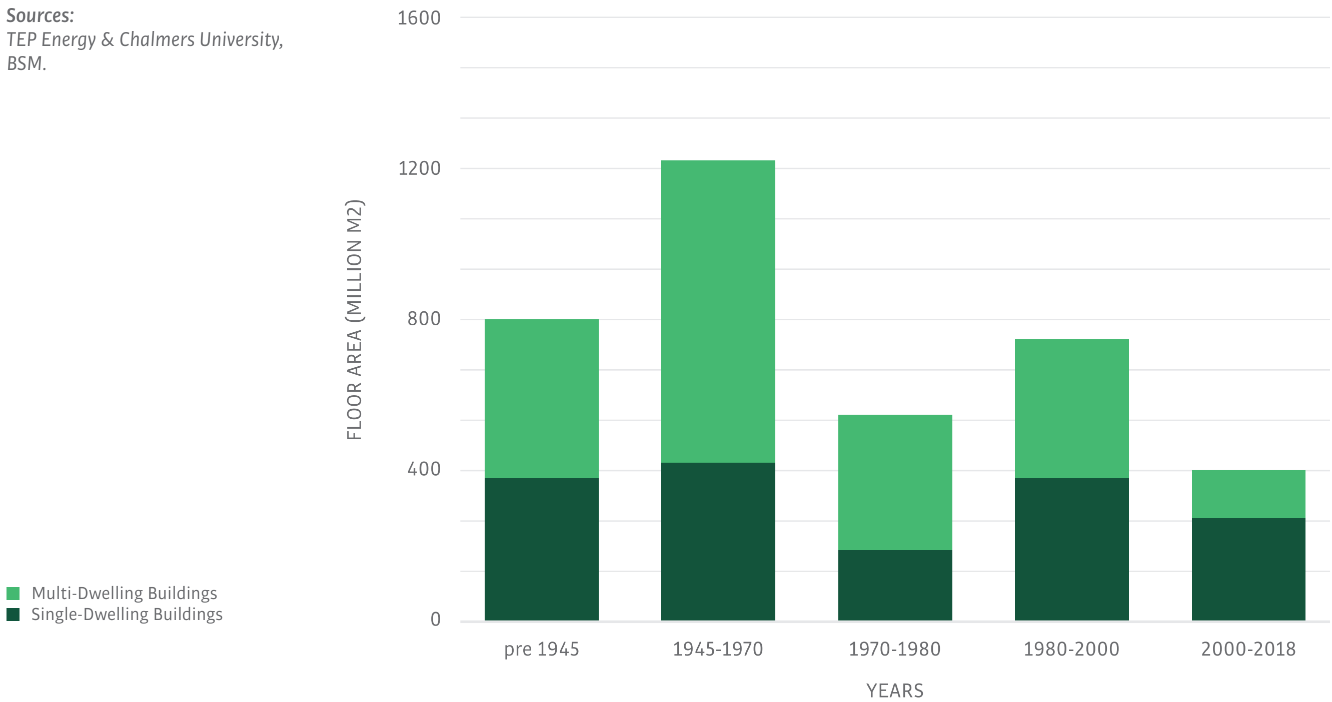
C1 Status quo of the building stock
Structure and greenhouse gas emission intensity

Germany's residential building stock currently encompasses around 17.1 million buildings and 43.5 million dwellings totalling in about 3742 million m² of heated floor area. The residential building stock is dominated by single-and duplex-dwelling buildings (SDB) with a share of 75% of the total number of residential buildings. However, with about 56% of the total floor area, multi-dwelling buildings (MDB) make up a larger share of the stock in terms of heated floor area.

The age distribution illustrates a large share of old buildings with almost 70% of the heated floor area (HFA) having been built before 1980 (see Figure C.1.1) followed by the introduction of specific building codes in the year 1979. The majority of HFA stems from the post-war period up to the 1970s (33% in total for SDB and MDB). In just one decade, 15% of the HFA of MDB was added during the construction boom between 1970-1980. In the last period (2000-2018), the construction activity has more than halved compared to the years from 1980-2000, resulting in an add-on of only 10% of the stock, representing a low share of buildings with higher efficiency standards.

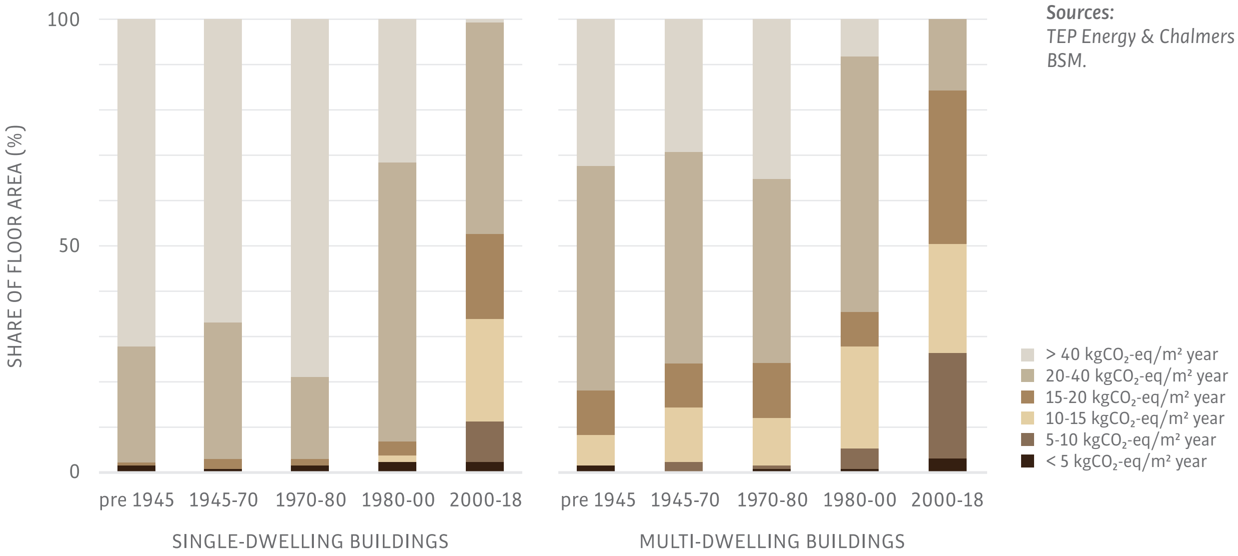
C1.1 – *Age Distribution of the German Building Stock, differentiating between SDB (including duplex houses) and MDB.*

Sources:
TEP Energy & Chalmers University, BSM.



The carbon-efficiency of the stock expressed in CO_2-emissions per m² and year of HFAs varies greatly across construction periods (see Fig. C.1.2). The effect of the first building code and its amendments and the renewable heat act can be seen in SDB, reducing greenhouse gas emissions after 1980. In recent years, especially after 2000, the shares of ultra-low-carbon buildings increased (<15 $kgCO_2$-eq/m²/year). Multi-dwelling buildings tend to have slightly lower CO_2 emissions per floor area as compared to SDB due to their more compact building format. In fact, MDB account for a greater percentage of the buildings in all building periods with less than 40 kg CO_2-eq/m²/year. From 2000 onwards, MDB have also represented a significant percentage of buildings with less than 10 $kgCO_2$-eq/m²/year due to the construction of new buildings with highefficiency standards. Nevertheless, the percentage of fossil-free heating systems (<5 $kgCO_2$-eq/m²/year) is still almost negligible.

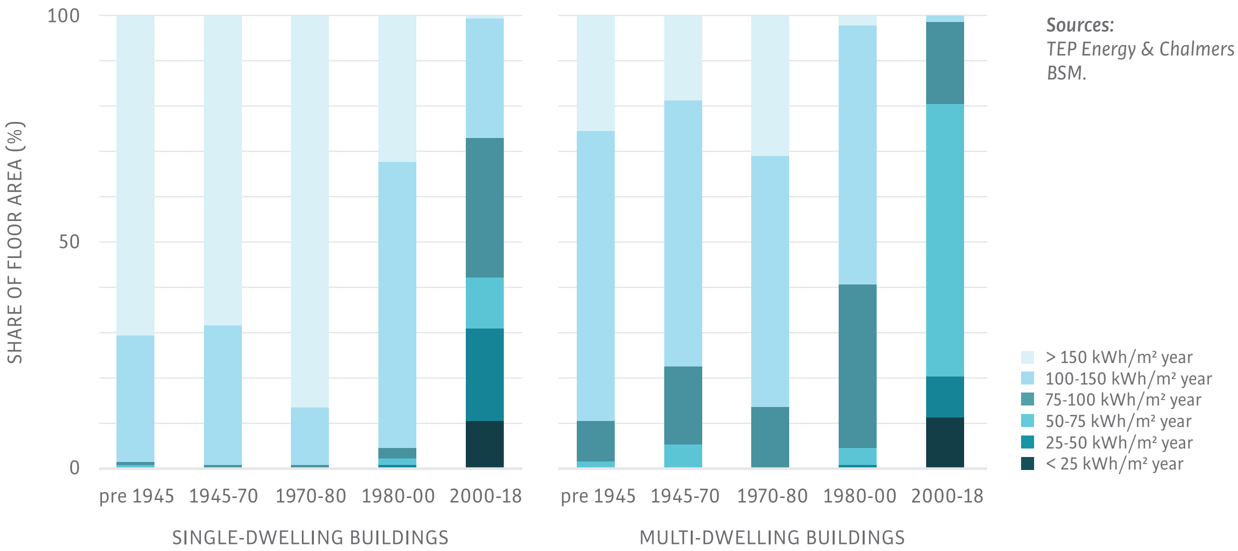
C1.2 – *Greenhouse gas intensity of the current building stock by construction period for SDB (left) and MDB.*



Sources:
TEP Energy & Chalmers University, BSM.

In addition to the reduction of carbon emissions due to the shift towards renewable heating systems, the reduction of specific energy demand per floor area (expressed in kWh/m²/year) contributes to the decarbonisation of the building stock. This reduction in energy demand per heated floor area is also in keeping with the introduction of building codes in 1979 (see Figure C.1.3). From then on, the average heating demand of >150 kWh/m²/year in SDB and > 100 kWh/m²/year in MDB was reduced to below 100 kWh/m²/year in the case of SDB and below 75 kWh/m²/year in the case of MDB in the last period until 2018.

C1.3 – *Specific energy demand per floor area of the current building stock by construction period for SDB (left) and MDB (right).*



Sources:
TEP Energy & Chalmers University, BSM.

C2 Policy scenarios
To shape carbon emissions

Notes:
The Reference Scenario is defined to represent an upper bound of the future carbon emissions. It consists of current and decided energy and climate policy goals and instruments and some moderate re-enforcements.

The 2 Degrees Scenario is designed to achieve ambitious climate change mitigation goals. The <2°C goal of the Paris Agreement of 2015 serves as a guideline. National peculiarities and implementation approaches that typically could be expected for Germany are part of this scenario.

At present, Germany already has implemented various policy instruments to foster energy-efficiency and the use of renewable energy sources (RES) and to curb CO_2-emissions, see section A.4. The development of the market volumes very much depends on economic and policy framework conditions. To reflect uncertainties in these framework conditions (arising for instance from decisions about policy instruments still to be implemented), two scenarios have been defined. Market volumes are then calculated for these two scenarios to constrain uncertainties.

- Current and decided energy and climate policy goals and instruments are part of the Reference Scenario (RS). On the European scale, these are the Renewable Energy Directive,[1] the Energy Efficiency Directive,[2] the Directive on Energy Performance of Buildings,[3] and the Ecodesign Directive.4 On the national scale, these are the acts on energy efficiency (EnEG),[5] renewable heat (EEWärmeG)[6] and energy relevant products (EnVKG),[7] including the subordinate ordinances on energy savings (EnEV)[8] and financial support instruments such as market stimulation programmes for renewable heat (MAP)[9] and energy efficiency (APEE)[10], reduced heat pump electricity prices, amongst others. However, far-fetched climate change mitigation goals are not part of the Reference Scenario.

- The 2 Degrees Scenario (2DS) is designed to achieve ambitious climate change mitigation goals. These goals are to be achieved by the Climate Action Programme 2020 (CAP2020)[11] and its commitment to reduce CO_2 emissions by 40% in 2020. The CAP2020 was complemented by the Climate Action Plan 2050[12] reducing emissions to approx. 55% in 2030 compared to 1990 and the need to reinforce action on climate mitigation and adaptation. To reach the <2°C goal of the Paris Agreement of 2015, some further reaching measures are needed to cut direct CO_2-emissions (almost) completely from the buildings sector. As the EnEV requires all new buildings to be nZEB from 2021 onwards, additional measures, such as refurbishment requirements for existing buildings and heating systems in order to limit the CO_2-emissions per m^2 or even a ban of fossil heating systems in some cases, need to be considered.

To ease comparison across the two scenarios, other drivers that might have some uncertainties such as population growth or energy price developments are the same in both scenarios (see section C.3). The impact of such drivers is highlighted by sensitivity analyses, which are available from the CUES foundation.

To achieve aforementioned ambitious climate change mitigation goals, concrete, tangible policy instruments need to be implemented. Respective assumptions are laid out to substantiate input for the building stock model (BSM) calculation and to underpin results regarding the short-, mid-, and long-term development of different market segments (see also Figure C.2.1).

- Building codes that are already ambitious in the Reference Scenario (RS) are tightened even more in the 2 Degrees Scenario (2DS). An increased rate of nearly Zero Energy Buildings (nZEB) and a ban of fossil energy in the case of new buildings are part of this scenario.

- As renewable heating systems need to play a major role due to the phase-out of fossil supply in the housing sector, further mandatory energy-efficiency standards (MEPS) are appropriate for the 2DS in order to assure efficiency of appliances such as heat pumps, heat exchangers, flat plate collectors, etc.

- In the 2DS, an extra effort is to be undertaken to reinforce compliance with codes and standards and to secure the efficient operation of building technologies, particularly heating and hot water systems.

- In order to foster the diffusion of low-carbon and efficient technologies and retrofitting measures, the existing energy levy is increased and existing subsidies and grants prolonged and extended in the 2DS.

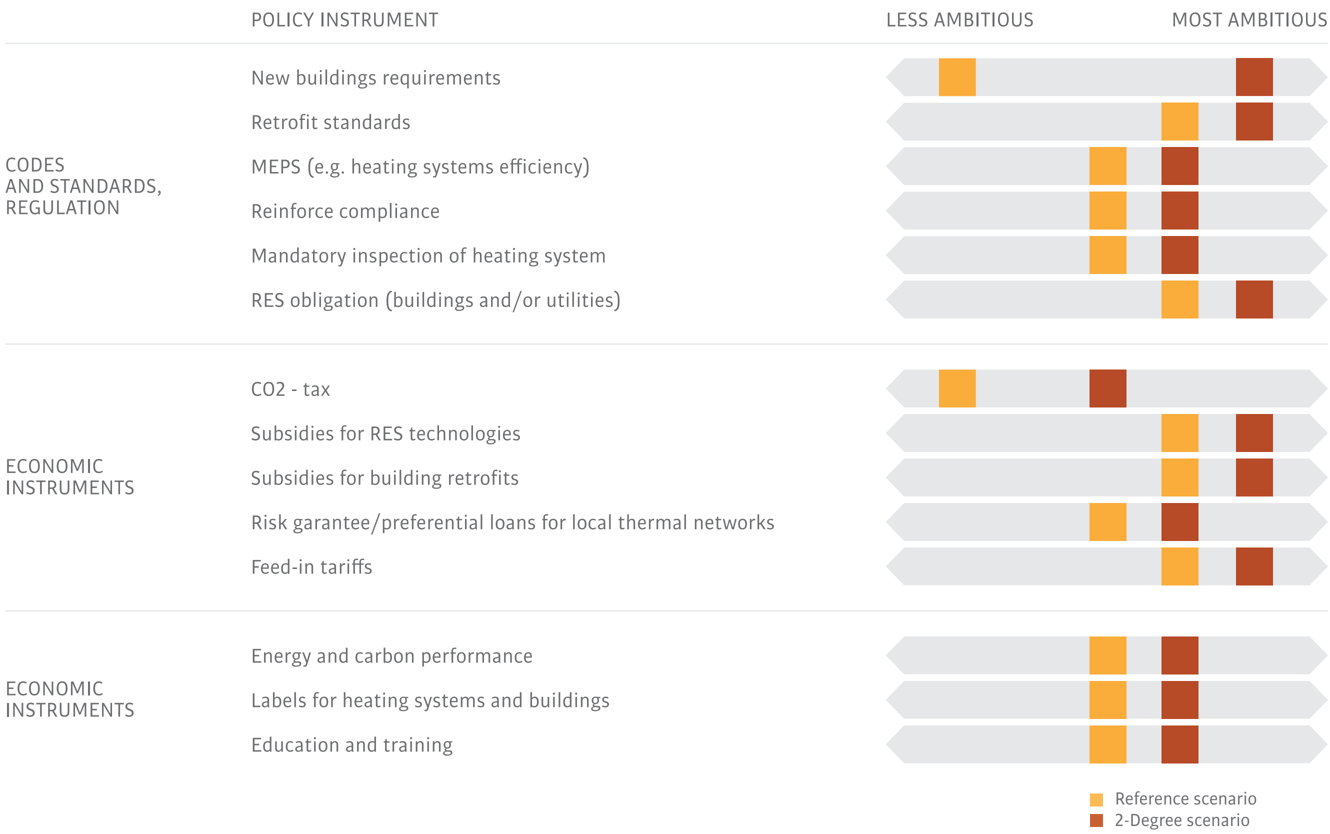
- Based on urban energy planning, the gas grid is partly replaced by up-to-date district heating (and cooling) networks in order to supply high-energy-demand-density areas and districts with energy from RES and residual heat, particularly in the 2DS. The share of biogas is also increased, based on evaluations of available biomass potentials.

- These policy instruments are complemented and underpinned with coherent information measures (e.g. energy and performance labels and certificates) and an education programme that includes builders, installers and planners.

*The **building stock model** (BMS) simulates the dynamics of the building stock and the energy- and climate-related decisions of building owners and tenants. Decisions, e.g. regarding choice of heating system or whether to retrofit depend on:*

- *Technology prices and their energy performance,*
- *Energy prices (including taxes),*
- *Subsidies, tax exemptions and other financial incentives,*
- *Codes and standards, and*
- *Availability (e.g. of RESs and of energy infrastructure)*

C2.1 – *Scenario definition.*

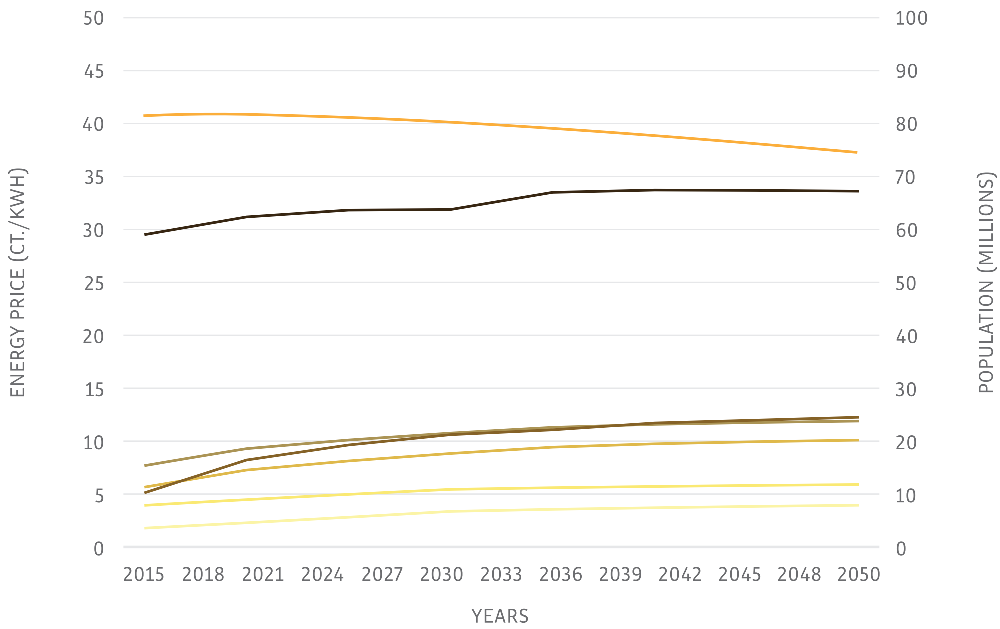


C3 Development scenario
Drivers and general implications

Drivers such as population growth and energy price developments were kept the same in both scenarios in order to increase comparability. These drivers target different aspects of the building stock development and its energy intensity. Population development and the specific floor area per person principally drive the net new construction activity in the market, while energy price development is a key driver for the diffusion of low-carbon technologies and retrofitting activities. As a result of the framework conditions outlined above and the assumptions concerning population growth and the price development of energy carriers (see Figure C.3.1), the general implications are as follows:

C3.1 – *Development of population (right axis) and of energy carrier prices (left axis) for the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
EU Reference Scenario, EUROSTAT, ENERGIFORSK, TEP and Chalmers.



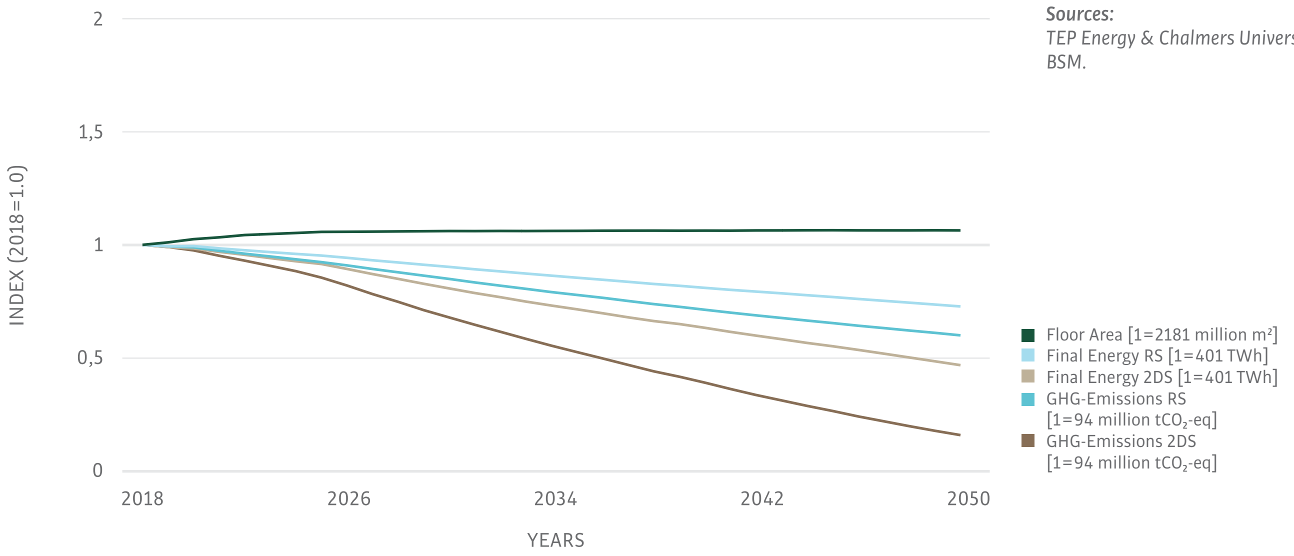
— Based on population projection data (average scenario) from the German statistical office, an 8% population decrease has been estimated in the RS and the 2DS. The aging population mainly drives this decrease, which is only partially compensated for by additional immigration. However, the floor area is expected to increase by 6% until 2050, whereas final energy demand for heating, hot water and ventilation decreases by 22.7% in the RS and by 37.1% in the 2DS (see Figure C.3.2). This is due to building code requirements for new buildings, the impact of the renewable heat act, and retrofitting activities that take place in both scenarios. Yet, in the 2DS, final energy demand (which includes renewable energy sources (RES)) is decreased more than in the RS. This is due to the effect of increased retrofitting activities and more stringent standards in the 2DS.

— Currently, oil and gas are the dominant energy carriers in the German housing sector (see Figure C.3.3). In the RS, fossil demand is decreased by 38.6%, whereas in the 2DS fossil fuels for heating purposes are almost completely phased out. New business strategies are therefore highly relevant for energy supply companies driving structural changes in the market.

— Decreasing sales of fossil fuels are partially compensated for by increasing sales of biomass and district heating systems, as well as increasing shares of electricity for heat pumps.

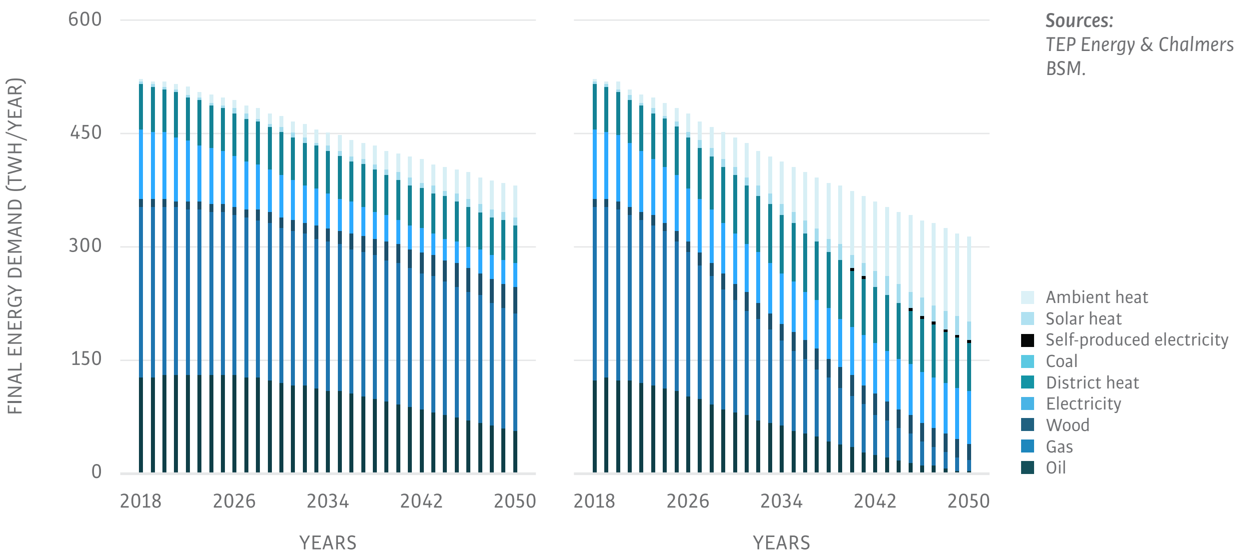
— To incentivize heat pumps, a specific electricity price is considered throughout the whole scenario horizon in the RS and 2DS. The price reduction makes up approx. 25-30% of the regular electricity price.

***C3.2** – Development of floor area, energy and greenhouse gas emissions according to the modelled Reference Scenario (RS) and the 2 Degrees Scenario (2DS).*



*Sources:
TEP Energy & Chalmers University, BSM.*

***C3.3** – Development of final energy demand and the respective energy carriers in the Reference Scenario (left) and the 2-Degrees Scenario (right).*



*Sources:
TEP Energy & Chalmers University, BSM.*

C4 Structural change of the building stock
Short-, mid-, and long-term development

Notes:
Partially refurbished means: a building has 1-2 building components that were energy efficiently refurbished since 2015.

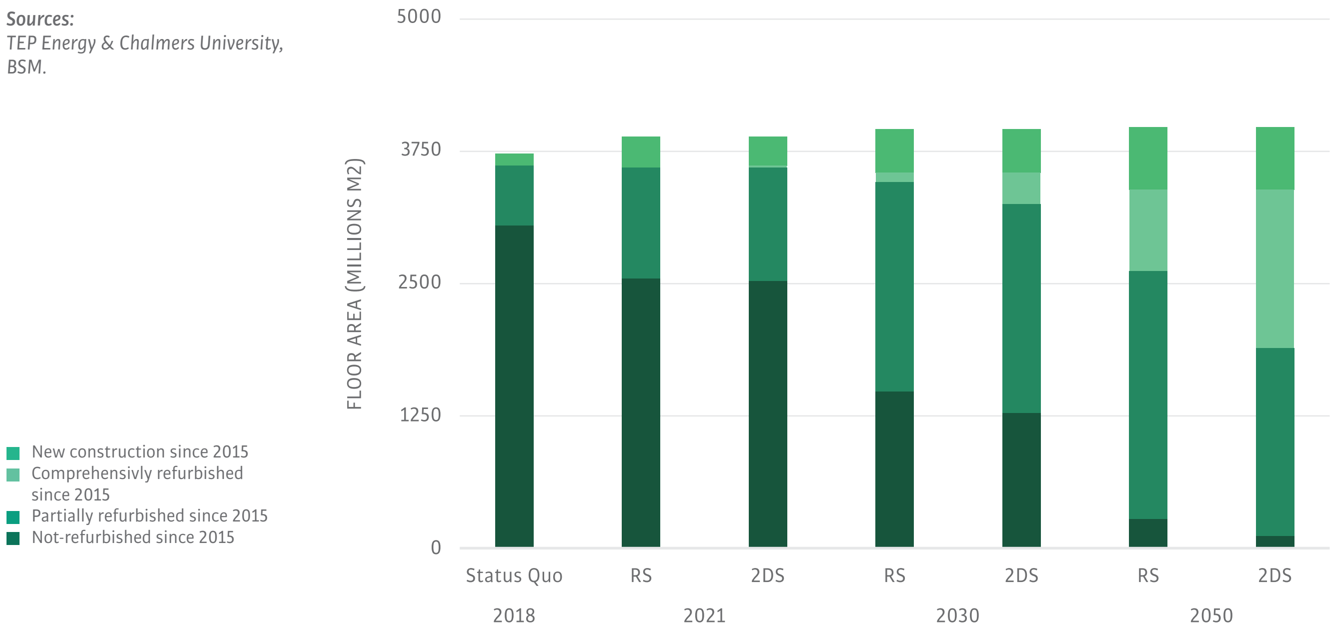
Comprehensively refurbished means: a building has 3 or more building components that were energy efficiently refurbished since 2015.

The residential building stock in Germany is still projected to grow by more than 238 million m² of floor area to almost 4 billion m² in 2050. This means that the floor area should increase by 6% by 2050. The currently existing stock, however, is projected to decrease over this time period by almost 10% to 3.4 billion m² in 2050 as a result of demolition. Newly constructed buildings will make up 15% of the stock in 2050. The increase in floor area is mainly driven by an increasing demand for floor area per person. The latter is mainly explained by the decrease of the average number of persons per dwelling due to a continuous trend towards smaller household sizes

In both scenarios, the refurbishment activities in the existing stock are on-going processes until 2050 by which time most buildings are at least partially refurbished (see Fig. C.4.1). In the short term, the refurbishment rate is projected to remain almost the same under both scenarios, resulting in similar percentages of partially refurbished buildings. In the medium term, the refurbishment activity should increase more in the 2DS than in the RS. This will occur as a consequence of more stringent building codes, subsidies, tax incentives, and increases in CO_2 taxes. The increased refurbishment activity in the 2DS will, among other things, be reflected in the larger percentage of comprehensively refurbished buildings (7.0% of the stock) compared to the RS (2.3% of the stock). By 2050, about 38.0% of the floor area is comprehensively refurbished in the 2DS, which is almost double what is refurbished in the RS. This increased activity towards comprehensive refurbishment in the 2DS is a consequence of the specific scenario assumptions (e.g. incentives, taxes, etc., see section C3 for details).

C4.1 – *Refurbishment and new construction activities in the building stock according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



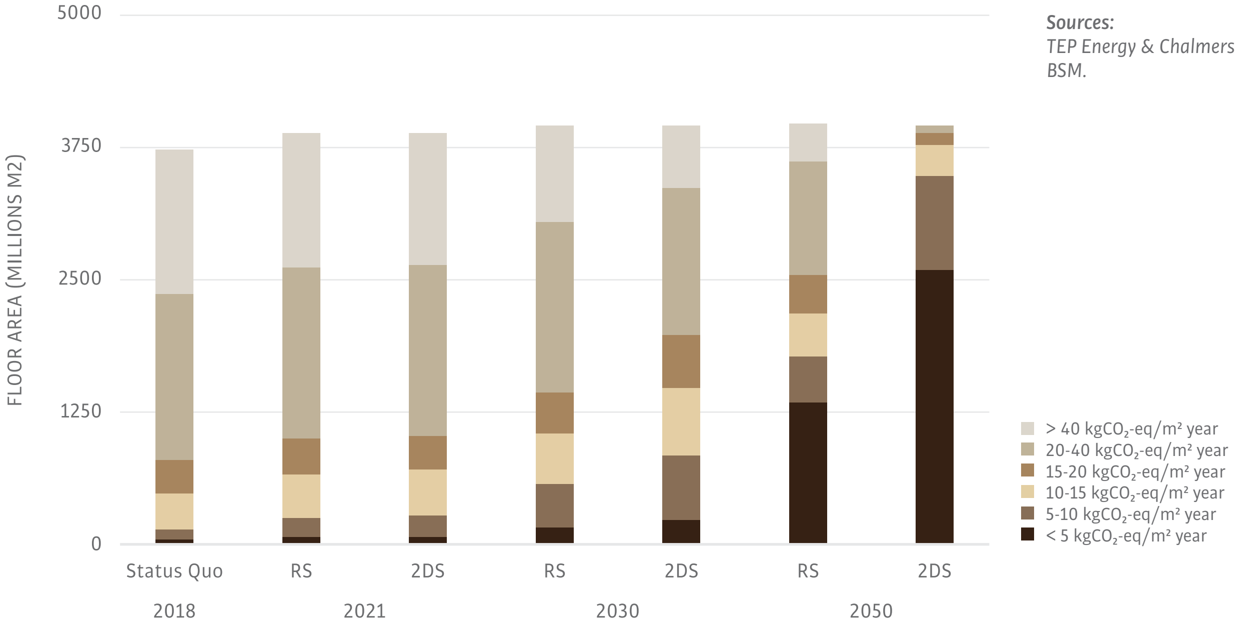
Currently, most of the residential buildings in Germany emit more than 20 kg CO_2-eq/m²/year with 21% of the floor area covered by buildings emitting less than that (see Fig. C.4.2). In the short term (until 2021), there are only minimal changes in both scenarios in terms of the GHG intensity of the building stock. Nevertheless, the percentage of buildings emitting less than 20 kg CO_2-eq/m²/year grows in both scenarios. This increase stems mainly from new buildings added to the stock after 2018, 87% of which have carbon intensities of less than 20 kg CO_2-eq/m²/year.

Meanwhile, in the medium term until 2030, the majority of the buildings still emit more than 20 kg CO_2-eq/m²/year in the RS. In the 2DS, the share of buildings emitting less than 20 kg CO_2-eq/m²/year reach approx. 50% of the floor area and is therefore substantially higher compared to the RS (36%). These changes mainly stem from the increased retrofitting intensity in the 2DS and additional new buildings being added to the stock after 2018, which implies an average carbon intensity between 8.9-13.9 kg CO_2-eq/m²/year. In part, a switch to renewable energy sources also contributes to the increase of more carbon-efficient buildings in 2030.

There must be a clear shift to low-carbon buildings after 2030, especially in the 2DS, which results in the majority of the stock emitting less than 5kg CO_2-eq/m²/year. This is triggered by policies dedicated to reducing energy demands and removing fossil fuels from the heating sector, primarily enabled by a shift to district heating and electric heat pumps. An important prerequisite to this development is the decarbonisation of the German electricity generation and district heating sectors according to the EU reference scenario.13 In the RS, the shift towards low-carbon buildings is less pronounced even if the percentage of low-carbon buildings further increases. This is due to the fact that in this scenario, fossil fuels are still largely contributing technologies in the refurbishment of the existing stock, and RESs such as heat pumps are less frequently used in this scenario.

Notes:
Greenhouse gas intensity: Greenhouse gas emissions from final energy consumption including electricity for heating, hot water, ventilation and cooling from a life-cycle perspective. Example: 10 kg CO2-eq per m² are equivalent to 45 kWh per m² of a gas-supplied building.

***C4.2** – Structural changes in the greenhouse gas intensity of the building stock according to the Referrence Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

C5

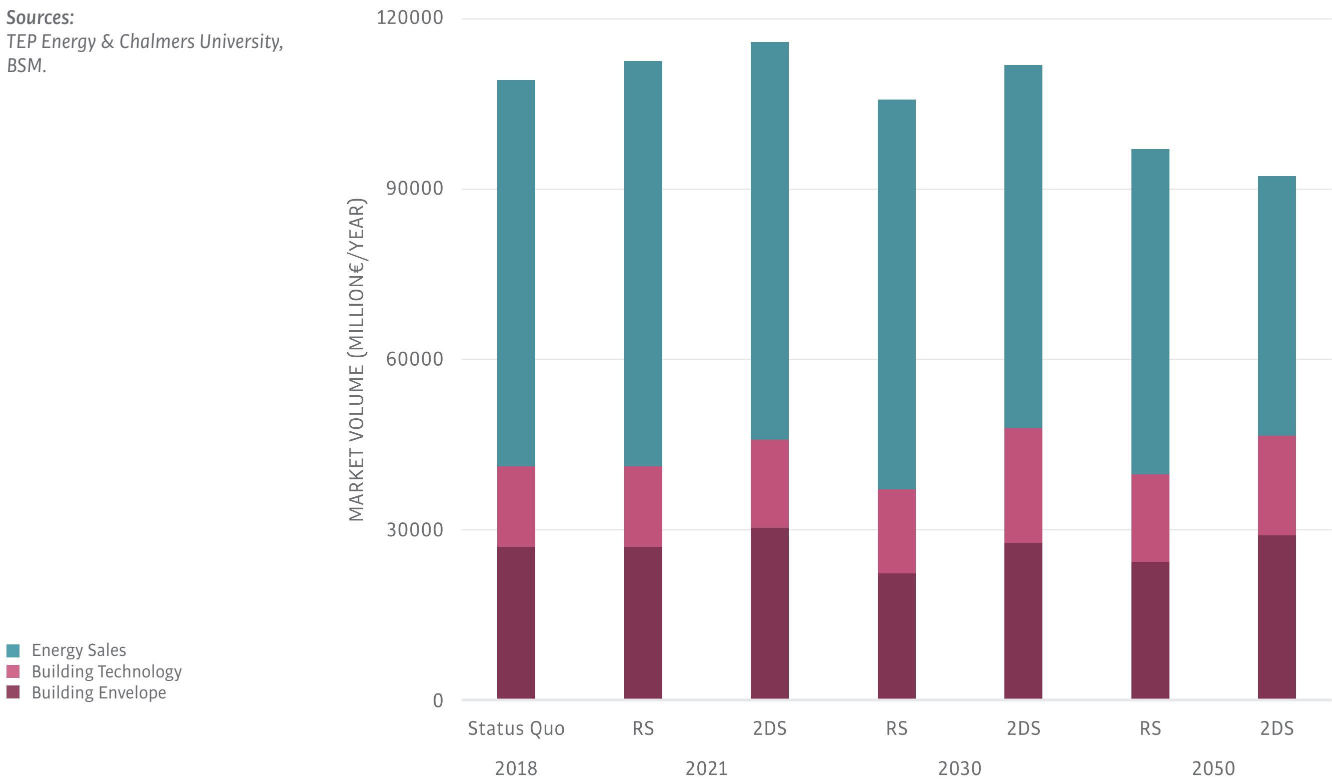
Structural change of the building market
Short-, mid-, and long-term development

In this and the following sections, the energy and GHG related building market are assessed. This includes the building envelope market, the building technology market and related energy sales. Within this scope, the building envelope market encompasses all construction, retrofitting and overhaul activities on building envelope components (walls, roofs, floors and windows). The building technology market includes heating, hot water and ventilation technologies. In the category of energy sales, all energies related to cover demand within the building envelope based on building technologies are included, whereas electricity sales for household appliances and CO_2-taxes are not balanced. Hence the whole value chain related to energy consumption and greenhouse gas emissions including planning, installation, material and product sales, operation and maintenance etc. is covered for both existing buildings through refurbishment and the construction of new buildings. Note that construction activities not directly related to energy and GHG emissions (e.g. structural or interior work, kitchen and bathroom) have not been considered.

According to the calculations, the total market volume of the energy and GHG related building market including energy sales amounts to €110 billion per year (see Fig. C.5.1). More than 60% of this market volume comes from energy sales (€68 billion per year), even though electricity sales for household appliances are not included in this figure. Investments in building technologies are lower (€14.4 billion per year) compared to the building envelope market (€27.1 billion per year).

C5.1 – *Development of energy-relevant market volumes in the residential building market in the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



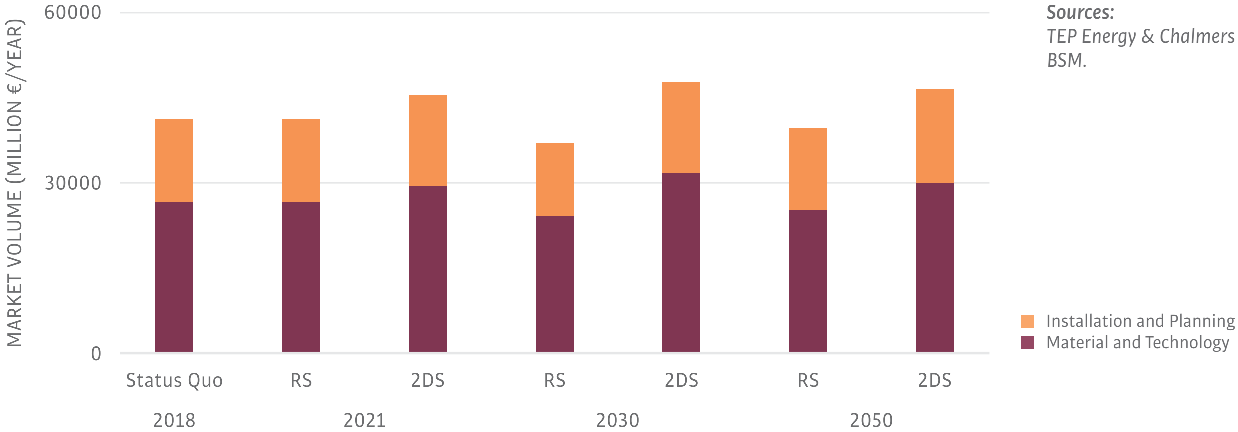
In the short term (until 2021), the market volume remains quite stable in the RS. There is a slight increase in energy sales, mainly coming from an increase in energy prices, rather than an increase in volume. However, in the 2DS, there is already an increase in the market volume from building envelope measures (+ 12.9%) and building technologies (+6.8%). This is mainly triggered from early adoption of policies taking effect in 2020, targeting an increase in deeper refurbishment as well as speeding up the phase out of fossil fuel heating systems.

Until 2030, the total market volumes decrease in both scenarios compared to the 2021 markets, although in different aspects. In both scenarios, mainly the market volume for building envelope decreases. This is due to the reduced investments in new buildings and the age distribution of the old building stock, which would be refurbished during this period. In the 2DS, the higher rate and higher depth of refurbishment and consequently a lower energy demand result in higher market volumes for the building envelope (+22.4%) and building technologies (+36.5%) but lower volumes for the energy sales(-6.4%).

In the long term (until 2050), the overall market volumes decrease in both scenarios. A reduction of the energy demand in the building sector in both scenarios leads to a decreased market volume in energy sales (-11.2% in the RS and up to -15.6% in the 2DS compared to 2018), which cannot be offset by the shift to higher price energy carriers anymore. At this point, energy utilities should have adjusted their business. The market volumes for building technologies and the building envelope are projected to remain stable or slightly increase until 2050 compared to 2030 (but for the building technology volumes in the 2DS). Refurbishment has a strong focus on comprehensive renovations in the 2DS. The need for additional insulation material, therefore increases due to the higher efficiency standards (+10.5% in the RS and +5.9% in the 2DS, resp. in 2050 compared to 2030). Buildings, however, refurbished in the last period between 2030 and 2050 are mostly built after the introduction of the first building codes in 1979, and therefore they require fewer additional measures to reach more stringent efficiency targets, limiting the market volume increase. New construction, mainly replacing existing buildings, only grow slightly, driven by the declining population of Germany until 2050, contributing by 11.8% to the overall market volume for building envelope.

The market volume for the building envelope and technology is split about 35%–65% between installation, engineering, and technical planning (€14.5 billion per year) and material and technology (€26.8 billion per year) (see Figure C5.2). The increase in the market volume in the 2DS in the short term and the medium term mainly results from the material and technology category, for which the market volume increases to €29.8 billion per year (+10%) in 2021 and €31.8 billion per year in 2030 (+19% compared to 2018). In 2030, there is also a clear trend towards more expenditure in building technologies as compared to the building envelope.

C5.2 – *Development of energy-relevant market volumes (excluding energy sales) for material and technology, and installation and planning according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

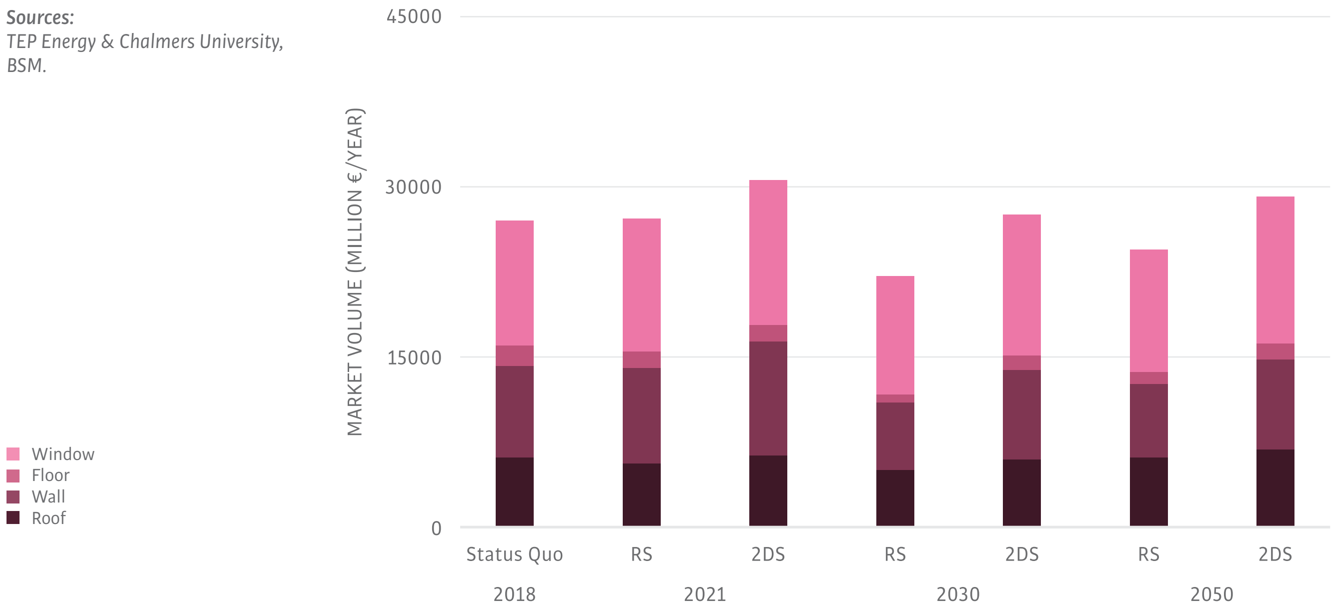
C6 Building envelope
Market volumes and development

The current annual market volume in the building envelope market amounts to €27.2 billion per year. The market volume is split between the different main building components (see Fig. C.6.1). Windows make up the largest share (€11.1 billion per year) followed by walls (€8.1 billion per year). Significantly lower are the shares of roofs (€6.1 billion per year) and floor/ basement ceiling insulations (€1.8 billion per year)

In 2018, about 42% of the building envelope market stems from the construction of new buildings, and the other 58% from retrofitting existing buildings (an equivalent of about 1% of the building envelope is retrofitted energy efficiently, and an additional 1% is overhauled each year).

C6.1 – *Development of energy-relevant market volume of different building components in both new construction and refurbishment for the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



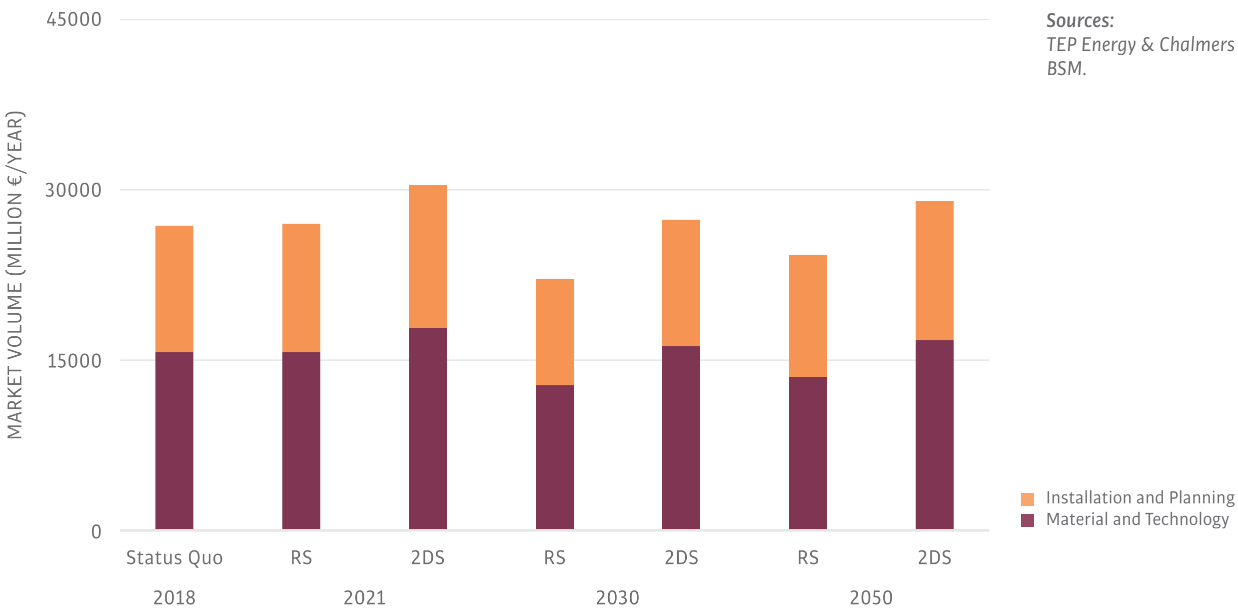
In the short term, the envelope market volume only increases in the 2DS as policies to increase the rate and extent of refurbishment take hold, and a further strong increase in floor area is also expected. The market volume for almost all compounds grows, though most significantly for walls, which increases to €10.1 billion (+24%) and windows, which increases to €12.7 billion per year (+15%). In contrast, the market volume remains almost constant in the RS since, as compared to the previous years, increasing floor areas compensate for low refurbishment.

In the medium term, the envelope market decreases to €22.3 billion per year in the RS, mainly because the number of new constructions per year decreases compared to earlier periods. In the 2DS, market volumes also decrease to a total of €27.7 billion per year and reaches market volumes similar to those of 2018. The distribution of market shares between the different building elements remains constant compared to 2018, with windows making up 45% of the market volume and walls making up 29%. The remaining shares are dominated by roof applications, which make up 21% of the market.

In the RS and in the 2DS, the envelope market volume increases in the long term compared to 2030 as the market volumes for comprehensive refurbishment measures increase. As compared to 2018, however, the market volume declines across all components in the RS, but reaches similar levels in the 2DS. Market volumes change most significantly for windows, which increase to €13 billion per year in the 2DS by 2050 (+5% compared to 2030). In the RS, the market volumes increase across all building components (+11% in 2050 compared to 2030). Independent of the scenario, the construction industry should therefore also be prepared for a more challenging business environment. As the market for new buildings increases only slightly in the short term, the refurbishment sector gains further relevance and competition between market actors increases.

The envelope market volume is currently split about 41%-59% between installation, engineering and technical planning (€11.2 billion per year) and material and technology (€15.9 billion per year) (see Fig. C.6.2).

C6.2 – *Development of energy-relevant market volume for material and technology and installation and planning for building envelope components in the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

In the medium term (until 2030), the market decreases in both scenarios compared to 2021. The decrease in market volume in the RS is similarly divided between material and technology (-19% to €12.8 billion per year) and installation and planning (-17% to €9.4 billion per year). The reduction of market volumes for installation and planning as well as material and technology between 2030 and 2021 is with -10% smaller in the 2DS compared to the RS. This reduction in installation and planning activity as well as material and technology demand are in part a result of a reduced new construction rate and a limited need for additional material.

In the long term, in both scenarios, the importance of installation and planning gains relevance compared to the material and technology category. The RS, however, projects higher percentages for installation and planning than the 2DS does due to the stronger increase of buildings being first time refurbished between 2030 and 2050 in the RS compared to the 2DS where the shares of comprehensive refurbishment drive the growing market volume for material and technology.

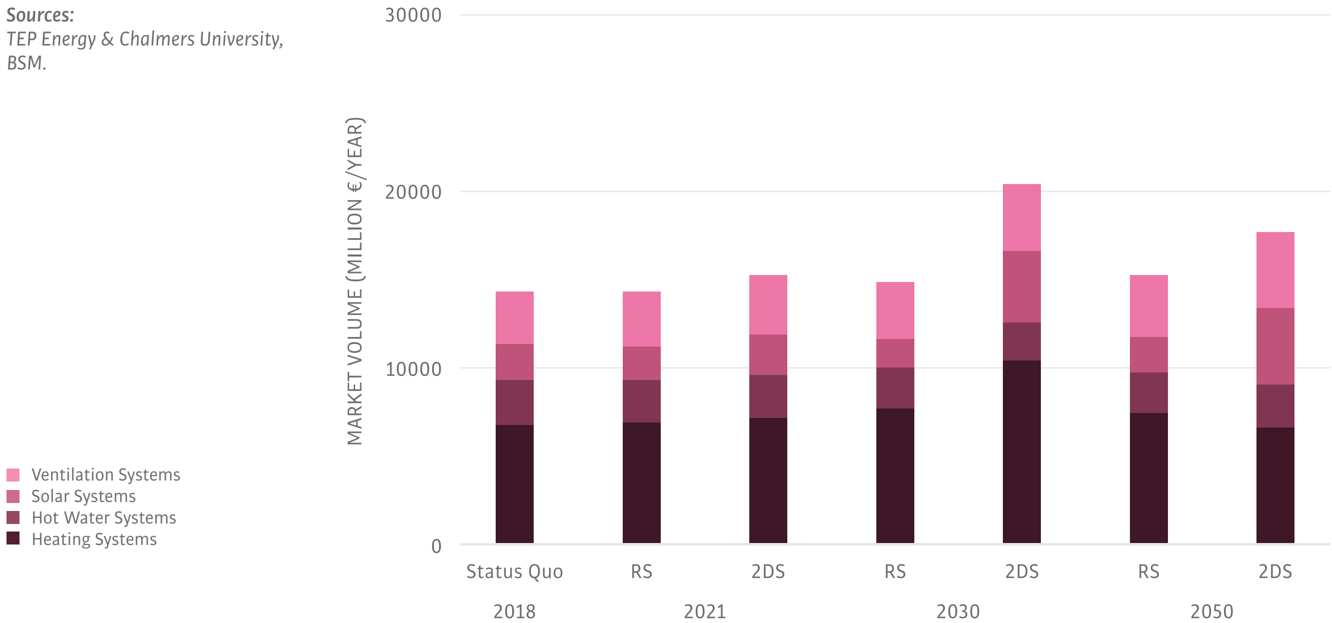
The most challenging business environment in both scenarios would largely be the material and technology category for which the market volume shows higher variability between the scenarios and time instances as compared to the installation, engineering and technical planning.

C7 Building technologies
Market volumes and development

The current market volume of the German building technologies market amounts to €14.4 billion per year. About 65% of this market is made up of heating and hot water systems with €6.8 billion and €2.6 billion per year, respectively (see Fig. C.7.1). The remaining market volume is split into solar systems (both thermal solar collectors and photovoltaic systems) with a market volume of €2.1 billion per year and ventilation systems with about €2.9 billion per year.

C7.1 –Development of energy-relevant market volume of different building technologies in both new construction and refurbishment for the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).

Sources:
TEP Energy & Chalmers University, BSM.



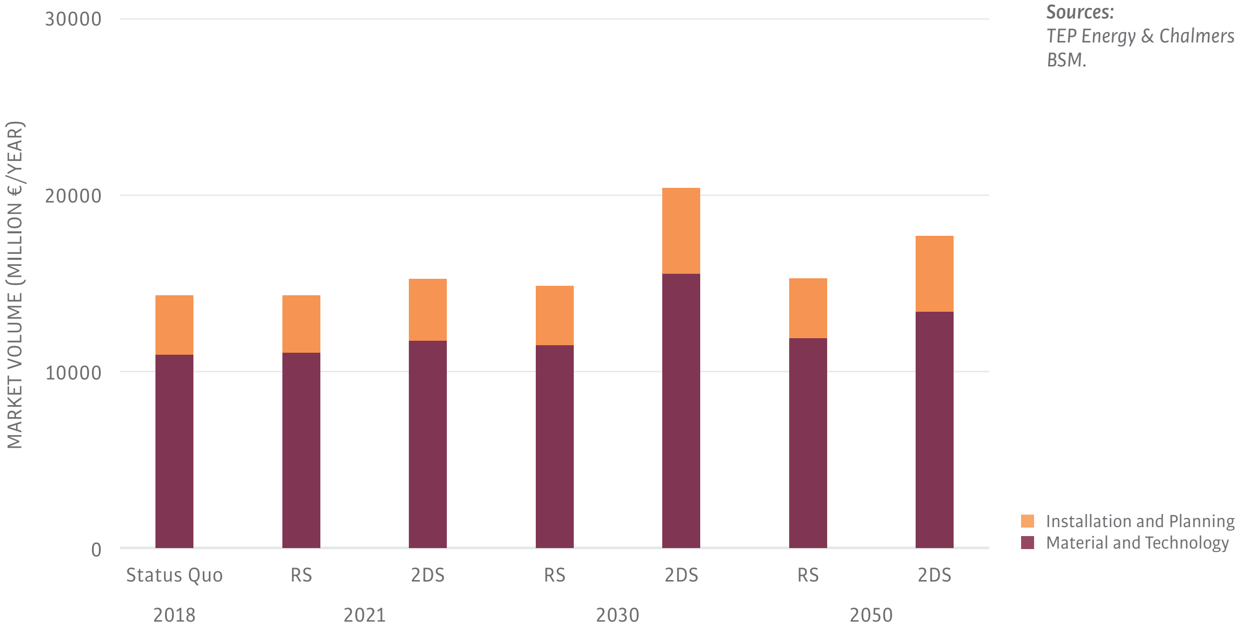
In the short term (until 2021), the market volume for building technologies remains largely stable in the RS. It only increases in the 2DS (to €15.4 billion per year, i.e. by about +7%). The main driver of this increase is the rapid adoption of new regulations until 2021 and the related replacement of fossil fuel heating systems with heat pumps and more wood-based and district heating systems. Additionally, solar systems increase their market volume by 16.5% to €2.4 billion per year, and ventilation systems by 14.4% to €3.4 billion per year.

In the medium term (until 2030), the market volumes remain stable in the RS and increase further in the 2DS. The reduction of fossil fuel systems also affects the market volume in the RS, although it is lower compared to the 2DS. In the 2DS, the phasing out of fossil fuel systems results in reduced spending on energy carriers, and the additional incentives for renewable heating systems help finance the shift towards more sustainable heating solutions.

In the long term (until 2050), the market volume in the 2DS decreases after 2030 due to reduced sizes of heating systems required as the specific heating demand further decreases. Compared to 2030 levels, these reductions are only partially compensated for by additional investments in solar and ventilation systems required due to the applied building codes. Market changes are therefore also expected in the building technologies sector, including a shift from heating systems expenditures to other building technologies, such as solar or ventilation systems. Additionally, the relatively small market volume comprised of new construction must be compensated for by an increase in replacement sales under higher market competition, and especially by increased sales of heat pump systems.

The building technologies market volume is made up of about 24% installation and planning (€3.4 billion per year) and 77% material and technology (€11.0 billion per year, see Fig. C.7.2). The short- and mid-term increases of market volume in the 2DS are mainly due to the material and technology category, for which the market volume increases to €11.9 billion per year in 2021 (+7.8%) and to €15.6 billion per year in 2030 (+41.5% compared to 2018). In the long run, the market volumes decrease after 2030, mainly due to the reduced capacity size of heating systems and a shift toward other building technology systems such as solar and ventilation systems. In the RS, the market volumes for material and technology hardly change over the whole timespan; however, slight adjustments between the different categories occur, based on the refurbishment needs of the existing building stock and the relevant building policies.

***C7.2** – Development of energy-relevant market volume for material and technology and installation and planning for building technologies in the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

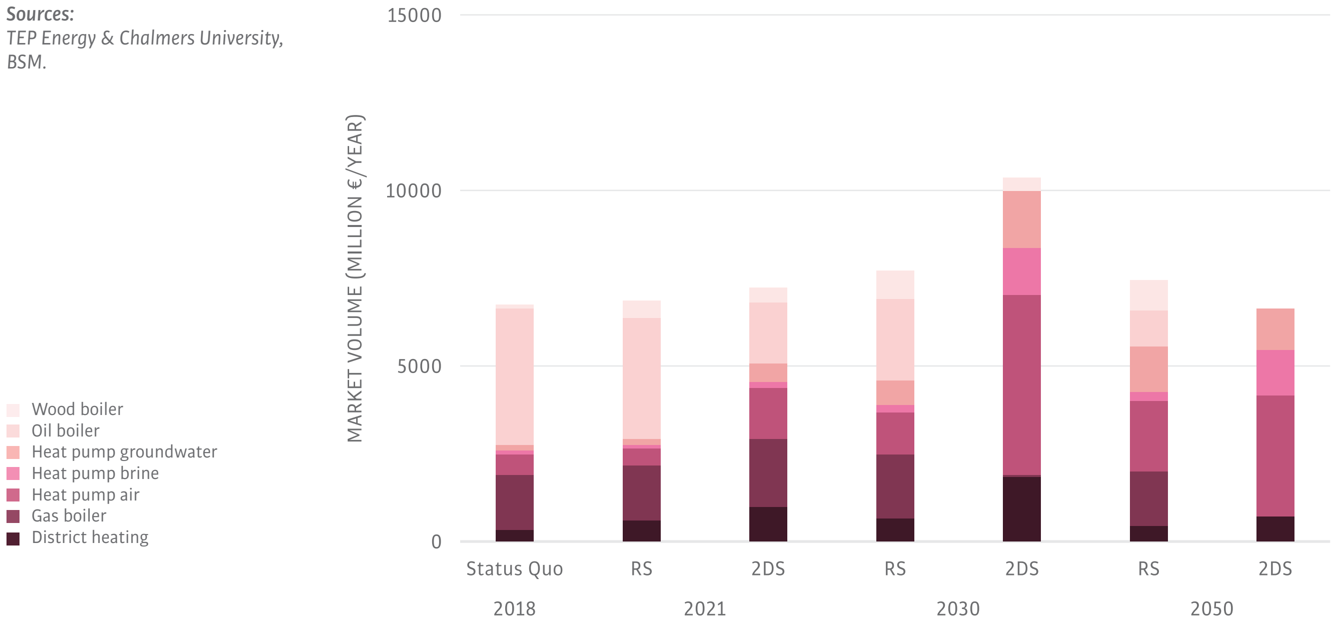
C8 A deep dive into heating systems
Market volumes and development

The current annual market volume for heating systems amounts to €6.8 billion per year. The majority of this volume comes from sales and installation of oil and gas boilers with a market volume of about €3.8 billion and €1.5 billion per year, resp. Further shares stem from the sale and installation of heat pumps that amounts to €0.9 billion per year, district heating systems with €0.3 billion per year. The rest of the market volume is made up from other heating systems with lower market shares such biomass-based heating systems (see Fig. C.8.1).

In the short term, the market volume remains stable in the RS but increases in the 2DS to €7.3 billion per year (+6.7%). Policies to phase out fossil fuel systems, as well as support measures for renewable systems, take effect and reduce the market volume for oil and gas boilers. In particular, oil-based systems are primarily replaced by an increase in the market volume of air source heat pumps (€1.4 billion per year), district heating (€1.0 billion per year), and wood boilers (€0.4 billion per year).

C8.1 – *Development of the market volume of different heating system technologies (construction of new buildings and refurbishment of existing ones) in the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.

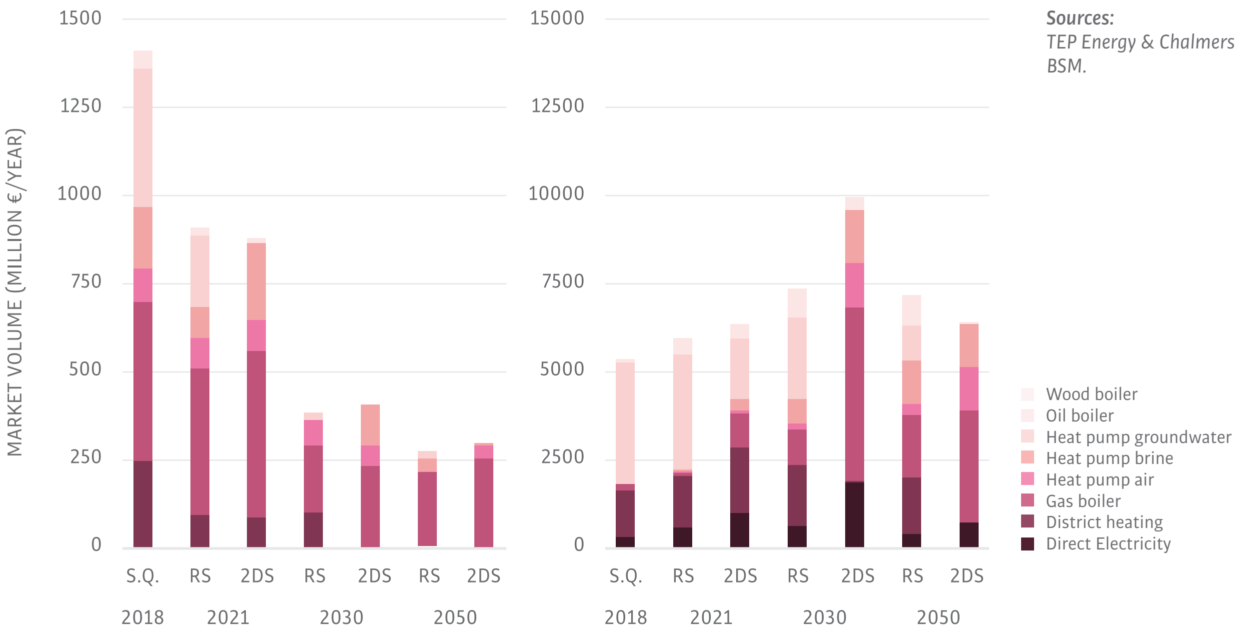


Until 2030, both scenarios show an increase in the heating systems market volumes. In the RS, only oil boilers begin to reduce their market volumes (-€1.5 billion per year compared to 2018) as they are replaced by increasing sales of gas boilers, heat pumps and wood-based heating systems. The 2DS shows an almost complete phase out of oil and gas boilers and an additional increase of the market volume for air and groundwater heat pumps (€8.1 billion per year), district heating systems (€1.9 billion per year) as well as wood boilers (€0.4 billion per year).

The long-term development up to 2050 demonstrates a decreasing market volume in the two scenarios, mainly due to the installation of smaller systems as a result of the improved specific energy demand per floor area. Additionally, the existing building stock distribution with relatively higher efficiency standards in 2050 influences the need for investments in heating systems. In the RS, fossil fuel systems still comprise up to 35% of the market volume for heating systems (€2.6 billion per year). In the 2DS, fossil fuel systems are completely phased out and different heat pump systems dominate the market, comprising 89% of the market volume.

In 2018, the heating system market (see Fig. C.8.2) is made up of about 21% new construction (€1.4 billion per year) and 79% refurbishment (€5.4 billion per year). Both market segments are still dominated by oil and gas boilers, which in both cases make up more than 80% of the market. In the case of existing stock, the remaining market is primarily made up of a small number of heat pumps and district heating systems. Heat pumps are mainly installed in new buildings (€0.7 billion per year), where they make up the largest percentage of installed heating systems after oil and gas boilers.

***C8.2** – Development of energy-relevant market volumes for different heating system technologies for the market segments new construction (left) and refurbishment (right) in the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

In the medium term and in the long term, heat pumps (air and ground source) are the dominant technologies in market segment of new constructions in the RS and 2DS with a small share of fossil-fuel heating systems in the RS.

In the existing stock, oil and gas-based heating continues to dominate in 2030 and partially in 2050 in the RS. Yet in the long term, fossil-fuel boilers are replaced by an extension of district heating, heat pumps and wood boilers in German cities. In the 2DS, mainly heat pumps and district heating systems are applied over time for refurbishments. In this analysis, district heating is partially needed to achieve the stringent climate targets, as growth rates for other technologies are limited, especially in the inner cities.

F2 Building inventory factsheet

Single-dwelling
BUILDING

Construction period		1920	1945	1960	1980	1990	2000	2010
Details								
Cumulative floor area (million m^2)	222.9	171	240.5	385.9	207.8	173.3	148.3	51.1
Heated floor area (m^2)	122	121	125	129	136	137	134	138
Average number of floors (#)	2	2	2	2	2	2	2	2
Envelope surface area (m^2)	302	291	305	305	319	316	306	318
Window wall ratio (%)	18%	18%	18%	18%	20%	19%	22%	21%
U-Value (W/m^2 a)								
Wall	1.18	1.21	1.08	1.25	0.63	0.65	0.36	0.3
Roof	0.89	0.88	0.9	0.66	0.64	0.64	0.36	0.3
Floor	1.74	1.74	1.72	2.33	1.3	1.28	0.36	0.3
Window	2.07	2.04	2.05	2.03	2.22	2.21	1.98	1.38
Heating Systems								
Oil boiler	21%	24%	40%	32%	29%	20%	11%	3%
Gas boiler	43%	52%	52%	43%	53%	68%	63%	39%
District heating	1%	2%	2%	4%	3%	4%	6%	5%
Heat pumps	1%	1%	1%	1%	3%	1%	16%	53%
Wood stove	4%	2%	2%	1%	4%	1%	3%	0%
Direct electricity	30%	20%	20%	18%	9%	6%	1%	0%
Coal boiler	0%	0%	0%	0%	0%	0%	0%	0%

Multi-dwelling
BUILDING

Construction period		1920	1945	1960	1980	1990	2000	2010
Details								
Cumulative floor area (million m^2)	267.3	162.6	436.8	717.1	221.1	148.4	72.5	24.8
Heated floor area (m^2)	433	378	517	508	514	487	483	566
Average number of floors (#)	3	3	3	3	3	3	3	3
Envelope surface area (m^2)	574	516	602	597	600	589	598	637
Window wall ratio (%)	27%	27%	29%	29%	33%	33%	35%	36%
U-Value (W/m^2 a)								
Wall	1.16	1.2	1.12	1.25	0.64	0.64	0.36	0.3
Roof	0.91	0.88	0.9	0.63	0.64	0.64	0.36	0.3
Floor	1.72	1.71	1.73	2.33	1.28	1.28	0.36	0.3
Window	2.05	2.05	2.07	2.04	2.21	2.21	1.99	1.4
Heating Systems								
Oil boiler	10%	9%	17%	17%	13%	13%	10%	2%
Gas boiler	52%	51%	35%	37%	35%	35%	61%	46%
District heating	11%	17%	21%	21%	36%	36%	16%	21%
Heat pumps	1%	0%	0%	0%	0%	0%	4%	14%
Wood stove	2%	1%	0%	1%	1%	1%	1%	9%
Direct electricity	25%	23%	26%	24%	15%	15%	8%	8%
Coal boiler	0%	0%	0%	0%	0%	0%	0%	0%

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