German Japanese Energy Transition Council

© Anna Röttger

Strategies, concepts and measures for decarbonizing the building stock by 2045/50

Imprint

Publisher:

Wuppertal Institute for Climate, Environment and Energy
Döppersberg 19
42103 Wuppertal
Germany
www.wupperinst.org

The Institute of Energy Economics, Japan
Inui Bldg. Kachidoki,10th,11th Floor
13-1, Kachidoki 1-chome, Chuo-ku,
Tokyo 104-0054
Japan
https://eneken.ieej.or.jp/en/

Authors:

Toshiyuki Kudo, Naoko Doi, Toshiya Okamura (Institute of Energy Economics Japan)
Stefan Thomas, Lotte Nawothnig, Fiona Bunge (Wuppertal Institute)
Manfred Rauschen, Thomas Rühle, Jonas Rütter, Sascha Kunstmann, Melanie Bierhoff (Öko-Zentrum NRW)

Please cite the publication as follows:

Nawothnig, L.; Kudo, T.; Rauschen, M.; Thomas, S.; Doi, N.; Kunstmann, S.; Okamura, T.; Bunge, F.; Pöter, M.; Bierhoff, M.; Rühle, T.; Rütter, J. (2023): Strategies, concepts and measures for decarbonizing the building stock by 2045/2050. Wuppertal Institute and Institute of Energy Economics, Japan.

Short reference: Nawothnig et al. 2023

Contact:

GJETC Secretariat
gjetc@wupperinst.org
Phone: +49 202 2492-298
Fax:+49 202249210

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

METI Ministry of Economy, Trade and Industry

Table of Contents

List of Abbreviations, Units and Symbols

Abbreviations

BEV	Battery electric vehicle
BMWK	German Federal Ministry of Economic Affairs and Climate Action
EEA	European Environment Agency
ETS	Emission Trading Scheme
EU	European Union
Fig.	Figure
GDP	Gross domestic product
GHG	Greenhouse gas
IEA	International Energy Agency
HVAC	Heating, ventilation and air conditioning
IPCC	Intergovernmental Panel on Climate Change
LCA	Life-cycle assessment
NECP	German Federal Government's Integrated National Energy and Climate Plan
SMEs	Small and medium-sized companies
Tab.	Table
Wuppertal Institute	Wuppertal Institut für Klima, Umwelt, Energie GmbH

Units and Symbols

$	US dollar
%	Per cent
€	Euro
°C	Degrees Celsius
bn	Billion
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalents
Gt	Giga tonne
kg	Kilogram
km	Kilometre
kt	Kiloton
kW	Kilowatt
kWh	Kilowatt hour
m	Million
MJ	Megajoule
Mt	Metric tonne
Nd	Neodymium
Nm^3	Normal cubic metre
p.a.	per annum
pkm	Passenger kilometres
ppm	Parts per million
s	Second
t	Tonne
vol%	Percentage by volume

List of Tables

List of Figures

Executive Summary

To reach the climate neutrality goals in Japan (2050) and Germany (2045), ambitious policy measures are crucial. Particularly in the building sector, the potential for greenhouse gas (GHG) emission reduction is important: Through better insulation, the energy needed for floor heating or cooling can be reduced significantly; the installation of PV-systems on the rooftop and the switch from fossil fuel-based heating systems to heat pumps running on renewable electricity will further facilitate the decarbonization of the building sector. While environmental-sound constructions of new buildings are important, it is even more important to foster renovations in the existing building stock. At the same time, renovations are also challenging because of lacking information, financial resources or often long payback times, and the difficulty to impose regulations on mandatory investments.

In Germany, a policy called first *Heat Insulation Ordinance* setting energy efficiency standards for new buildings was first introduced in 1979 and revised/tightened numerous times ever since. Following increased climate policy ambition in Germany and the EU and Russia's war of aggression against Ukraine, the newly inaugurated German government put high priority on the decarbonization of the building sector. Most importantly, new buildings shall be close to zero-energy standards from 2025; every new heating system shall use at least 65% of renewable energies from 2024; and government funding for financial incentives to support decarbonizing the building stock shall be increased to 12 billion Euros/yr until 2026. In Japan, on the other hand, the Top Runner program that had been put into place in 1998 to improve the energy efficiency of commonly used electronic appliances, was adapted to the building sector in 2017 as *Residential Top Runner System* with periodic revision. More recently, the Japanese government presented the roadmap of the *Green Transformation* (GX Transformation) that also includes measures to foster the energy performance of buildings. Against this background, comparing the situation in both Japan and Germany can be beneficial to better understand the common or deviant situations of each country and learn about best-practices.

Based on their geographical characteristics, Japan and Germany face partly different challenges: While Germany is prone to colder and longer winters, most parts of Japan heavily suffer from hot summers. In addition, the energy consumption also differs due to rather cultural factors, such as the habit of just heating those rooms actively used as is common in Japan, contrasting the practice of heating the entire housing with a central heating system in Germany. On the other side, most Japanese practice bathing daily, which contributes to a large share of energy used to produce hot water. At the same time, both countries provide a high level of technology standards.

To reduce the energy consumption in the building sector the governments of both countries set standards/energy efficiency levels. While in Germany it is now mandatory to present the Energy Performance Certificate (EPC), the consumption performance label in Japan is voluntary. Contrary to Japan, where the installation of rooftop PV depends on the ruling of the municipalities, it will become mandatory for new German buildings. Overall, the focus on the Japanese policies lies rather on improving the energy efficiency of appliances than the building envelope.

Both countries still need to increase their efforts in increasing the annual renovation rate while also phasing out fossil fuel boilers by replacing them e.g., by heat pumps. Another challenge for both countries concern the building floor space and the embedded carbon emissions related to constructions. Finally, investments in retrofits must become easier and more attractive through e.g., prefabrication of elements, the active usage of Renovation Passports, and One-Stop-Shop services.

1 Introduction

Based on the Paris Agreement adopted in 2015, Japan announced in October 2020 that it aims to achieve carbon neutrality by 2050. In addition, consistent with the long-term goal of carbon neutrality in FY2050, Japan declared its ambitious goal of reducing greenhouse gas (GHG) emissions by 46% from FY2013 level by FY2030 and expressed its determination to continue to take on the challenge of achieving a further 50% reduction. Currently, discussions and efforts are underway to find a way to achieve this reduction target.

In 2019, the German government agreed on a Climate Change Act that specifically set sector targets to reduce the GHG emissions in the fields of energy, industry, transport, building, agriculture, waste (and others). Following a ground-breaking ruling of the German constitutional court in April 2021, the law was revised with the overall target to reach climate neutrality already in 2045, and the sector targets and interim targets were also tightened. In light of Russia's war of aggression against Ukraine, the government launched an ambitious program of measures to decarbonize the German building sector. New initiatives of the European Union (EU) further trigger the policy developments in Germany: Based on the European Green Deal, the EU put in place the fit for 55 plan that seeks to reduce the Member States' GHG emissions by 55% until 2030. Among the measures included, the recast of the EU Directive on the energy performance of buildings (EPBD) and the creation of a second European Emission Trading Scheme (ETS 2) for the transport and building sector are noteworthy for decarbonization of buildings.

Established in 2016, the German-Japanese Energy Transition Council (GJETC) strives to promote bilateral cooperation between Germany and Japan on energy transition. Among other studies and topical papers, an output paper in 2020 (Rauschen et al., 2020) already compared the energy efficiency in buildings in both countries with a particular focus on heating and cooling. One important finding of this output paper was that further efforts in the building sector are needed to improve the energy efficiency of buildings in Germany and Japan. Following the more ambitious climate protection targets in both countries, this study seeks to analyze the German and Japanese policies put in place to accelerate the decarbonization of the building sector. The decarbonization of the vast number of buildings that both Japan and Germany are facing will be a major contribution to achieving the GHG reduction targets of both countries and should continue to be discussed among experts and developed into a discussion among policy makers.

This report examines and compares the characteristics of the building stock in both countries (chapter 2), as well as existing policies and new strategies and policies that are planned or discussed to achieve energy conservation and decarbonization of buildings (chapter 3). The current shape of buildings, especially houses, is greatly influenced by the land area of the country corresponding to the available space for buildings, the natural environment surrounding the country, the natural resources available, and the lifestyle and cultural ideas that have been passed down and taken root over time. Therefore, it might be difficult to compare them and the corresponding strategies and policies with the same yardstick, so we also discuss common or deviant situations (chapter 4). Through this joint research, we aim to find each other's advantages and challenges and to develop useful and concrete policy recommendations (5) that will contribute to decarbonization policies in both countries.

2 Context: Building Stock Characteristics and Existing Policies

In order to lay the foundation for the analysis of potentials for decarbonizing the building stock and of policies to harness the potentials, this chapter presents the characteristics of the building stock as it has emerged in both countries until now.

Following a description of the development of the building stock's size and growth (2.1), the average age of building stocks, and structure of the buildings' age (2.2) as well as the energetic characteristics based on the construction material (2.3) are addressed. Subsequently, current data for the average building energy intensity (2.4) and the overall energy consumption (2.5) are presented as background data that might contribute to comprehend differences in the policy development of both countries.

2.1 Size and growth of building stocks

2.1.1 Germany

Out of a total of 21,356,912 buildings, the residential buildings account for 19,375,912 buildings, with ca. 3,900 million m^2 of floor space, compared to 1,981,000 heated non-residential buildings with ca. 1,800 million m^2.

A large proportion of the existing housing stock in 2021 were single- and two-family houses that are mostly owned by families living there (dena 2022) (16,105,498). However, slightly more than half of all households live in rented dwellings, mostly in multi-family houses. These account for almost 17% of all buildings. At the end of 2021, there were a total of 43,084,056 housing units in residential and non-residential buildings. On average, dwelling units in single- and two-family houses are about 119 m^2 and in multi-family houses 70 m^2 large (dena 2022).

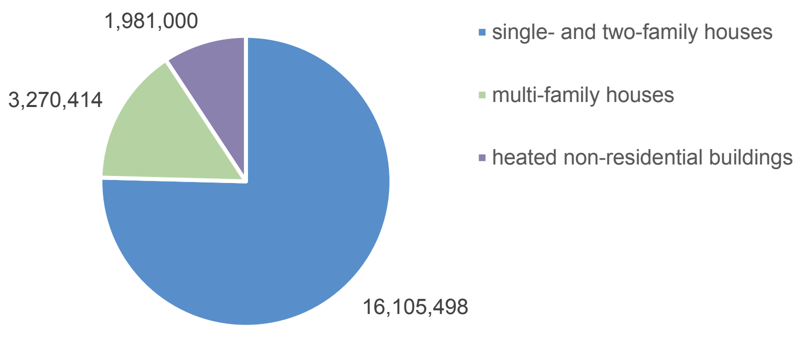


Figure 2-1: Building stock in Germany 2021
Source: dena 2022

Around 60% (140,000) of the non-residential buildings are owned by the public sector (federal government, federal states, municipalities, institutions/corporations under public law), among which mainly schools, day care centers and other care facilities (dena 2022).

The population of Germany amounts to 84.1 million as compared to that of Japan amounting to 125.7 million inhabitants. In Germany, the average per capita floor area has gradually increased from 1990-2009 and now is 47.7 m^2. One possible reason for this considerable increase since 1990 is related to a growing demand for larger apartments and houses, while the number of people living in the same households is going down (UBA 2022). After 2010, the average per capita floor area has been considerably stable due to increased immigration (dena 2022).

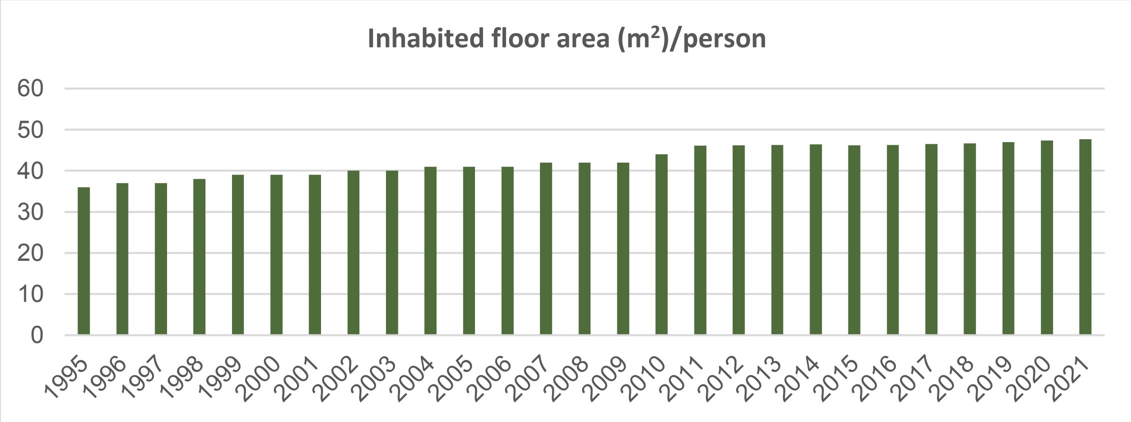


Figure 2-2: Inhabited floor area per person in Germany
Source: Destatis 2023/UBA 2022a

2.1.2 Japan

Of the 7,735 million m^2 of total building floor area in Japan, residential buildings account for 5,749 million m^2 compared to 1,987 million m^2 of non-residential buildings. About three quarters (72.7%) of residential buildings are detached or row-houses, and about 60% are owner-occupied. About 33% (646 mn m^2) of non-residential buildings are owned by the public sector (national or local government), mostly administrative office buildings, schools, daycare centers, and other care facilities.

Japan's population was 126.75 million as of 2018, with an average floor space per capita of 45.4 m^2/person out of the total residential area. The growth rate of the population turned negative for the first time in 2005 and has remained negative ever since, while the number of construction starts has been steadily increasing.

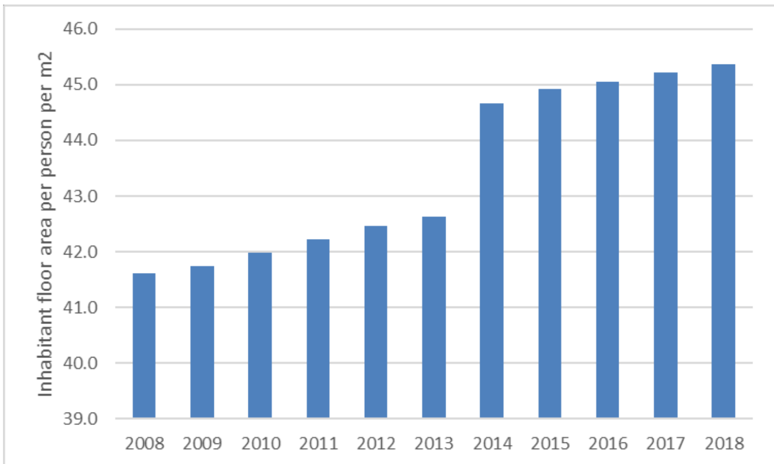


Figure 2-3: Inhabited floor area per person in Japan
Source: estimate of the population and Building Stock, Statistics, e-Stat

2.2 Average age of building stocks, and structure of buildings' age distribution

2.2.1 Germany

Around two thirds of the existing building stock in Germany was built before 1979. Compared to new buildings, the energy demand in existing buildings is on average up to five times higher.

2.2.1.1 Residential Buildings

Figure 2-4 shows that for residential buildings respective dwellings, around two-thirds were built before 1979, and almost half during the reconstruction after the damages of World War II.

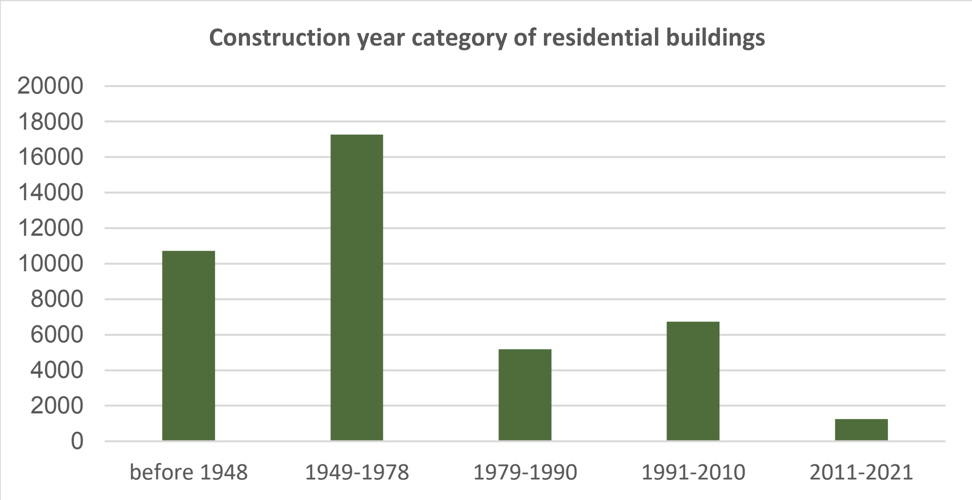


Figure 2-4: Construction year category of residential buildings in Germany
Source: Destatis 2022a

Since 1995, and particularly between 1999 and 2009, the annual number of new residential buildings in Germany declined, before rising again after 2011. Currently, approximately 110,000 new residential buildings are constructed each year, with a noteworthy decrease by 9% in 2021 (dena 2022).

Parallel to the declining number of new residential buildings, the number of demolitions has decreased, but remains at very low levels below 10,000/yr (Destatis 2022a).

2.2.1.2 Non-residential Buildings

Similar to the developments in the group of residential buildings, the constructions of new build have decreased considerably after 1979. The Institute for living and environment (*German*: Institut für Wohnen und Umwelt, *abbrev*.: IWU) categorized the construction age class in three types: (a) old building (before 1978), (b) "Zwischenbau" (1979-2009) and (c) new build (after 2010).

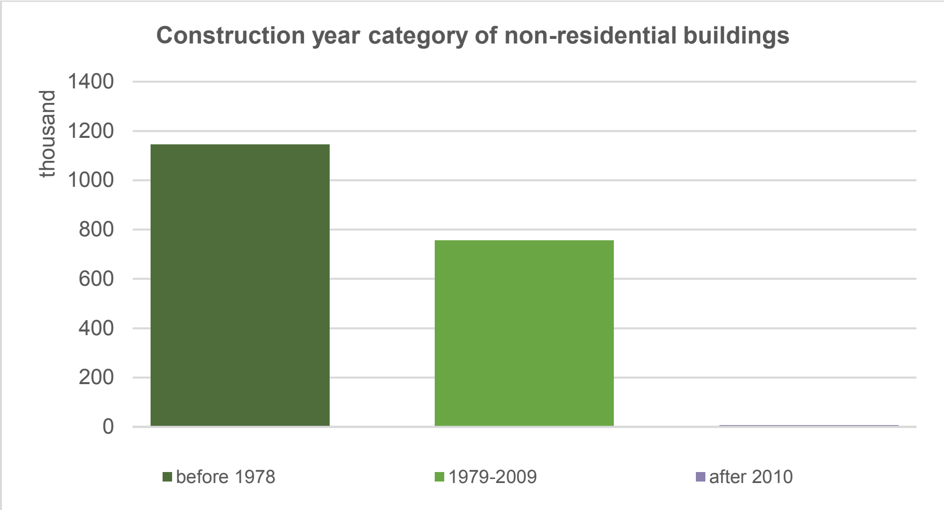


Figure 2-5: Building stock of non-residential buildings in Germany according to construction age class
Source: IWU 2022

2.2.2 Japan

Figures 2-6 and 2-7 show a comparative age distribution of existing buildings up to the year 2018. Most residential and non-residential buildings are constructed from the year 1971 to 1990. In Japan, there has been a serious shortage of buildings since World War II. Thus, for the last six decades, construction activities in Japan have mainly focused on new building activities. A lot of houses built in Japan in the 1950s-1970s were built cheaply and quickly to cater to a booming population. At that time, the quality of buildings was not as important as it is today, and the standards were very different from those of today.

In earthquake-prone Japan, earthquake resistance standards have been strengthened after each major earthquake, and in 1981, based on the 1978 Miyagi Prefecture Off-shore Earthquake, the earthquake resistance standards were fundamentally revised. However, approximately 10 million houses built before 1980 do not meet the new standards. In addition, about 90% of the houses in Japan do not meet the current energy conservation standards because the energy conservation standards for houses established in 1980 were recommended standards, not mandatory standards.

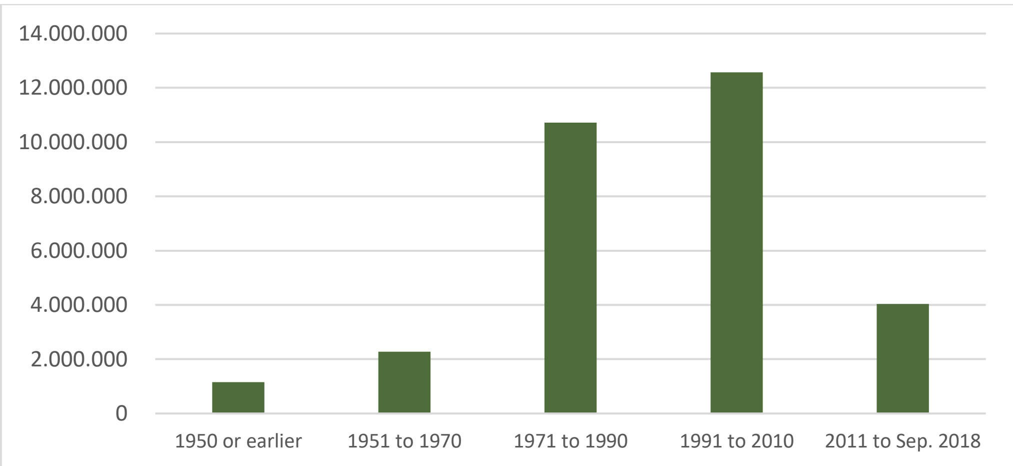


Figure 2-6: Residential Buildings in Japan by Year of Construction as of 2018
Source: Building Stock, Statistics, Ministry of Land, Infrastructure, Transport and Tourism (2018)

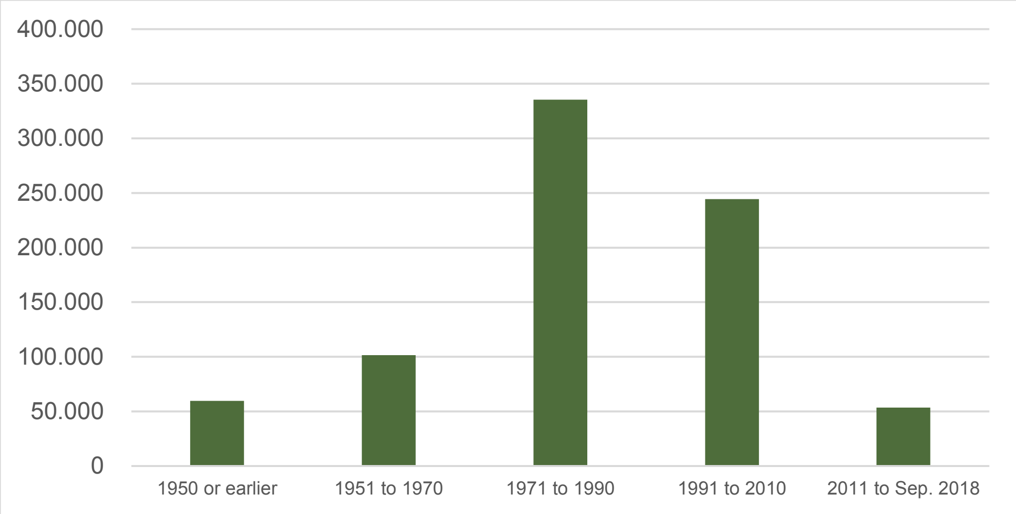


Figure 2-7: Non-residential Buildings in Japan by Year of Construction as of 2018
Source: Building Stock, Statistics, Ministry of Land, Infrastructure, Transport and Tourism (2018)

2.3 Energetic characterization of building stocks

Given differences in the geographical characteristics (climate, likelihood of earthquakes, humidity) of Japan and Germany, the (energetic) characterizations of the buildings in both countries also differ considerably regarding the construction material and the insulation level. These particularities are also partly reflected in different cultural habits, such as the usage of floor heating and practice of a hot bath.

2.3.1 Germany

Around one third of the existing building stock in Germany was built before 1979 and thus before the first *Heat Insulation Ordinance* came into force. Many of these old buildings have not been fully renovated in terms of energy efficiency or have hardly been renovated at all, while new buildings today must meet high energy standards. Compared to new buildings, the energy demand in existing buildings is on average up to five times higher.

Commitments for new construction of *efficiency houses* or to renovate to efficiency house standards have increased enormously since 2018. *Efficiency houses* are buildings with particularly energy-efficient construction and building technology, with a better overall energy performance than required by law. The energy performance of buildings is measured in terms of transmission heat loss and annual primary energy demand. In new construction, *efficiency house commitments* in 2018 were still just over 30,000; in 2021, they were already close to 150,000. Applications for financial incentives for renovation into *efficiency houses* have risen from around 12,000 in 2018 to 23,000 in 2020, due to adjustments in subsidy rates (dena 2022).

From 2010 to 2016, the energy refurbishment rate in Germany was around 1% per year. The highest energy consumption is recorded in existing buildings built up to 1978. The overall refurbishment rate of old buildings built up to 1978 in Germany was 1.4% in 2010-2016 (IWU 2018).

According to an estimate by the German Energy Agency (dena), around 36% of Germany's existing buildings were retrofitted with insulation.[1] Due to subsidies for the Eastern German states after German reunification, the total share of energy renovation in Eastern Germany is about 16 to 22% higher than in the west. Roofs or top floor ceilings are the most frequently retrofitted building components, followed by exterior walls and basement ceilings or floors (dena 2019).

While single-glazed windows dominated in existing buildings from 1950 to 1978, uncoated insulated windows were increasingly installed from 1970 onward. Since the mid-1990s, these have been replaced by coated 2-pane thermal insulation glass with inert gas filling and typical U_w-values of 1.3 W/m^{2}K. Triple thermal insulation glass (U_w below 1.0 W/m^{2}K) has been on the market in Germany since 2005 (VFF / BF 2017).

2.3.1.1 Residential Buildings

Brick, followed by other masonry units, is the predominant building material used in residential buildings built between 2000 and 2002. Until 2011, other masonry units also included sand-lime bricks. From 2003, except for 2010, other masonry blocks were predominantly used. Since 2011, other masonry units have been subdivided in the statistics, so that bricks are the predominantly used building material for residential buildings, with a share of around 34% in 2011 and just under 30% in 2021. The share of construction completions of wood-framed residential buildings has increased from about 12% in 2000 to nearly 15% in 2010 and most recently to about 19 % in 2021 (Destatis 2022b).

As a consequence of the low energy efficiency renovation rates of the past, in the residential building stock, still almost 60% of all dwellings are in the four worst-performing energy classes E to H of the Energy Performance Certificate. For single- and two-family homes, it is even almost 70%, and 24% in the worst energy class H. Only 7% achieved an A or A+ rating, which is the best-performing class; these are mostly new buildings from the las 20 years.

According to a study by the Federal Association of Energy and Water Industries (*German*: Bundesverband der Energie- und Wasserwirtschaft; BDEW), of the 18.9 million residential buildings in Germany, 81.8% were equipped with central heating systems in 2019. About half of these, 40.5%, are natural gas-fired, 29.8% oil-fired, and 2.8% wood or pellet-fired. 3.4% of central heating systems are supplied by electric heat pumps, 5.4% are LPG/coal central heating, gas heat pumps, and other central heating systems. Only 5.4% of all residential buildings are heated with natural gas floor heating systems, 6.6% have district heating, and 6,2% have individual heating systems for each room, such as (night) electric storage heaters, or heaters using wood/pellets, gas, oil, coal, or others (BDEW 2019).

[1] The estimates are based on the building stock data from the Institute for Living and Environment GmbH (*German*: Institut Wohnen und Umwelt, IWU) in 2018.

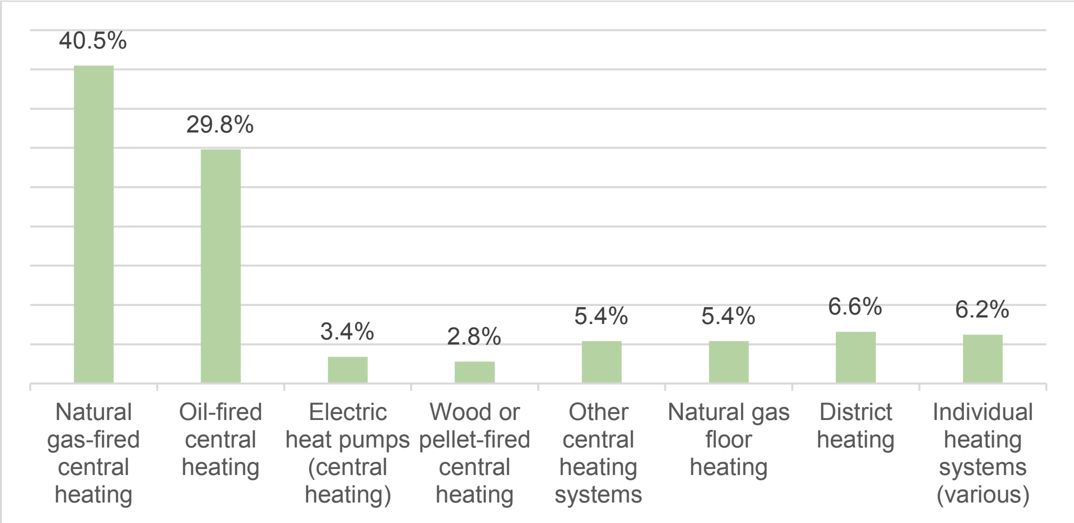


Figure 2-8: Germany: Heating systems in residential buildings 2019

2.3.1.2 Non-residential Buildings

The building materials predominantly used in non-residential buildings in construction completions from 2000 to 2021 were reinforced concrete, followed by steel. Other masonry units, wood, and miscellaneous building materials were used over the years with minor differences in the shares of total building materials. From 2010-2021, the share of reinforced concrete in the building material use has increased with fluctuations. The total annual volume of about 40,000 construction completions of non-residential buildings in 2000, decreased to about 27,000 in 2010, and was only about 22,000 in 2021. In contrast, the share of wood construction of non-residential buildings increased from about 12% in 2000 to about 20% in 2010 and 2021 (Destatis 2022b).

Of the approximately 215,839 residential building completions in 2020 and 2021, about 89% of the buildings were equipped with central heating, 8% are supplied with district heating, and only about 2% were built with block heating. The share of installed floor heating systems and individual room heating systems was far below 1% in this period. 194 buildings were constructed without heating (Destatis 2022c).

2.3.2 Japan

The traditional Japanese building method is the wooden structure. Starting from the 19th century, construction methods other than wooden construction methods were promoted for larger buildings, because wooden buildings were considered vulnerable to fires and inferior in terms of durability. According to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the average lifespan of a wooden house is 27-30 years, while for reinforced-concrete apartment buildings, it is around 37 years.

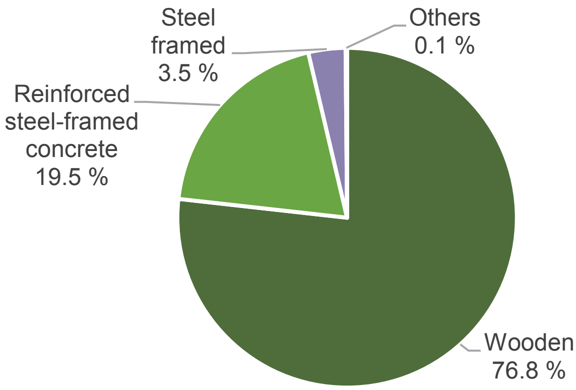


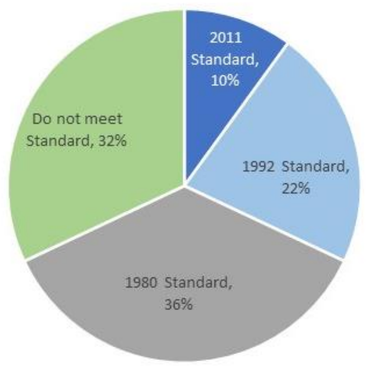
Figure 2-9: Structure type of residential building (FY2018)
Source: Building Stock, Statistics, Ministry of Land, Infrastructure, Transport and Tourism (2018)

2.3.2.1 Residential buildings

The government aims to achieve carbon neutrality in residential and non-residential buildings by ensuring and improving energy efficiency and expanding the introduction of renewable energy. As specific indicators, the government aims to ensure (1) that newly constructed residential and non-residential buildings have energy-saving performance at the level of the ZEH/ZEB standard in 2030, and (2) that the average energy-saving performance of the stock of residential and non-residential buildings will be at the level of the ZEH/ZEB standard in 2050. A Net Zero Energy House (ZEH) is a house with an annual net energy consumption around zero (or less) by saving as much energy as possible and using renewable energies while maintaining a comfortable living environment. This can be achieved through better heat insulation, high-efficiency appliance/equipment, and creating energy with photovoltaic power generation.

A large majority of 90% of the existing housing stock does not meet current energy efficiency standards. By 2050, it is expected that a considerable number of houses will be rebuilt to meet energy-saving standards. However, not all houses will be rebuilt and there will be leftovers of old houses. Thus, in order to reduce the current residential energy consumption as soon as possible, it is essential to promote insulation and energy-saving retrofitting of existing homes. Housing business operators use government subsidies, such as for housing thermal insulation renovation support projects using high-performance building materials, to renovate the entire house or partial insulation and energy-saving renovations.

Heating and cooling account for approximately 30% of the household energy consumption in Japan. An energy-efficient home uses less energy for heating and cooling. In winter, the warm air in the room does not escape, and in summer, heat from the outside does not enter the room, so you can have a comfortable time with less energy for heating and cooling. In other words, it can be said that an energy-efficient home equals comfort and well-being in housing. To realize an energy-efficient home, the three pillars of an energy-efficient home are heat insulation, solar radiation shielding, and air tightness.



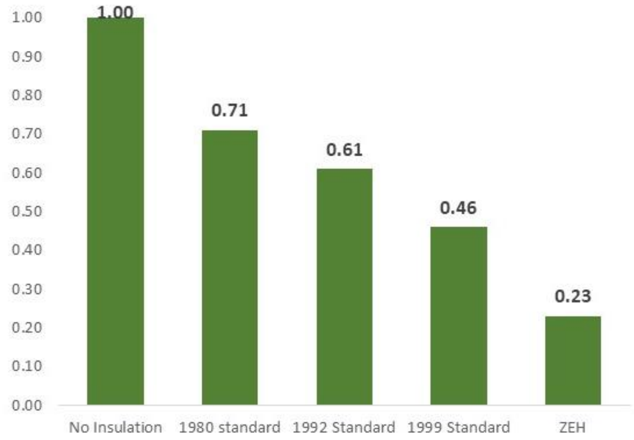


Figure 2-10: (Left)Thermal Insulation performance of about 50 million housing stock (FY2017) (Right) Relative Housing Insulation Performance

Source: Building Stock, Statistics, Ministry of Land, Infrastructure, Transport and Tourism (2018)

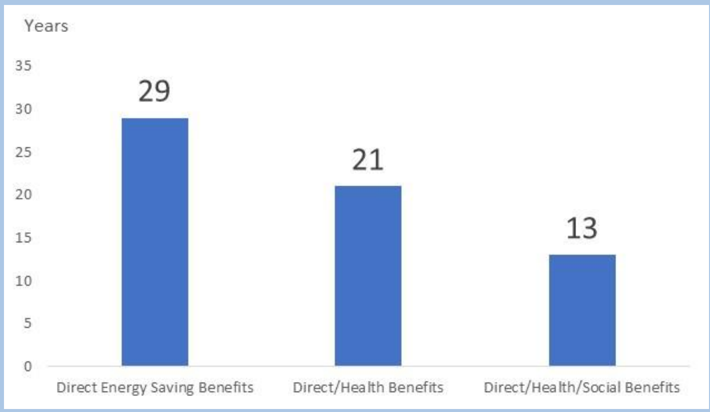
Health Benefits of Thermal Insulation: Case in Japan

High thermal insulation of residential buildings can yield such benefits as energy-savings. Meanwhile, it is important to note the secondary benefit such as the effect on health or wellbeing. In Japan, annually about 19,000 people died from heat shock caused by the difference in temperature between the living room and the dressing room in the bath, which contrasts with the number of people who died in traffic accidents at 2,610 in 2022. A study by Ikaga et al., presents the results of a questionnaire regarding how people's health conditions improve by moving to highly insulated and highly airtight housing. Specifically, the improvement rates are: for cerebrovascular disease (84%), heart disease (81%), diabetes (71%), bronchial asthma (70%), and arthritis (68%).

The effect of improving health condition through insulation is expected to reduce the burden of medical expenses on household expenses. The secondary effect of reducing the burden of medical expenses on the national government is significant as well. In the research by Ikaga et al., the secondary benefit of insulation per household is estimated to be 27,000 yen per year which covers both the avoided burden of medical expenses and the prevention of loss from work. On the other hand, according to the results of the above-mentioned questionnaire, the total benefit per household is estimated at 12,000 yen per year for the avoided medical expenses for heart disease and cerebrovascular disease, which have the highest rate of improvement due to relocation, reduction, and prevention of lost work time.

With reference to this, assuming the investment requirements for thermal insulation at one million Yen, energy savings only can take 29 years to recover the cost. Meanwhile, health benefits combined with energy saving benefits can improve the cost recovery to 21 years. By considering the direct benefits of high insulation, the reduction of medical expenses for households, the prevention of loss of work lost, and the effect of reducing social medical expenses, it will be reduced to 13 years.

Box: The number of years required for cost recovery from thermal insulation



https://xtech.nikkei.com/kn/atcl/bldhbd/15/1703/111100001/

2.3.2.2 Non-residential sector

A ZEB is a building with considerably reduced annual energy consumption by saving as much energy as possible via better heat insulation solar radiation shielding, natural energy and high-efficiency equipment as well as creating energy (e.g., with photovoltaic power generation), while maintaining comfortable environments. To achieve ZEBs, the government of Japan has also decided to introduce an obligation for newly constructed buildings and houses to meet the energy efficiency standards by 2020. The obligation to meet the standards has started to be phased in for large-scale non-residential buildings based on the Building Energy Efficiency Law established in 2015. The act expanded the mandatory sector to medium-scale non-residential buildings in 2021, and all the sectors including residential housing will be covered in 2025.

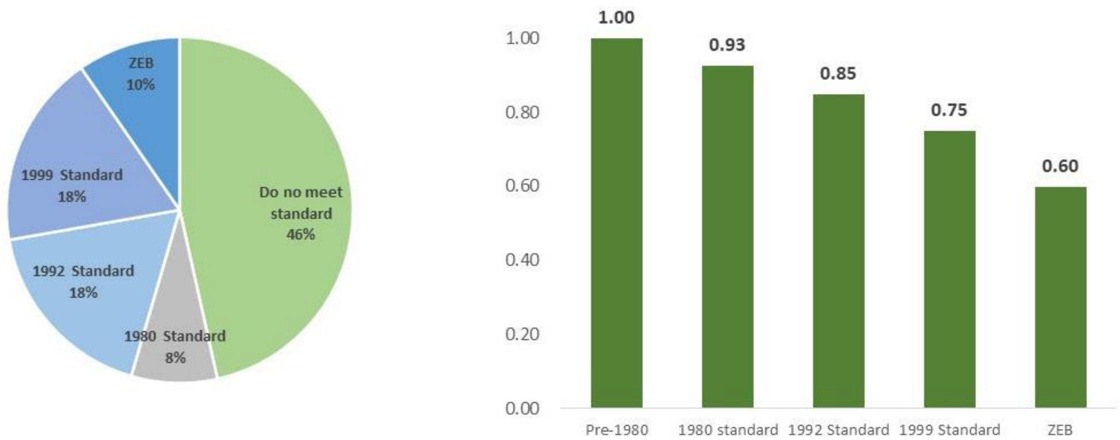


Figure 2-11: (Left)Thermal Insulation performance of non-residential building stock (FY2017) (Right) Relative Non-residential Building Insulation Performance

Source: Building Stock, Statistics, Ministry of Land, Infrastructure, Transport and Tourism (2018)

Similar to the residential building stock, the majority of existing non-residential building stock does not meet current energy efficiency standards.

2.4 Buildings‘ energy intensity

Due to several measures aiming at better insulation of buildings as well as increasing the overall efficiency of heating, cooling, and other electric and electronic appliances used in buildings, the energy intensity of buildings has been gradually reduced throughout the years in both countries.

2.4.1 Germany

While Germany’s overall per capita floor area has increased, there has been a reduction of the energy intensity: The calculated final energy intensity for 2020 for residential buildings amounts to 156.4 kWh/m^2/yr as compared to 204.9 kWh/m^2/yr in 2010, based on not-weather-adjusted data (BMWK 2022). This can be related to improvements in the building insulation as well as in energy efficiency of heating systems. While it is almost a 20% improvement, it is far not harnessing the potentials yet (cf. Rauschen et al. 2020), and far too little for a cost-effective decarbonization of the building stock.

Due to the predominantly central heating systems in Germany and the heating-dominated climate (3,500 to 4,000 heating degree days, 10 to 50 cooling degree days incl. zero dehumidification needs), a large share of the overall energy used in buildings is accounting for heating. Notably, the energy used for cooling in residential buildings has first been measured in 2013, with considerably low values at 0.33 kWh/ m^2/yr on average. Only a tiny part of all residential buildings is equipped with space cooling appliances at all.

A new assessment of the floor area that non-residential buildings account for has only recently been published again, which makes it difficult to show the development of the energy intensity of non-residential buildings throughout the years. Taking the most recent available energy data from the year 2020 and the floor area from 2021, the overall final energy intensity for non-residential buildings of the year 2020 can be said to be approximately 136.2 kWh/m^2/2020 (BMWK 2022).[2]

[2] Please note that the data for the floor area considered has been taken from the year 2021.

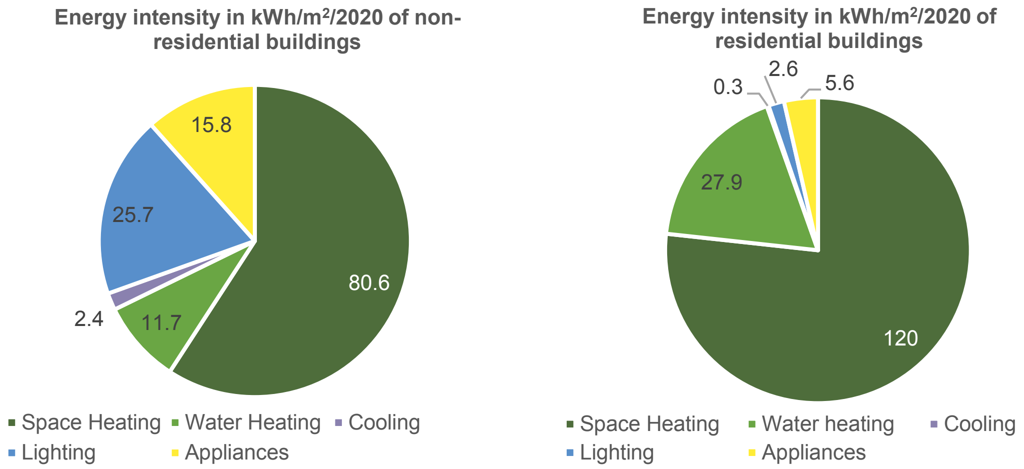


Figure 2-12: Final energy intensity of non-residential and residential buildings, overall and by end use
Source: BMWK Energy data (2022)

Space heating accounts for the largest share of the thermal energy used in the buildings, amounting to 85%.

2.4.2 Japan

In the residential sector, energy intensity in this section is defined as the energy consumption per household. Based on Fig.2-13, it can be observed that Japan's residential energy intensity has increased up to 1995, then improved with a strong decoupling from its economic development. From 1980 to 2020, Japan's GDP per capita increased by 77%, while its residential energy intensity improved by 3.8%.

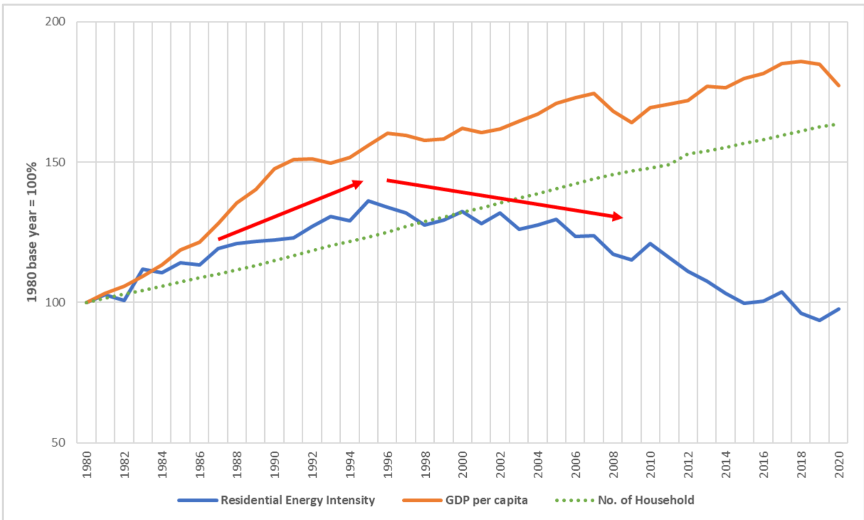


Figure 2-13: Trends in Residential Sector Energy Intensity, No. of Households, and GDP per capita
Source: EDMC (2022). "Handbook of Energy & Economic Statistics"

2.4.2.1 Non-residential sector

In the non-residential sector, energy intensity in this section is defined as the energy consumption per unit of floor space. The trend toward the service economy in the non-residential sector and increasing floor space have contributed to higher energy demand. From 1980 to 2020, Japan's GDP increased by 90%, while its non-residential energy intensity improved by 29%.

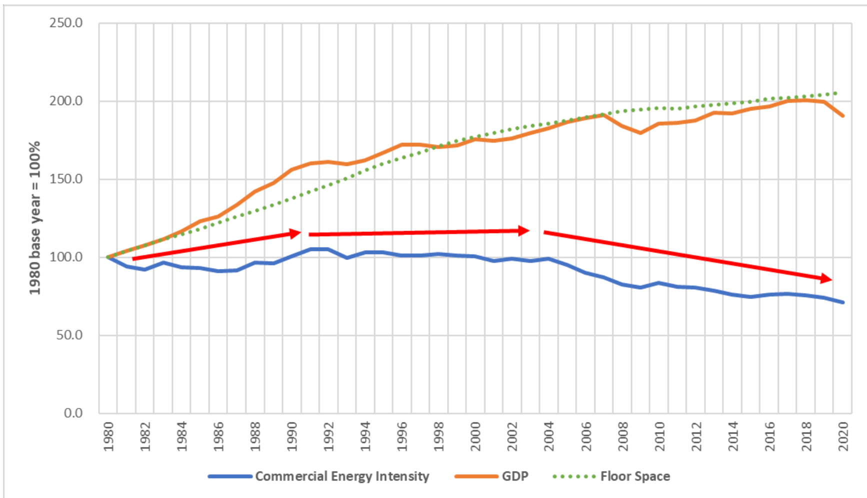


Figure 2-14: Trends in non-residential sector Energy Intensity, Floor Space, and GDP
Source: EDMC (2022). "Handbook of Energy & Economic Statistics"

2.5 Buildings' energy consumption by end use and by type of energy

Developments in both countries to improve the energy efficiency have contributed to overall reduction of the energy consumption in Germany and Japan. While the energy intensity has thus improved in both countries, the overall consumption of energy is still at a high level because of an increase in floor space and the increase of (bigger) electronic appliances. To reduce the overall energy consumption of buildings, the focus of Japan and Germany differs notably: While Germany pushes for the improvement of insulation and heating systems, Japan's focus lies on improving the energy efficiency of electric and electronic appliances.

2.5.1 Germany: energy consumption by type of end use and type of energy

Following the introduction of higher standards (cf chapter 3), the overall energy consumption of buildings per sqm has been successfully reduced. However, due to an increase of per capita floor area, the energy consumption in the building sector remains high. In Germany, 36% of the total energy consumption in buildings are attributed to non-residential buildings (dena 2022).

Figure 2-15 shows the final energy consumption for residential and non-residential buildings over a period of 25 years (1996-2021) sorted by end use (dena 2022). The total energy consumption amounted to 907 TWh in 2021, while a great share of 817 TWh accounts for space heating and hot water, of which 69% was used by private households. In comparison, only a small share of 25% was used by the tertiary sector and 6% by the industry. While the total energy consumption did not reduce further since 2014, the share of air conditioning has risen from 1% in 2018 to 3% in 2021. Other appliances are not included in these data.

In Germany, the energy amount used for space heating decreased between 1996-2014 from 658 TWh (2369 PJ) to 408 TWh (1469 PJ) and increased again to 459 TWh (1652 PJ) until 2021. The final energy consumption for hot water has also increased from 92 to 106 TWh (331 to 382 PJ) in 2021. Despite the effort to reduce final energy consumption, no significant overall savings could be achieved in recent years. The reason for this is the growth in population and floor area, which compensated for the reduction in energy intensity especially since 2014.

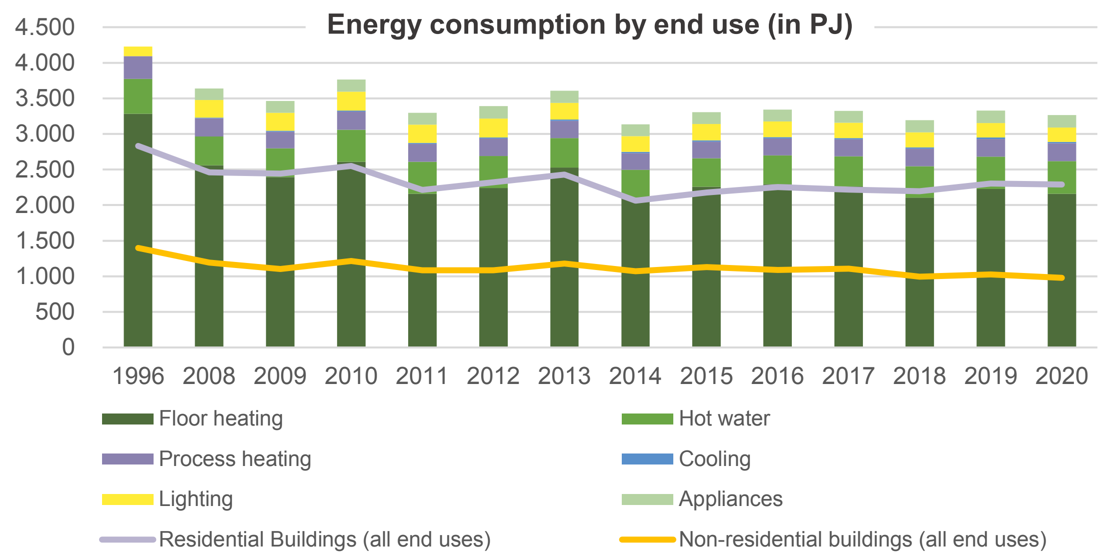


Figure 2-15: Energy consumption by end use in all buildings and total final energy consumption in (non-)residential buildings in Germany (in PJ)
Source: BMWK Energy Data 2022

Figure 2-16 illustrates how the types of final energy source used in the buildings evolved since 2010. The greatest share still contains oil and gas, which constantly remain by about 75% of heating energy supply, although the oil demand decreased by about 4%. Gas takes the largest share for hot water with 58%, followed by electricity with 14% and oil with 13%. The picture is similar for space heating in residential buildings. Here, gas also accounts for the largest share (48%), but here followed by renewables (21%, mainly wood) and oil (17%).

District heating decreased from 16% to 5% in the non-residential sectors, but was stable for residential. The share of renewable energies increased from 3% to 15% for heating and hot water since 2008. However, the share of renewables only gradually increased since 2017.

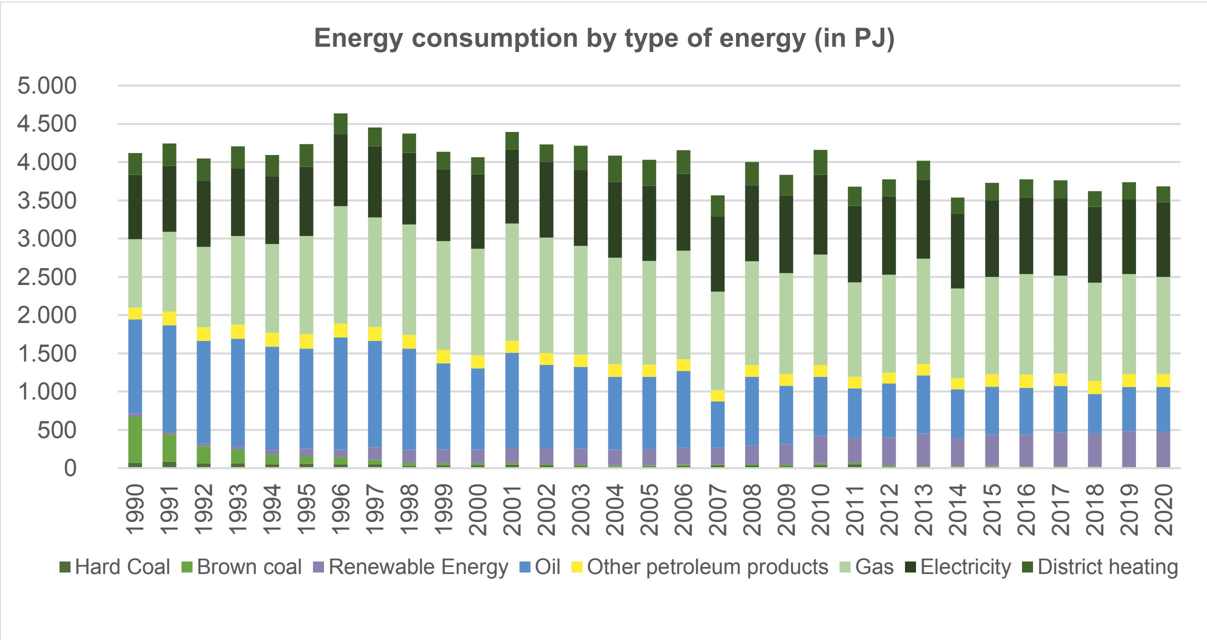


Figure 2-16: Energy consumption by type of energy (in PJ)
Source: BMWK Energy data, 2022

Electric and electronic appliances for various purposes are on the rise in Germany. Among the most populated ones are televisions, cold appliances, and clothes washers, followed by DVD players and dishwashers: More than 96% of all Germans have at least one TV at home (2000-2022). Ownership rates are similar for cold appliances and clothes washers (nor shown in the Figure). A considerable high percentage also possessed a dishwasher in 2022 (74.6% as compared to 48.3% in 2000) or a Personal Computer (92% in 2022 as compared to only 47.3% in 2000). While the overall distribution of DVD players has increased throughout the early millennium years (14.1% in 2002 compared to 70.8% in 2010), they seem to have been replaced recently by Blue-Ray-only-Players amounting to 24.8% in 2022. Other important electronic appliances concern tumble dryers (31.8% in 2000 and 42.7% in 2022) as well as automatic coffee machines (25% in 2022). Such an increase in numbers of appliances contributes to the overall energy consumption of households, while their efficiency is increasing.

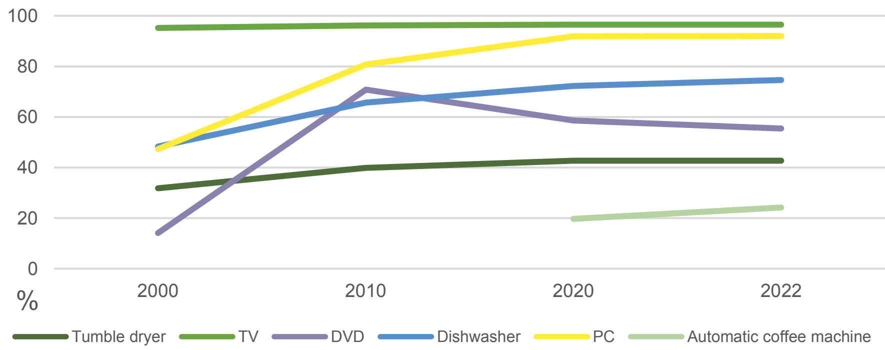


Figure 2-17: Ownership rates of electric and electronic appliances in Germany (2000-2022)
Source. Statista 2023

2.5.2 Japan: Energy Consumption by end use and by source

Figure 2-18 shows that the energy is utilized for various purposes like heating, cooling, kitchen utilities, hot water, lighting/appliances in the residential and non-residential sector. Energy consumption by lighting/ appliances continues to grow, driven mainly by increasing numbers of buildings and ownership of appliances and digital gadgets.

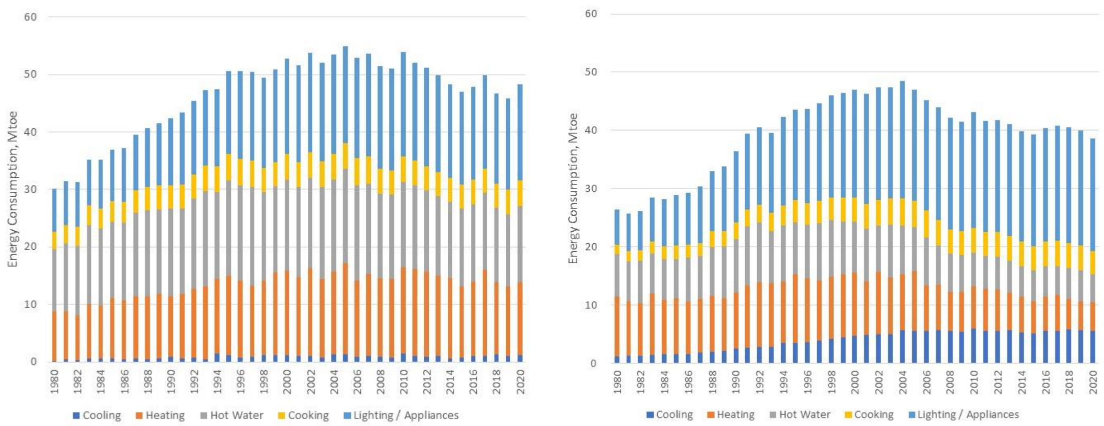


Figure 2-18: Comparison of energy consumption by usage in residential (left) and non-residential buildings (right)
Source: EDMC (2022). "Handbook of Energy & Economic Statistics"

Figure 4-1 shows that energy consumption and end-uses in Japanese households differ significantly from other developed nations. Japan's energy consumption for "heating" is particularly low, while the consumption of "hot water" is higher. It is mainly due to the differences in heating methods and different climates. While people in other countries heat/cool their homes using central controlled systems, most Japanese housings are using "intermittent heating/cooling." Japanese people heat/cool their homes only at the place and time they require heating/cooling. In addition, the Japanese practice hot water bath, which results in higher energy consumption in "hot water" compared to other nations.

The socioeconomic development has raised living standards and directly contributed to the overall increase in residential and non-residential buildings' energy consumption.

Figures 2-19 show the historical trend of residential and non-residential energy consumption by type. Electricity consumption has increased significantly due to the increase ownership of electric appliances and shifts from oil and coal. From 1980 to 2020, residential electricity consumption increased by 18%, while non-residential electricity consumption increased by 34%.

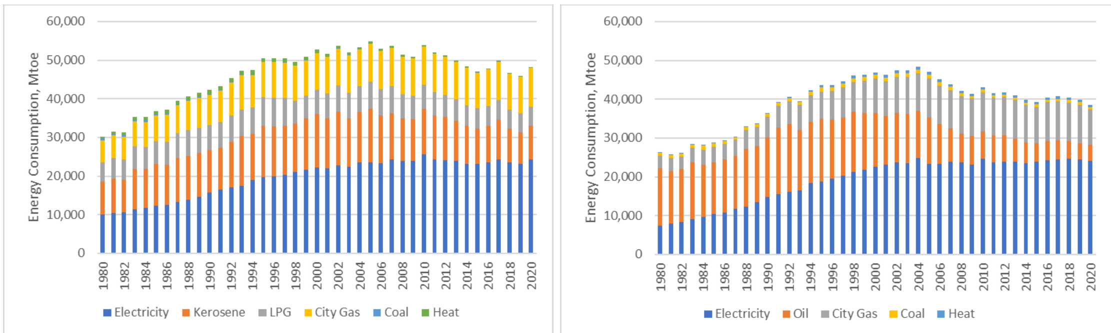


Figure 2-19: Comparison of residential energy consumption in residential (left) and non-residential (right) buildings by type of energy
Source: EDMC Statistics (2022)

	1980	1990	2000	2010	2020
AC	57.9	126.5	217.4	259.9	282.7
TV	150.9	201.3	230.6	239.6	207.6
DVD	-	-	-	133.1	122.5
Computer	-	12.7	65.8	122.9	128.3
Washlet	-	-	53	95.9	113.2

Table 2-1: Ownership rate of appliances (units/100 households)
Source: Consumption trend survey, 2020

The socioeconomic development has led to a widespread diffusion of electrical appliances and increased electricity consumption. The average ownership rate of household appliances has been growing steadily from 1980 to 2020. Nevertheless, because of rising electricity prices observed from 2011, people are shifting towards more energy-efficient appliances, albeit at relatively higher costs.

3 Policies and Strategies towards Decarbonization

3.1 Overview of major existing policies

3.1.1 Germany and the European Union

In 1979, the first *Heat Insulation Ordinance* was introduced, setting new energy efficiency standards for German buildings. Today, the policies in Germany are often required and guided by EU directives (cf textbox “EU regulations and its impact on Germany’s policies” at the end of this chapter). In addition to regulations described in 3.1.1.1 that are imposed on building owners, there are also several information and advice programs as well as financial incentives/financing mechanisms to support them in implementing energy efficiency measures, such as energy renovation and exchange of heating systems (cf. 3.1.1.2).

Among the major existing policies aiming at improving the building sectors’ energy efficiency are the following:

1) Energy performance and renewable energy requirements, and other provisions in the Buildings Energy Act (Gebäudeenergiegesetz, GEG)
2) Energy performance certificates and energy advice programs
3) Financial incentives and financing schemes

In addition to specific energy efficiency policies for buildings, there is also the German Climate Change Act that sets sector targets, including for the building sector (cf. chapter 3.2). Following the revision of the German Climate Change Act in 2021, the sector targets have been tightened, now aiming at a reduction of annual emissions by 53 Mt CO_2 (44%) until 2030 in the building sector compared to 2018. So far, however, little progress has been made. Generally, the GHG emissions gradually decreased since 1990 with a sharp decline in 2020 due to the pandemic (cf. figure 3-1). However, particularly the transport and the building sector missed their targets for 2020 and 2021. Accordingly, substantial additional measures are necessary to eventually meet the targets in 2030, cf. chapter 3.2.

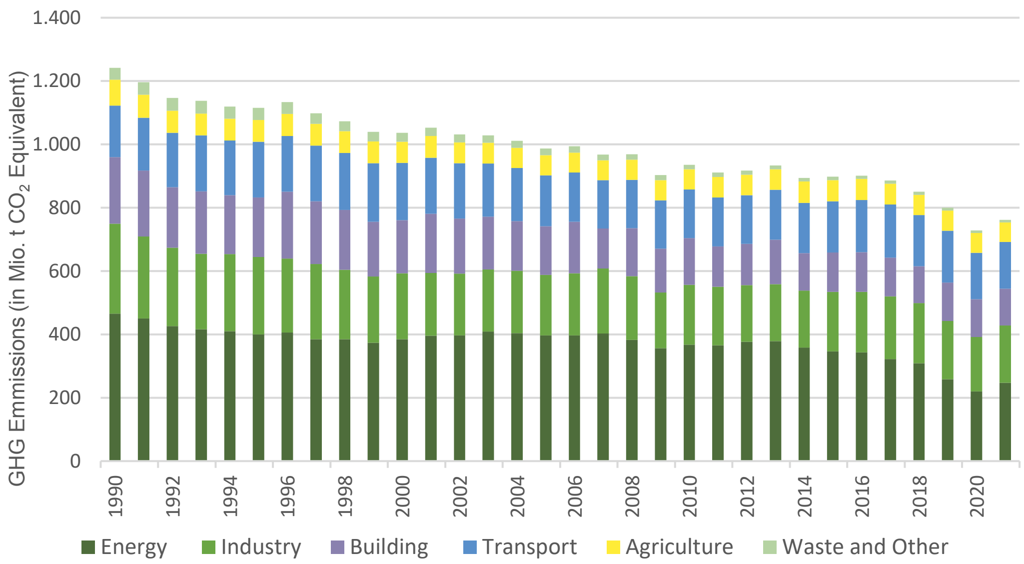


Figure 3-1: Sector specific development of GHG emissions in Germany (UBA 2022a)

3.1.1.1 Buildings Energy Act (GEG)

The *Buildings Energy Act* (GEG) was introduced on 01.11.2020. It is a combination of the former *Energy Saving Act* (EnEG, 1976-2020), *Energy Saving Ordinance* (EnEV, 2002-2020) and *Renewable Energies Heat Act* (EEWärmeG, 2009-2020) into a uniform set of regulations. Compliance with it is mandatory for new buildings and in case of major renovation[3], in which case energy-efficient renovations are required. The GEG is the legal basis for the energy assessment of residential and non-residential buildings. It represents a uniform system of requirements, in which thermal insulation and the overall performance of the building envelope, energy efficiency of the installed systems, and renewable energies are integrated.

Buildings Energy Act (GEG): Energy performance requirements

The German law distinguishes between requirements for new buildings and renovations as well as between residential and non-residential buildings:

- For new buildings, requirements are set for the annual primary energy demand of the building, the energy quality of the building envelope and the use of renewable energies. When defining the primary energy factors of energy sources, the energy demand for their extraction, processing and transport is considered by means of lump-sum primary energy factors.
- Residential buildings' energy requirements are set for heating, domestic hot water, ventilation, and cooling. Non-residential buildings also have energy requirements for the same end uses plus lighting.
- The maximum allowed value for the annual primary energy demand of a new building is determined individually for each building, based on a reference building with the same shape and size.
- According to current legislation, the annual primary energy demand of new planned buildings with the planned thermal insulation and technical equipment must currently be at least 45 % below the annual primary energy demand of the reference building.

Figure 3-2 presents an example of the development over time of the requirements for new residential buildings (step curve), following advances in research and development (lower curve).

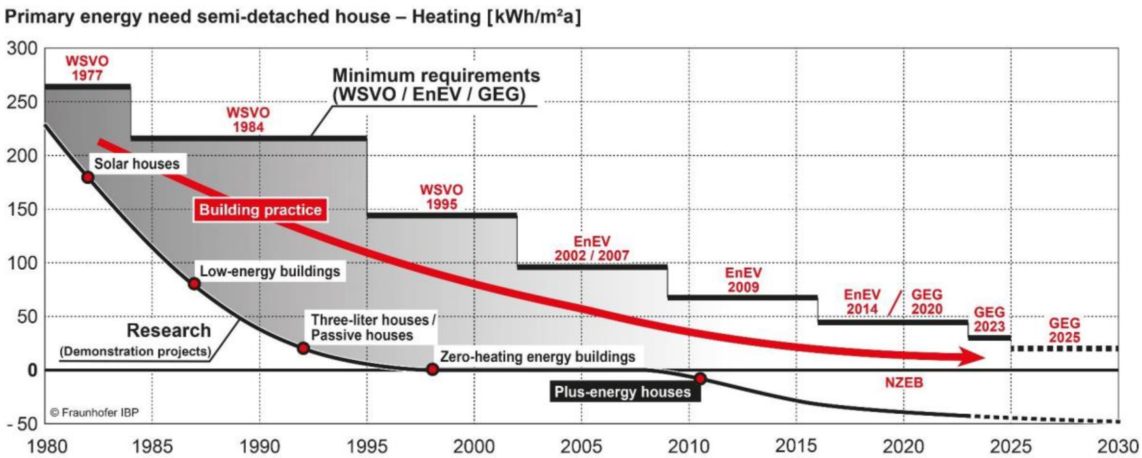


Figure 3-2: Evolvement of energy performance requirement for a common type of new residential buildings
Source: Hans Erhorn, Head of Department of Energy Efficiency and Indoor Climate, Fraunhofer IBP 2022

[3] Major renovation is defined as 'more than 25% of the surface of the building envelope undergoing renovation' (for whichever reasons).

3.1.1.2 Energy performance certificates

A building that is sold or rented must have an *Energy Performance Certificate* (EPC) according to the building energy act. The final and primary energy demand are shown in the EPC. Calculation is based on *DIN 18599 Energy Performance of Buildings*. For residential buildings, there is an energy classification on an A+ to H scale.

- It must be presented to interested parties at the latest when viewing the property.
- After conclusion of a purchase, lease, or rental agreement, it must be handed over.
- It is also an orientation for the energetic building renovation and shows energetic deficiencies of the building as well as possible measures to improve the energy performance.

3.1.1.3 Energy advice system and financial incentives for energy consulting for residential buildings

The current directive on the promotion of energy consulting for residential buildings came into force on 01.02.2020. Comprehensive energy consulting for residential buildings is eligible for grants, in case of the German form of a *renovation passport* with 80% of the cost. This type of an energy refurbishment concept must show to the building owner how a residential building can be comprehensively refurbished for energy efficiency step by step over a longer period or how, with the help of the comprehensive refurbishment, an *efficiency house standard* can be achieved that can be funded by the federal government.

3.1.1.4 Financial incentives for energy-efficient renovation and renewable heating systems

The funding for financial incentives and soft loans for the energy efficiency of buildings and the use of renewable heat is provided since ca. 2005. The last major revision of the programs was on 01.07.2021. It is now named *federal funding for efficient buildings* (BEG). The total amount of government spending for these programs used to be around € 2 billion/yr and was increased to around € 5 billion/yr in 2021/22 as a countermeasure against the recession caused by Covid-19. The BEG contains three subprograms: (1) residential buildings (systemic), (2) non-residential buildings (systemic) and (3) individual measures.

Financial support is offered for systemic measures, with which a specified efficiency level of the entire building is achieved during the renovation or new construction of buildings. The new or renovated building must meet the requirements of a so-called *efficiency house standard*. The higher the *energy efficiency standard*, the higher is the grant, up to 45% in renovation. Specific requirements for an efficient building are defined in terms of the annual primary energy demand, as a percentage of the demand of the reference building as defined in the GEG. Applicants can choose between a loan with a reduced interest rate and a grant component or a direct investment grant. Grants of 15% are also offered for individual measures for the energy-efficient refurbishment of residential and non-residential buildings. If the owner has a renovation passport, the grant will be 5% higher.

Prerequisite for the loan and/or grant is the compliance with minimum technical requirements, and an approved energy efficiency expert must be involved, who accompanies the subsidized construction measures and certifies compliance with the subsidy requirements.

The use of renewable energies in residential as well as non-residential buildings is rewarded with a 5% higher grant and a € 30.000 higher maximum subsidy amount for each efficiency house class. To achieve this *renewable energy class*, at least 55% of the heating and energy requirements of the efficiency house must be covered by renewable energies or waste heat. Alternatively, the consideration of sustainability aspects in non-residential buildings is rewarded with the higher maximum subsidy amounts for each efficiency house class too. With sustainability certification, energy-efficient non-residential buildings can achieve the so-called *sustainability class* for the higher grant percentage limits.

3.1.1.5 Lifecycle Assessment and Embodied Energy (non-renewable primary energy) – Existing Policies

Requirements for CO_2 eq. kg/m² (GWP) and non-renewable primary energy MJ/m² (embodied Energy) and other environmental impacts, have existed in the German sustainability certification systems (DGNB (German Sustainable Building Council) and BNB (Assessment System for Sustainable Buildings) since 2008. A life cycle assessment (LCA) must be carried out for all buildings to be certified.

Since July 2021, the federal government has been promoting sustainability aspects through its own *NH-Klasse* (Nachhaltigkeitsklasse, *engl.* sustainability class) as part of the BEG. The required proof for the financial support is provided by awarding the building related QNG (Qualitätssiegel für Nachhaltige Gebäude, *engl*. Quality Seal Sustainable Building). The requirements for the QNG include the following (using residential buildings as an example):

- General requirement: the building must be certified according to an approved registered sustainability rating system.
- Specific requirements (selection): Compliance with defined requirements for greenhouse gas and non-renewable primary energy. Use of wood from sustainable forestry for at least 50% of wooden building parts.
- There are different requirements for residential and non-residential buildings.

Since about 2010, data and calculation tools are available free of charge for LCA calculations (cf. Appendix).

3.1.1.6 The EU Ecodesign Regulation

In 2005, the EU agreed on the Ecodesign Directive which aims at reducing the environmental impact of energy-related products by setting minimum requirements for the product design. ‘Energy-related product’s refers to products that either do or do not directly need energy to be operated but partly influence the energy consumption (e.g., the amount of (hot) water running through a shower head). Importantly, the directive, that has been revised in 2012 and 2016, considers not only the energy used to operate the products but the entire life cycle of the products. The Energy-Related Products Act (EVPG) transposes the directive into German law.

In addition to self-regulatory initiatives by the industries, certain products are subject to strict regulation if:

- they reach an annual sales volume of 200,000 pieces and more
- they have a significant impact on the environment according to the defined priorities of the European Commission (cf. 1600/2002/EG)
- considerable potential to improve the environmental-friendliness without causing excessive costs

The current list of products subject to regulations comprises a number of 29 products, among them refrigerators, circulation pumps, dish washers, windows, insulation materials and light.

According to the estimation of the European Commission, the release of ten new Ecodesign regulations in 2019 will potentially lead to energy savings amounting to 167 TWh by 2030, which corresponds to roughly 46 million tons of CO_{2eq}. Based on this EU regulation, the industries' competitiveness is ensured while their costs for energy and resources are reduced.

EU regulations and its impact on Germany's policies

Since 2002, the EU has a framework directive on the overall *Energy Performance of Buildings* (EPBD, currently Directive 2018/844/EU). Together with the *Energy Efficiency Directive* (2012/27/EU), the EU thus established a legislative framework to boost the energy performance of buildings among the Member States, aiming at:

- a highly energy efficient and decarbonized building stock by 2050
- a stable environment for investment decisions
- the provision of information enabling consumers and business to make more informed choices to save energy and money

It has been revised twice since then, and it requires the EU Member States to implement certain types of policy instruments as listed below:

1. **long-term renovation strategies** aiming at the decarbonization of the national building stock by 2050 (with indicative milestones for 2030 and 2040) aligned with the national energy and climate plans (NECPs)
2. **minimum energy performance requirements** for new buildings for existing buildings undergoing major renovation, and for the replacement or retrofit of building elements like heating and cooling systems, roofs and walls;
for all new buildings built after 2021 (for all new public buildings since 2019) the nearly zero-energy building (NZEB) standard applies
3. **energy performance certificates** must be issued and displayed upon sale and rental
4. **regular inspections** for heating and air conditioning systems are required
5. once exceeding a certain size, car parks must provide the necessary infrastructure for **electro-mobility**
6. enabling the installation of **smart technologies** (e.g., devices that regulate temperature at room level) that also address health and well-being of users

7. ensuring the improvement of energy efficiency of buildings by providing a list of **national financial measures** (increasing transparency)
8. (based on the *Energy Efficiency Directive*) ensuring that at least 3% of the total floor area of public buildings undergo **energy efficient renovations**

It is, therefore, the EU framework for most of the national policy measures presented above.

3.1.2 Japan

3.1.2.1 History of energy efficiency legislation for buildings

The two oil crises in the 1970s triggered the establishment of "*The Energy Conservation Law*" (hereinafter referred to as EC Law) in 1979 to promote energy saving and energy conservation. Historically, the EC Law was enacted to improve energy efficiency in the industry sector. To cope with climate policies and rising energy consumption, the EC law was amended to include the residential and the non-residential sectors. When the Kyoto Protocol came into force in 1998, Japan was required to accelerate further energy conservation efforts to achieve its GHG emission reduction target. In 1998 *the Top Runner Program* was introduced in the revision of the EC Law to save energy consumption in the residential and non-residential sectors by setting ambitious efficiency targets for appliances. It is now considered one of the most significant climate policies of Japan, as the Top Runner Program covers 70% of appliances energy usages.

After the Great East Japan Earthquake in 2011, Japan faced an energy crisis in its electric power supply due to the nationwide shutdown of nuclear power plants. It was necessary for Japan to secure the effective utilization of fossil fuels and increase renewable energy to make up for the generation losses from nuclear power. On top of these supply-side-measures, it was necessary for Japan to improve the energy efficiency and conservation of residences, buildings, facilities, and equipment in the non-residential and residential sectors. Against this background, the EC Law was revised to add measures relating to (1) the promotion of electricity demand leveling and (2) the expansion of *the Top Runner Program* to include further energy-consuming equipment. In addition, since 2015, building energy regulations for new buildings are provided by the *Building Energy Conservation Law*.

1979	**Energy Conservation Law**	
	Envelope Standard	**Primary Energy Use Standard**
1980	Class 2 Standard	
1992	Class 3 Standard, Heat Loss(Q) and Solar Heat Gain (μ) Coefficient	
1999	Class 4 Standard, adding Air Tightness (C)	
2006		Energy Performance reporting (non-res.,FS>2000m²)
2009		Energy Performance reporting (non-res. 2,000>FS>300m²) Top Runner Housing (Built Single Home suppliers)
2013	2013 Standard, Heat Loss (Ua), Solar Heat Gain (ηa) Coefficient	Primary Energy Use Standard, with 8 climate regions
2015	**Building Energy Conservation Law**	
2016	2016 Standard	**Mandatory** Energy Performance (non-res.,FS>2000m²)
2021		**Mandatory** Energy Performance (non-res.,2,000>FS>300m²)
2025		**Mandatory, all new housing and buildings**

3.1.2.2 The Top Runner Program

The products covered in the Top Runner Program are chosen by their high energy usage or widespread usage in the community. After the introduction of the program, the targeted products' energy efficiency has increased, and the number of items covered has been expanded to 32 appliances/technologies. As an example for an important appliance for buildings in Japan, Figure 3-3 shows how the standard annual energy consumption of a 2.8 kW air-conditioner unit has improved over the years under the Top Runner Program.

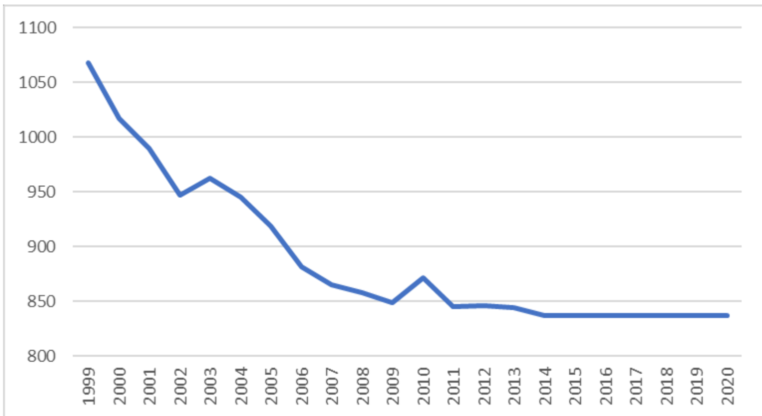


Figure 3-3 Annual AC Electricity Consumption (standard kWh/yr for a unit of 2.8kW)
Source: Ministry of Economy, Trade and Industry (2022). "Catalogue of Energy Efficiency Performance of Appliances"

Energy efficiency standards are set to be achieved within a given number of years based on the most efficient model on the market (the 'Top Runner'). Manufacturers' weighted average product sales are analyzed to evaluate compliance with the standard. Manufacturers must ensure that the weighted average efficiency of the products they sell in a target year achieves the standards. Therefore, not all of a manufacturer's products have to meet the standard, but the weighted average of all products has to be compliant. This flexibility enables manufacturers to provide a wide range of models to meet the market demand while guiding the overall market to higher energy efficiency.

The Energy Conservation Law requires major appliances to achieve target efficiency performance and the performance labeling to be displayed. Tables 3-1 and 3-2 present recent improvements of target efficiency performance for building-related appliances and components.

Table 3-1: Major appliances and their target EE performance

Appliance	EE target	update	Improved Efficiency
Room Air Conditioner	APF 6.6, with capacity < 4.4kW APF 5.3-6.6, proportional with Capacity	2022	14% more efficient with Capacity <4.4kW 16%-35% more efficient with Capacity>4,4kW
Refrigerator	kWh consumption, with a product storage volume	2020	22% more efficient than 2014 Standard
Hot Water Boiler	Efficiency ratio to the input energy	2021	5%-7% more efficient
Gas Cooking Stove	Wh: input energy	2019	16%-25% more efficient
Lighting and bulbs	Lm/W: unit consumption	2019	Overall improvement 293% Fluorescent lamp 6.6% improvement LED lamp 51% improvement

Table 3-2: Housing and Building Energy Efficiency Performance

Segment	Material	update	Improvement
Wall Insulation materials	Standard heat loss prevention performance: Polyethylene foam:0.03232, Glass foam: 0.04156, Slug foam: 0.03781	2020	0.5%-6.2% improvement from 2012 Level
Window Sashes	Heat Loss Prevention Performance Formula, with the window area and the Sashe types	2019	3.0%-15.4% improvement from 2012 Level
Double paned Window	Heat Loss Prevention Performance <2 mm; 3.85 2 mm-16 mm: U=－1.00In (thickness)+4.55 16 mm<: 1.77	2019	7.3% improvement from 2012 Level

3.1.2.3 Promotion of energy consumption performance labeling

The building EE code requires the building EE performance label to be displayed in the advertisement of sales and rent. There are two types of labels, introduced in FY2009:

"*Energy efficiency Performance Label*" and *"Insulation Performance Label*". The "*Energy Efficiency performance Label*" represents the primary energy consumption by heating/cooling, hot water supply, and lighting. In contrast, the "*Insulation Performance Label*" means thermal loss prevention by exterior walls, windows, and doors, with recommended levels as the next-generation performance.

Each label has a different grade, the green-colored label is issued by an authorized third-party organization audit, and the constructor's self-audit issues the blue-colored label (Fig.3-4).

Figure 3-4: Housing and Building Energy Efficiency Performance Label

3.2 Recent or planned changes including amendments of existing policies

3.2.1 Germany

3.2.1.1 Buildings Energy Act (GEG)

From January 1, 2023, Efficiency House 55 has become the standard for new buildings (regarding primary energy demand but not for thermal insulation requirements). From 2025, the Efficiency House 40 will be the standard for new buildings. From 2024, the renovated components of major conversions and extensions to existing buildings must comply with the Efficiency House 70 standard.

From 2024, every newly installed heating system should use at least 65% of renewable energy, which is expected to boost heat pumps and district heating but also biomass. Details are currently being defined.

From the beginning of 2026, boilers fueled with heating oil or solid fossil fuels may only be put into operation if certain conditions are met, such as no alternatives using renewable energies being available. Oil and natural gas boilers installed up to 1996 may still be operated until 2026 at the latest. From 2045, no boilers may be operated using natural gas.

3.2.1.2 Federal funding for efficient buildings (BEG)

Details of the grant and loan schemes are adapted from time to time to changes in the market, such as commercial interest rates, renovation costs, and energy prices. Details of the changes implemented in 2021/22 and planned for 2023 are presented in the Annex. Here, we only highlight some important changes. The total amount of government spending for these programs shall be increased to € 12 to 14 billion/yr until 2026, increased from around € 5 billion/yr in 2021/22. The funding amount for very energy-efficient *new* buildings will be reduced, the focus will be on energy efficiency *renovation* of existing buildings in the future. From March 1 (2023), new buildings (efficient house 40 with sustainable class) are being subsidized via a new guideline.

A Worst-Performing-Building-Bonus (WPB-Bonus) for the refurbishment of the energetically worst buildings is 10% points of the investment, based on the worst classes of energy performance certificates. In addition, the WPB-Bonus is available not only for refurbishment to Efficiency House 55 and 40, but also for refurbishment to Efficiency House 70 with renewable energy class.

For residential buildings, a new bonus for "serial refurbishment" (SerSan bonus) of 15% points of the investment has been introduced, which can additionally be claimed in the case of refurbishment to efficiency house 55 or 40.

3.2.1.3 Federal funding for efficient heating networks

The German government wants to support and accelerate the decarbonization of heating and cooling networks in Germany with a new financial incentive program. Two areas are targeted with subsidies of 40-50 % of the investment: 1) the construction of new heating networks with high shares of renewable energies and waste heat as well as 2) the expansion of existing networks and their transformation to renewable energy sources.

3.2.1.4 Municipal heat planning

Municipal heat planning is considered important to provide guidance to building owners and energy suppliers on which buildings would be served by either district heating or individual heating in the future. Denmark has a successful history of more than 40 years with this tool, and it was the basis for the very high share of both district heating and renewable energies in heating the country's homes and buildings (State of Green 2018; Ea Energy Analyses & Viegand and Maagøe 2020). With a revision of the municipal guideline, an impulse subsidy for municipal heat planning has been introduced as of November 1 (2022). The federal government wants to legally obligate the states to have heat plans drawn up for a certain portion of the population and an associated space heating requirement (e.g., 75%).

In the new funding priority, the preparation of municipal heat plans by expert external service providers is supported with a grant. If applications are submitted by the end of 2023, the subsidy amounts to 90% of the total eligible expenditure; for financially weak municipalities and applicants from lignite mining regions, the subsidy amounts to 100%. After that, the grant rates are reduced to 60% and 80% respectively. After the federal law for municipal heat planning comes into force, every obligated municipality should have drawn up a heat plan after three years at the latest. The heat plans are to be updated every five years.

Developments in EU policies:
The European Green Deal and Fit for 55 and Revision of the EU Buildings Directive

In the context of the European Green Deal, the EU agreed on the Fit for 55 packages aiming at an overall reduction of 55% of the GHG emissions in the EU until 2030. To achieve this ambitious target, efforts in the building sectors need to be reenforced. Against this background, the European Commission published its a proposal for the recast of the EU's Energy Performance of Buildings Directive (EPBD) in December 2021.

- After the Commission proposal, the European Council and the European Parliament have debated it, and an agreement is expected during the summer of 2023.
- The main objectives of the revision are that all new buildings should be zero-emission buildings by 2030 at the latest and that existing buildings should be converted into zero-emission buildings by 2050.
- A "zero-emission building" is a building with a very high overall energy efficiency that requires no or a very small amount of energy, produces no CO_2 emissions from fossil fuels on site, and produces no or a very small amount of operational greenhouse gas

emissions.

- An important proposed new element is a mandatory requirement that the worst-performing buildings must improve to a certain energy performance level, closer to today's average level, by certain dates between 2027 and 2033. This is called 'minimum energy performance standards'.
- From 2025, Member States shall introduce 'renovation passports' on a voluntary basis. These include a roadmap on how stepwise energy efficiency renovation can lead to a very energy-efficient zero-emission status in the end.
- Life cycle assessment is to become mandatory throughout the EU from 2027 for large new buildings and from 2030 for all new buildings.
- In addition, there are lots of smaller amendments to improve the effectiveness of the existing provisions, cf. chapter 3.1.1.

Link: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0802

3.2.2 Japan

In June 2022, housing-related legislation mainly including the law about energy consumption performance gain of buildings (hereinafter called as "*Building Energy Conservation Law*"), *the Building Standards Act* and *the Architectural Act* was revised. The revision aims at a decarbonized society by encouraging the installation of renewable energy equipment (e.g., PV panels, solar heat, underground heat) in buildings and the use of wood in buildings. As a result of the revision, the reduction of approximately 8.89 million kLoe (345 PJ) in energy consumption for homes and buildings in FY2030 compared to FY2013 is expected.

This series of revisions was realized based on the *Roadmap of the Building sector Decarbonization toward 2050 Carbon Neutral Society* published in August 2021, which is outlined in the next sub-chapter.

Under the current law, the obligation to comply with energy conservation standards is imposed on builders of new constructions or expansion of medium- and large-scale (300 m^2 or more) non-residential buildings, while only notification was required for medium- and large-scale (300 m^2 or more) residential buildings. The current revision expands this obligation to include small-scale non-housing and residential buildings, making it mandatory for all new residential and non-residential buildings to comply with energy conservation standards. Specifically, before construction of a building begins, a "building permit" is issued to confirm that the construction plan complies with the Building Standard Law and other standards, and that compliance with energy conservation standards is inspected together with structural safety regulations.

In consideration of the current situation of small- and medium-sized construction companies and the inspection system, the implementation will start for buildings to be constructed in or after 2025.

	Building Energy Conservation Act (2015)		2022 Amendment	
	Non Residential	Residential	Non Residential	Residential
Large (FS >2,000m²)	**Mandatory (2017 Apr.)**	Performance Reporting	Mandatory (2017 Apr.)	**Mandatory (2025 Jun.)**
Medium (300<FS<2000m²)	**Mandatory (2021 Apr.)**	Performance Reporting	Mandatory (2021 Apr.)	**Mandatory (2025 Jun.)**
Small (FS<300m²)	Advisory notice required	Advisory notice required	**Mandatory (2025 Jun.)**	**Mandatory (2025 Jun.)**

Figure 3-5: Expansion of obligation to comply with energy conservation standards

Conformity to the standard will be required for additions and renovations by installing a certain amount of heat-insulating materials and windows in the walls, roof, and windows of the extension, and by installing equipment (air conditioning, lighting, etc.) with a certain level of performance in the extension which meets the requirement of energy conservation standards.

With the expansion of the obligation to comply with energy conservation standards, the scope of explanations to architects regarding compliance with energy conservation standards has also been expanded to include all buildings (new constructions and additions).

The Energy Conservation Law revised in 2008 introduced the *"Residential Top Runner Programme"*, which obliges businesses that supply more than a certain number of housing units in a year to make an effort to meet, on average, a standard that exceeds energy conservation standards set by the government ("Top Runner Standards") for newly supplied housing by the target year. The current law covers detached houses for sale, custom-built houses, and rental apartments. The current revision includes condominiums as well, with the aim of further improving energy-saving performance.

Housing Suppliers	Standard Design Built Detached Homes	Custom Built Detached Homes	Multi Dwelling Apartments (low, lease/owned, wood or steel)	**Condominiums (mostly high, owned, steel)**
	Housing Developer >150 units	Constructors > 300 units	Constructors >1,000 units	Constructors >1,000 units
Envelope	All units must comply the Act requirements			
Primary Energy Reduction from the Act Requirement **(ZEH Level)**	The average reduction of sold units.			
	another 15%	**another 25%**	**another 10%**	**another 20%**
Year of Application	From 2020	From 2024	From 2024	From 2026

Figure 3-6: Housing suppliers Top Runner Program leading to ZEH Level Performance

3.2.2.1 Promotion of introduction of renewable energy facilities

Renewable energy, mainly solar power generation, has been increasing since the introduction of *the Feed-in-tariff (FIT) scheme* in 2012, but to achieve the Green House Gas emission reduction target, it is necessary to expand the use of renewable energy in the building sector. On the other hand, since solar power generation is greatly affected by climate and location conditions, it would be more effective for municipalities to promote the installation of photovoltaic power generation based on local conditions rather than for the government to establish uniform regulatory measures throughout the country. Based on this recognition, the current revision requires municipalities to designate areas where solar panels and other renewable energy facilities must be installed ("renewable energy use promotion areas") and to prepare promotion plans that include the types of renewable energy to be installed and promoted. In particular height restrictions, floor-area ratio restrictions, and building-to-land ratio restrictions for buildings that conform to the promotion plan will be relaxed in the promotion zone through a special permit system, thereby encouraging the accelerated installation of renewable energy facilities.

A few municipalities implemented higher insulation grades with grant incentives, and Kyoto City has implemented mandatory rooftop PVs on new constructions. Kyoto's ordinance currently applies only the non-residential buildings, with constructors' obligation to advise the owner to install rooftop PVs. Tokyo metropolitan government is planning to implement the same ordinance in 2025.

In addition, architects will be held accountable for explaining the effects of installing renewable energy to building owners. Under this revision, an architect who, in the designated areas, is commissioned to design a building with installed renewable energy must explain to the owner certain matters related to the renewable energy facilities, such as the types and scale of renewable energy facilities that can be installed, the amount of energy created by the installation, and the effect of reducing utility costs.

The feed-in-tariff program with the rooftop PV is already phasing out, and therefore it is most cost-effective to use rooftop PV-generated electricity to be fully utilized at the premise. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of Economy, Trade, and Industry (METI) are vigorously promoting the deployment of battery storage in the building sector along with rooftop PV installation. The ministry of environment (MOE) provides a leading net-zero community subsidiary program. The applicant with rooftop PV and battery storage can receive up to 75% of the system/installation costs.

3.2.2.2 Rationalization of building standards to promote wood use, etc.

The use of wood is expected to have carbon fixation and emission reduction effects. Therefore, the rationalization of building standards has been implemented to promote the increased use of wood in the building sector, which currently accounts for 40% of the total demand for wood.

Wood materials have been popular in housing construction in Japan for a very long time. MLIT acknowledged the importance of the wood material promotions in the 2015 White Paper, with the long-term policy on the LCA (Life cycle assessment) low carbon housing or even an LCCM (Life Cycle Carbon Minus) housing. Wood materials carry lower embodied carbon than concrete and steel materials. Good forest management in the wood material industry is perfect for a carbon-neutral target country, such as Japan.

The study group of MLIT has been working on the expansion of the wood material use and necessary building guidelines and code amendments. The structural strength, especially the joint and the section, is one of the challenging issues. There are a few design-load changes, a roof weight considering wet snow conditions, heavier insulated walls and windows, and a rooftop PV panel. These heavier material uses also affect earthquake resistance designs.

The continuous R&D on fire-resistance materials made it possible to use fire-resistance materials, external layers, pillars, and walls made possible to survive a fire for several hours (Fig.3-6).

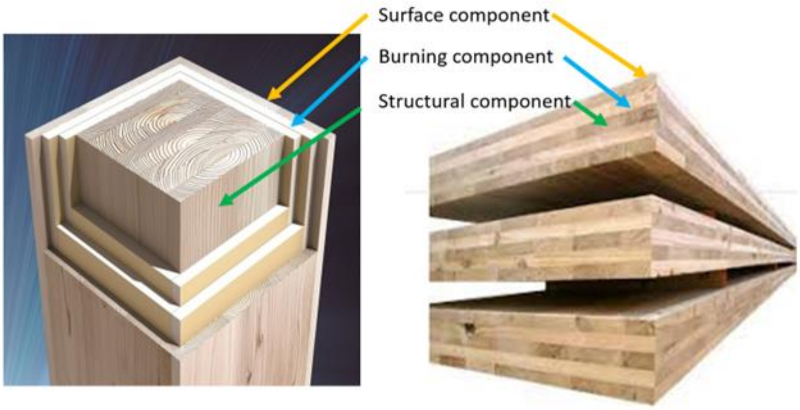


Figure 3-7: Examples of new wood materials in Japan

Fire prevention regulations

Currently, when a large-scale wooden building over 3,000 m^2 is constructed, the walls and pillars must be fireproof, or each 3,000 m^2 must be divided by a fireproof structure. However, if the walls, pillars, etc. of a wooden building are fireproof, the wooden portion must be covered with noncombustible materials such as gypsum board, making it difficult for users to appreciate the quality of the wood. In addition, when measuring off the building with fire-resistant structures, it is necessary to bisect the building, which imposes significant design constraints. Furthermore, all structural elements such as walls and columns are required to be fire-resistant without exception, making it difficult to use wood in parts of the building. Such regulation made it difficult to use wood for large-scale buildings in low-rise areas. There were no detailed standards regarding the required performance of fire-resistant structures according to the number of floors.

The revision relaxes these regulations and introduces a new structural method for large-scale buildings over 3,000 m^2 that allows the design of exposed structural elements, thereby promoting the use of wood in large-scale buildings. For large-scale buildings that are required to have fire-resistance performance, partial wood construction is possible for walls and floors to the extent that it does not interfere with fire prevention and evacuation.

In addition, the fire-resistance performance requirements for fire-resistant construction according to the number of stories have been streamlined for mid-rise buildings, which are in high demand for fire-resistant design using wood construction, and the bottom floor of buildings with five to nine stories can be designed with a 90-minute fire resistance rating.

The new standard also allows the wooden construction of the lower floors by treating the upper and lower floors as separate buildings under the fire prevention regulations, which are divided by high fire-resistance walls and corridors with sufficient separation distance.

Regulation Changes in structural calculation

Under the current law, structural calculation is not required for wooden buildings of 2 stories or less and total floor area of 500 m^2 or less. However, the number of buildings with large spaces has been increasing due to diverse needs, and it has become necessary to ensure structural safety for these buildings.

In addition to expanding the use of wood, the revision lowers the scale of new wooden buildings requiring structural calculation to a total area of 300 m^2 to ensure structural safety.

Under the current law, when constructing a wooden building that exceeds 13 m in height or 9 m in eave height, structural safety must be confirmed through advanced structural calculations (e.g., allowable stress calculations), and only a first-class architect is allowed to design or supervise the construction. This revision expands the scope of buildings that can be designed by a second-class architect using simple structural calculations to include buildings with three or fewer stories and a height of 16 m or less.

3.3 Future Directions for Meeting the 2050/2045 Carbon Neutral Target

3.3.1 Germany

In Germany, there is no official policy and technology roadmap or pathways for meeting the 2045 Carbon Neutral Target, at least not yet. However, the Climate Change Act has defined sectoral emissions reduction targets to be achieved year on year until 2030, which will be presented here below.

In addition, there are several scenario modelling analyses of pathways for meeting the 2045 carbon neutral target from various organizations, some with government funding, some private. A number of these have been analyzed in the study on long-term scenario analyses prepared by the GJETC 2021/22 (Obane et al. 2022). These show quite similar technology pathways for a GHG-neutral building sector, including:

- approximately **zero-emission** performance for new buildings
- **highly energy-efficient renovation** of ca. 2%/yr of the existing building stock as well as very energy-efficient appliances, ventilation and cooling systems, and lighting
- **conversion of heating systems** to
  - heat pumps (ca. 60 to 80 % of the stock in 2045)
  - green district heating (ca. 20 to 30 %, with large heat pumps; waste heat from industry, waste incineration, data centers, etc; CHP or heat generation plants using waste biomass; large solar thermal plants; and CHP using green hydrogen), and
  - a few % of individual biomass heating in most studies
- **zero-carbon electrification of heat** being enabled by conversion of power generation to almost 100% renewable energy sources.
- rooftop or other buildings-integrated PV is part of this shift to 100% renewables. It also enables charging stations for BEVs. These, as well as heat pumps and district heating with heat storage, must also be used as flexibility sources for the electricity supply network and system.

3.3.1.1 Climate Change Act (Klimaschutzgesetz) with sectoral targets

In April 2021, Germany experienced a ground-breaking step in its climate protection legislation, when the Federal Constitutional Court (German: Bundesverfassungsgericht, BVerfG) ruled that the German state was obliged to prevent any future disproportionate restrictions in the fundamental liberties of today's young generation (Constitutional Court 2021, 1 BvR 2656/18) and forced the government to take immediate action. Thereafter, the targets of the climate law from 2016 were tightened so as to achieve greenhouse gas emissions neutrality no later than 2045, with interim targets for greenhouse gas reductions until 2030 (-65% compared to 1990) and 2040 (-88% compared to 1990). In addition, the sector targets for the energy, industry, transport and building sectors until 2030 have also been tightened (cf. tab. 3-3) and will be further specified in 2024 and 2032.

It should be noted that the sector targets are binding for the responsible ministries, and a rigorous enforcement mechanism was decided in case that the reduction trajectories are missed. Since the buildings sector missed achieving its 2020 and 2021 targets by a few million tons of CO_2 and is expected to miss it in the next few years as well, the two ministries in charge (Economic Affairs and Climate Action; Dwelling, Urban Development, and Construction) released an immediate reaction program in August 2022. It includes the planned actions presented in chapter 3.2.1.

Table 3-3: Annual emission budgets for sectors according to the German Climate Change Act [Million t CO_2eq], Source: BMUV Climate Change Act (2021)

Annual emission budgets in million t CO_{2eq}	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy	280	*	257	*	*	*	*	*	*	*	108
Industry	186	182	177	172	165	157	149	140	132	125	118
Buildings	118	113	108	102	97	92	87	82	77	72	67
Transport	150	145	139	134	128	123	117	112	105	96	85
Agriculture	70	68	67	66	65	63	62	61	59	57	56
Waste and others	9	9	8	8	7	7	6	6	5	5	4

3.3.1.2 Planned energy efficiency law

At the EU level, there are energy saving targets for the Member States as a whole, regulated in the *Energy Efficiency Directive* (EED, currently Directive 2018/2002/EU). These targets are not binding to the EU Member States and not sector-specific, but they are formulated in terms of absolute target volumes of primary and final energy consumption.

The German government is now planning to also add a specific energy efficiency law to the Climate Change Act. The internal draft of October 2022 would set absolute overall target volumes of primary and final energy *consumption* for 2030, 2040, and 2045. For 2045, these would be equivalent to saving 57 % of primary energy and 45 % of final energy compared to 2008.

In addition, the law would obligate the federal government and the federal states to achieve certain new amounts of energy *savings* each year through energy efficiency policies and measures.

Although not sector-specific, the buildings sector will be a major contributor for the energy savings targets and measures. In addition, mandatory energy saving targets for the public sector and obligations for medium to large enterprises to install energy management systems or carry out energy audits will be regulated in the law. These obligations also cover energy efficiency in public, commercial, and industrial buildings.

3.3.2 Japan

As for the long-term policy on the building sector decarbonization, three ministries, namely MLIT, METI, and the Ministry of the Environment (MOE) have jointly published a "*Roadmap of the Building sector Decarbonization toward 2050 Carbon Neutral Society*" in August 2021. The Study group on energy-saving measures toward a decarbonizing society held meetings between April 2021 and August 2021, and the group proposed the roadmap in August 2021. The roadmap expects long-term policies to approach energy efficiency and renewable energy measures with the target milestones in 2030 and 2050.

3.3.2.1 The mid-term (2030) milestones

The energy efficiency building code expects the newly constructed buildings to conform to "ZEH/ZEB Level" to as much as 80% by 2030. The "ZEH/ZEB Level" consists of the following:

- The building uses an extra insulation level in the thermal transition coefficient.
- The energy consumption is 30%-40% lower than a mandatory level in medium-large buildings and 20% lower in small buildings.
- More than 60% of new construction single-family homes have rooftop PVs.

Table 5 shows the conformation level of the present market. It indicates that it will not be easy to achieve 80% fulfillment on the ZEH/ZEB Level by 2030.

Table 3-4: The EE Code and the ZEH/ZEB Level conformation as of 2019

Residential	EE Code	ZEH Level
Residential total	81%	14%
Large Apartment	68%	0%
Small-Medium Apartment	75%	2%
Single Family House	87%	22%

Non-Residential	EE Code	ZEB Level
Non-residential total	98%	26%
Large	Mandatory	32%
Medium	97%	21%
Small	89%	3%

3.3.2.2 The long-term (2050) milestones

The roadmap expects the long-term milestone with "the average performance with ZEH/ZEB" in building stocks by 2050, with most buildings and housing having rooftop PVs where engineering and economically possible. The table below shows the roadmap milestones for residential and non-residential buildings in 2025, 2030, and 2050.

Table 3-5: The roadmap milestones in 2025, 2030, and 2050

	2025	2030	2050
Residential	EE Code applies to all new constructions. Incentives to exceed EE Code requirement (20% primary energy reduction)	Higher EE Code with "ZEH ready" applies to top-runner constructions. 60% of new constructions install rooftop PVs.	The average EE performance of the stock achieves ZEH-Level.
Non-Residential	EE Code applies to all new buildings. Incentives to exceed EE Code requirement (30-40% primary energy reduction)	Higher EE Code applies to all new buildings. 30% reduction: in hospitals, hotels…,40% reduction: in offices and schools (compared to the code primary energy)	The average EE performance of the stock achieves ZEB-Level.

3.3.2.3 The approaches to energy efficiency improvement

The roadmap proposes effective measures according to the market characteristics, "Bottom-up", "Volume Zone", and "Top Runner". "Bottom-up" category represents a lower energy efficiency building/housing market, constructed by mostly smaller size builders. "Volume Zone" category represents most numbers of the constructions by both small and large constructors. The government intends to extend "Top Runner" category from "Volume Zone" Category.

Table 3-6: Market characteristics according to roadmap

	Market Bottom-up	Market Volume Zone	Top Runners
Regulation	Most new buildings are to comply with the building EE Code by 2025.	The multi-dwelling apartments comply with EE Code. More segments are included in top-runner programs.	ZEH/ZEB is expected for top-runner builders and constructors.
Support	Training programs are provided to help improve skills in insulation installations.	Municipals are expected to lead local market development with incentives with ZEH/ZEB.	Incentives are provided for better insulating materials with the top runner labelling.
Incentives	Incentives are provided for exceeding the code, indicating the upcoming regulation.	Incentives are provided for exceeding the code requirement.	

3.4 Factors/Technologies for Buildings' Carbon Neutral Target

3.4.1 Germany

Greenhouse gas neutrality in the building sector means not only greenhouse gas-neutral operation of buildings (energy consumption for heat and electricity), but also keeping emissions low during construction and demolition ('grey' energy and embedded GHG emissions).

3.4.1.1 Zero-Emission-Building

In low-energy houses and buildings (e.g., Efficiency House 40 standard), a very highly effective thermal insulation and usually also heat recovery ventilation is used, which minimizes heat loss through the building envelope. In the case of a Passive House, it is limited to 15 kWh/m^2/yr, and the Efficiency House 40 standard requires similar values. In addition, zero-emission houses and buildings cover their remaining energy consumption themselves by generating renewable energy on site. In balance, the energy consumption of this standard is zero. Plus-energy houses generate more energy than they consume themselves and can thus compensate for the consumption of other houses. Both heat consumption and electricity consumption are considered. Therefore, care is taken to install electric cooling systems only in exceptional cases (e.g., some types of public buildings may need it, even under German climate conditions) in order to keep energy consumption as low as possible.

In addition, heat pumps, solar thermal and photovoltaic systems, and energy storage systems, as well as heating networks based mostly on renewable energy, are primarily used to supply the buildings exclusively with renewable energy.

An important factor is also to expand the electricity mix in Germany with greenhouse gas-neutral renewable energies, so that heat pumps can also be operated in winter with renewable energy, if, for example, the building's own photovoltaic systems do not produce enough electricity. The new renewable energy law of 2022 includes a target of expanding the share of renewable energies in power generation to 80 % by 2030, and the objective is to reach close to 100% by 2035.

3.4.1.2 Wood as a building material in Germany

By using wood or wood-based materials (or renewable raw materials in general) from sustainable sources, a better greenhouse gas balance can be achieved from a climate protection perspective compared to the use of conventional building materials. Current studies determined the possible substitution performance of wood products in different construction methods.

In Germany, the share of timber construction in total construction activity varies greatly from region to region. In the densely forested, southern German states, the share is over 20%, while in the northern states the share is below 15% (Holzbau Deutschland 2020). In the future, it can be assumed that the share of wood used for construction activities in Germany will increase to approx. 25 - 41% by the year 2030 (Mantau et al. 2017).

With a life cycle assessment, the material flow and energy balance can be drawn up and an impact assessment can be made on this basis:

- The material flow and energy balance determine the amount of wood building materials used and the amount of primary energy (renewable and non-renewable) required to produce them.
- The impact assessment determines the environmental impact based on this, e.g., the greenhouse gas potential (GWP) in kg CO_2 eq. per kg.

The CO_2 stored when trees grow is removed from the atmosphere and temporarily stored (temporary biogenic carbon storage). Buildings made of renewable raw materials, such as wood, act as carbon stores. At the same time, finite raw materials are substituted.

A greenhouse gas accounting study shows that the CO_2 savings potential for single- and two-family homes ranges from 35-56%, while for multi-family homes it is 9-48% (Hafner et al. 2017).

Therefore, a higher wood usage in buildings is a policy strategy published in the charter for wood 2.0 in 2017 (BMEL 2021). The wood usage in buildings is supported by well-known scientists, experts, engineers, architects and planners through the initiative “Bauhaus der Erde” (Building of the Earth) (Bauhaus der Erde 2022). The local government can set up financial incentive programs and guidelines to use wood or wood-based-materials for buildings – so a lot of major cities have done this already. Furthermore, when municipal land is sold, it can be included in the purchase agreement and calls for urban planning competitions that the buildings are to be constructed in wood – which only a few cities have done so far. It is difficult for municipalities to set targets for the use of wood via other instruments due to restrictions in the German tendering and procurement law.

3.4.1.3 Recycling management

Finally, deconstruction must be considered. This is because if building materials can be separated according to type, they can usually be reused in other products or buildings. This extends the life cycle of the building material, so that the balance of the building material and consequently of the products made from these materials is also improved. In addition, the use of other, newly introduced resources can be avoided (resource efficiency).

3.4.2 Japan

3.4.2.1 The building electrification

There are growing trends and interest in building electrification in the carbon-neutral policy arena, replacing gas furnaces and boilers with electric heat pumps and the gas cooking stove with electric induction heating stoves. While all-electric housing has been a significant choice in the new housing market for two decades in Japan, such building electrification policy is not currently highlighted in the carbon-neutral policies in Japan. The all-electric housing market was fast growing until 2011's great East earthquake. The electric supply shortage has become a new normal until today, and the supply shortage may not go away anytime soon.

However, a decade-long all-electric housing market has learned lessons, especially the deployment in the existing buildings/housing. Many multi-stories buildings and apartments have implemented tankless gas boilers, usually wall-mounted with small projection spaces. The heat pump boiler needs a sizable installation space with little available space. One of the limited choices is the balcony space, where the fire escape code requires enough empty spaces in the balcony to escape to an adjacent room. An additional electricity capacity switching board is usually needed to use a heat pump boiler and electric induction cooking stove.

3.5 Gaps and Need for Further Improvement/Additional Policies

3.5.1 Germany

As the previous chapters have shown, the policy-mix on energy efficiency and decarbonizing heating systems in Germany is already considerably broad and will see a significant boost in ambition and budget funding in the next months and years. However, it still mostly centers around the functions of regulation, funding through financial incentives, and providing information. The sector target in the Climate Change Act (cf. chapter 3.2.2) provides a high-level policy signal; however, there are no operational targets regarding, e.g., the rate and depth of renovation, or the phase-out of oil and gas heating systems. Therefore, the Wuppertal Institute has analyzed, which comprehensive policy package would be able to accelerate the cost-effective and just building sector transformation to carbon neutrality further. This requires a combination of policies and measures that serve a total of ten functions as shown in the left column of Table 3-7. These add functions such as direction and support, capacity building, and incitement with corresponding policy instruments to the existing policy mix, but also additional or more ambitious instruments in regulation, funding, and information, such as minimum energy performance standards in existing buildings or making building renovation passports available to all inefficient buildings by 2028.

Policy package for energy-efficient and climate-neutral buildings: tasks 2021-2025

	Stopping growth in floor area	Energy efficiency	Green heat
Signal to market	Sector targets Climate and Energy: Fit for 1,5 degrees		
	Targets on maximum floor area	Targets on renovation rate & depth, oil and gas phase out	
Direction & Support	Strenghten governance: dena, BfEE, Länder energy agencies		
	Financial support to local one-stop-shops and city district management		
Cost effectiveness	Step up CO_2 price faster and further after 2025, use revenues to fund the transition; make price pass-through to tenants depend on energy efficiency standards		
Information basis		By 2028: Building Renovation Passports for all buildings built before 2001; Master plans for cities/districts	
Standards & Funding	Support remodelling, moving	Min. energy performance standards in existing buildings, KfW40+ in new build; funding to make it cost-effective, incl. for tenants	
Infrastructure			heat networks and green feed-in
Innovation		For example project aggregation, industrial preconstruction, support for increase in production	
Capacity	Capacity building, digitalisation and communication campaigns		
Incitement	Demonstration and pilot projects, networking and exchange		

Source: Wuppertal Institute 2022

Table 3-7: Proposal for an enhanced policy package for energy-efficient and climate-neutral buildings in Germany, with policy-making tasks for the legislative period 2021 to 2025
Source: Wuppertal Institute (2022), own translation

In the following, we briefly explain the policy functions and the concrete measures we see necessary as presented in Table 3-7. Here, the order of the functions is based on the importance as we see it, whereas it is oriented towards the investment journey in the Table.

- **Clear signals to provide long-term planning security to markets**. This would require the government to commit to **concrete targets for building energy renovation and the phase-out of fossil gas and oil heating**. From 2025, an annual rate of renovating at least 3% of the building stock to very high efficiency standards should be achieved, along with installation of at least 800,000 heat pumps and 150,000 connections to district heat per year, and an increase of green heat feed-in to the district heating systems of 12 TWh/yr.
- **Stopping the increase in building floor area and resource consumption.** The policy package should not only address energy efficiency of the building envelope and green heat, but also aim to stop the growth in buildings floor area. This growth is connected to most of the new build and hence embedded carbon emissions, and it also requires a lot of scarce resources and land. Here too, Table 3-7 shows that similar policy functions and types of policy measures are needed as for energy efficiency and green heat.
- **Standards and funding – minimum energy performance standards for existing and a phase-out law for fossil oil and gas heating.** The Building Energy Act (GEG) should be revised accordingly. By 2030, all buildings should have reached at least the EPC energy class D, by 2035 class C, and by 2040, class B. The maximum operating time of purely fossil natural gas and oil boilers should be successively limited more quickly than the government's plans presented in chapter 3.2.1.1 and from 30 to 15 years from 2024, reaching the 15-year limit in 2040 the latest. The financial incentives and financing schemes of the BEG need to make compliance feasible and even attractive. Monitoring of compliance should still be improved.

- **Improving the information basis.** By 2028, each house or building constructed before 2001 that is not yet renovated to at least Efficiency House 70 standard should have a **Building Renovation Passport** that shows how the house/building could become greenhouse-gas neutral in stepwise or comprehensive renovation. Progress should be recorded in a digital building logbook. The data should be integrated with the **municipal heat planning** discussed in chapter 3.2.1.4
- **Supporting and organizing implementation - One-Stop-Shops and City District Management.** These are important to actively approach building owners, reduce practical barriers for building owners by supporting them in organizing the implementation, and may even reduce the costs through bundling of projects that, e.g., allows pre-fabrication. The federal government should fund such organizations in all cities or regions across the country.
- **Strengthening the energy and climate governance:** This concerns the tasks, capacities and funding of the relevant ministries, agencies (such as dena, BfEE, UBA and agencies of the federal states) sa ell as their mutual coordination.
- **Supporting innovation in the construction industry.** Project aggregation in combination with pre-fabrication of renovation components based on new digital tools could make energy efficiency renovation faster and cheaper. The government should provide financial support for wide application of such and other innovative approaches.
- **Qualification, digitalization, and communication campaigns.** There is a severe lack of trained staff for the transformation of the building stock, which needs strong efforts by market actors with government support to train existing and attract new experts. Digital building logbooks and “twins” may reduce time and cost requirements for renovation. The advantages of zero-carbon houses and buildings need to be communicated widely.
- **Supporting the increase in production capacities.** There may be the need for financial support to industry for the conversion from gas and oil boilers to heat pumps and other low-carbon heating systems.
- **Creating incitement through pilot and demonstration projects.** The best would be to have at least one good practice example in each street. Networking and exchange of experiences between home and building owners should be supported.

3.5.2 Japan

3.5.2.1 Energy efficiency retrofit policies and challenges (previously 3.3)

Building transactions provide an opportunity for building retrofits, including energy efficiency, before the new owners move in. Therefore, a low rate of building transactions will slow down the energy efficiency retrofits, and increasing the transaction rate will support the speed of retrofits. MLIT has been working on the promotion of the existing building market for a decade. In the White Paper of Housing Policy report of MLIT in 2015, MLIT acknowledged many barriers and challenges. Figure 3-8 shows the stock market transaction ratio to the total building transaction, and Figure 3-9 compares with other countries.

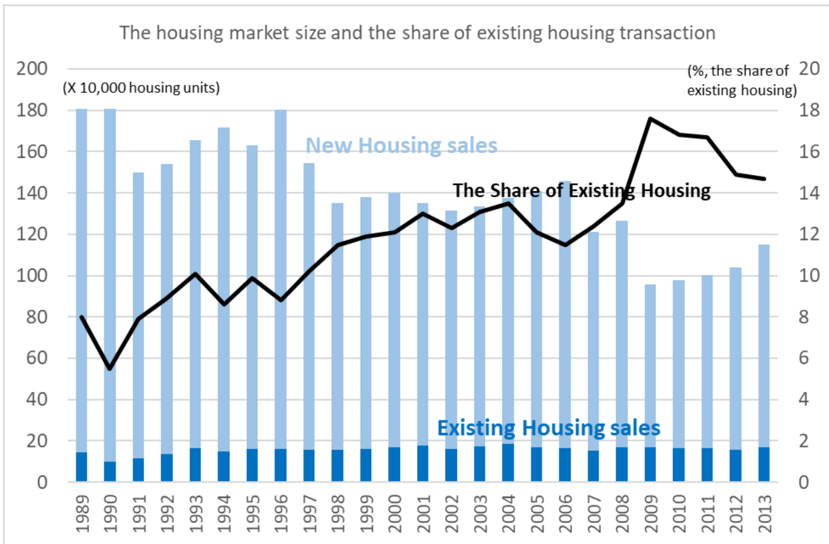


Figure 3-8: The share of the existing housing transactions in Japan 2013, The White Paper MLIT

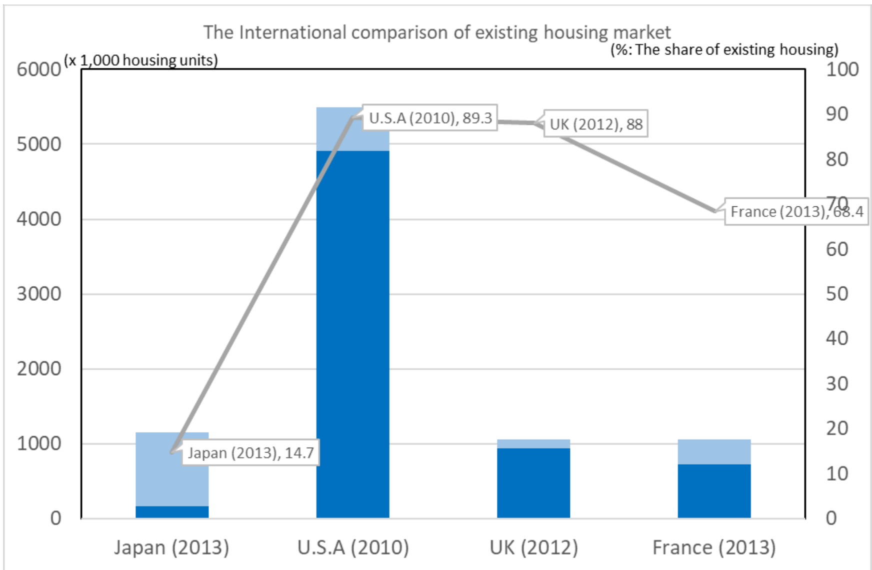


Figure 3-9: The international comparison of the existing housing transactions Source: 2013 White Paper, MLIT

MLIT acknowledged that the poor performances in earthquake resistance and the energy efficiency in old buildings are the main reason for a small existing housing transaction. Figure 3-10 shows the distribution of the existing houses' qualifications for the earthquake resistance and energy efficiency codes.

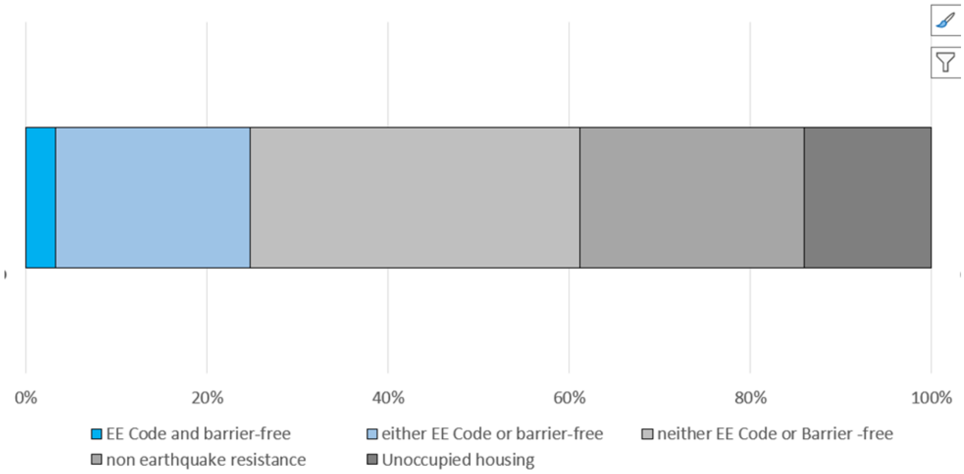


Figure 3-10: The conformation of standards by housing stocks in Japan (2013)
Source: MLIT, Social Infrastructure Development Council Residential Subcommittee Vol.47, Document 5, 12th September 2019

The existing building market should focus on the potentially code-compliant buildings. From a buyer's interest, it is hard to tell which building may be suitable for retrofits to comply with the earthquake resistance and energy efficiency codes. Finding a skilled constructor to perform the retrofit work is also difficult, including the appropriate cost estimates. MLIT made progress in the development of the following:

- Licensed support centers for the retrofit, where consumers can receive a free consultation and the work plan quotation check
- Existing Housing Sale Warranty Insurance, an insurance package that covers both inspections and warranty to defects
- Provisions for the registration and licensing tax on existing housing acquisition involving the earthquake resistance work
- A revision of the real estate acquisition tax. The retrofit plan should meet a high level of quality improvement and earthquake resistance code to become eligible for a tax break. In 2015, MLIT reduced the real estate acquisition tax for the existing housing transaction.

MLIT's committee on the housing policy understands that these measures are not enough to accelerate the existing building transactions. There are still serious barriers to overcome. The committee is currently working on the appropriate valuation of the retrofit building in the housing market.

The appropriate valuation of the retrofit building in the housing market

The housing valuation in the Japanese market has been customarily depreciating the housing value within 30 years, no matter what the housing condition is with or without retrofit work, which has discouraged homeowners and real estate agencies from investing in improving housing quality. The study group of the MLIT's housing committee has found in the 2020 report that potential buyers want to acquire good quality existing housing with fewer costs than a newly built one, and many buyers want to invest in the retrofit of the existing housing. The housing market stakeholders should work together to change this customary valuation of the existing housing, reflecting the retrofit values so that many buyers and real estate agencies would willingly invest in the retrofit.

As a result of the two-years long MLIT's committee discussion, a summary report proposed guidance in the further developments of policies in:

(1) improving building evaluations methods to establish a good second-hand building market,

(2) creating a supply chain with quality housing,

(3) financial assistance measures to promote the second-hand housing market,

(4) stimulating a better single-family rental house market,

(5) more active participation by local municipalities in the second-hand housing market.

3.5.2.2 The approaches of renewable energy use promotions

The roadmap toward 2050 building decarbonization expects the rise of renewable energy use as the primary pillar and energy efficiency improvement. Using onsite renewable energies will realize the ZEH/ZEB building.

Rooftop PV deployment

The total rooftop PV installation is over 2 million single-family housing, which is about 7% of the single-family housing stock of 27 million. About 70 thousand newly built single-family housing have rooftop PVs, and 50 thousand existing houses are installing rooftop PVs yearly. Despite the continuous decrease in installation cost and popularity, rooftop PVs are not growing fast enough. The study group of the 2050 building decarbonization discussed the mandatory requirement of the rooftop PV on the new buildings, while there are still obstacles to overcome. One of the positive pathways is the municipal ordinance's lead. The building code was amended to allow more flexibility in the municipal's jurisdiction with an additional energy efficiency requirement through ordinances.

A few initiatives in municipalities and change of policies in solar PV has already noted in the Section 3.2.2.1.

Promotions of solar heating hot water

Along with the deployment of rooftop PVs, solar heating hot water has been in the market for several decades, but the market is tiny and is not growing either. Tokyo metropolitan government promoted more solar heating panels for smaller rooftop housing and non-residential building between 2012 and 2014, but the focus quickly shifted to rooftop PV.

Another renewable energy promotion policy is looking at the broader application, such as sharing renewable energy across multiple buildings. Aggregated energy demand/supply management is one expected business model to increase.

4 Comparison of Key Results of the Study

4.1 Building Stock Characteristics

The study on the building energy consumption of Germany and Japan quickly highlighted the difference in the energy use sector, notably for space heating. The difference is associated with two factors; one is the climate due to the geographical latitude of the countries, and the other is the typical heating system.

Fig. 4-1 shows the average household energy consumption comparison, and the main difference is in the space heating energy consumption.

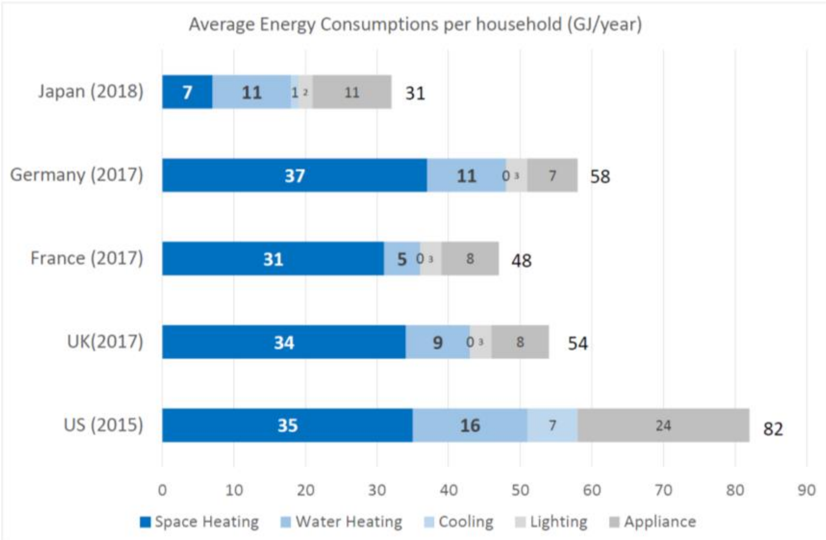


Figure 4-1: Comparison of average energy consumption per household (GJ/year)

Fig.4-2 illustrates the geographical location in the latitude. Germany is located at a much higher latitude. In fact, the most southern town in Germany is located at the same latitude as the most northern town in Japan.

Figure 4-2: Geographical latitude of Japan

The heating demand in Germany is due to around 3,500-4,000-degree days, while it is 1,000-degree days on average in Japan. Most of Japan is in a very warm and humid climate, comparable to West Europe/Africa. Tokyo's latitude is slightly southern to Algiers (Algeria) and slightly northern to Casablanca.

Fig.4-3 shows the energy consumption in different geographical regions in Japan. The northern regions', particularly Hokkaido's energy consumption is much closer to the consumption in Germany.

The most populated regions, Kanto (East), Kansai (West), and Chubu, are all in warmer regions. 70% of the Japanese households are in these three regions. With such a warmer climate, most houses use partial/intermittent space heating. Central heating is hardly found in Japan, except in the northern region, Hokkaido.

This difference in space heating leads to different energy conservation measures. Space heating energy conservation is the priority target in Germany. On the other hand, the Top Runner program for lighting/appliances, including separate room air conditioning and hot water boilers, is an effective choice in Japan. Still, improving thermal insulation has its benefits, which are reflected in the energy efficiency requirements of the *Building Energy Conservation Law* and the "*Roadmap of the Building sector Decarbonization toward 2050 Carbon Neutral Society*" of August 2021 (chapter 3.3.2).

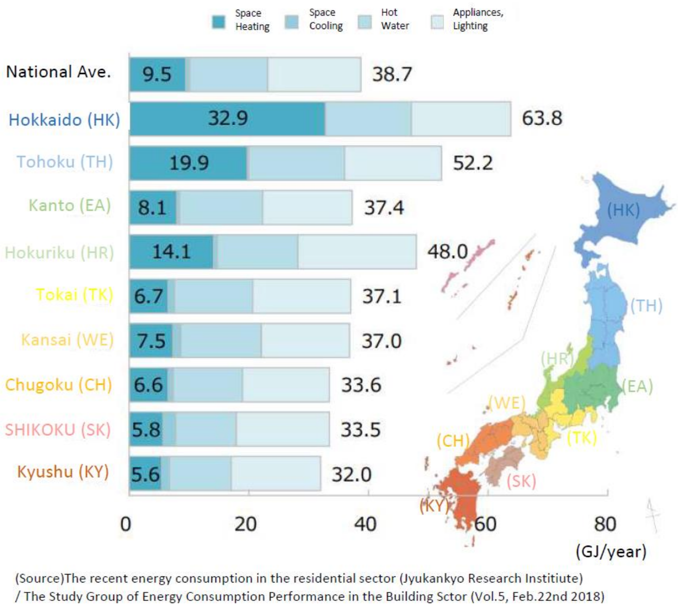


Figure 4-3: Different Energy Consumptions along different climate regions in Japan
Source: MLIT, Jyukankyo Research Institute "The recent energy consumption in the residential sector" at Study Group of Energy Consumption Performance in the Building Sector Vol.5, Feb.22nd 2018

(1) Renewable energy use

The study shows the same policy trends in new construction with tighter envelopment and more efficient heating, ventilation, and air conditioning (HVAC) systems in Germany and Japan. Both countries share the same policy trend to use more renewable energy, but the implementation measures are different. Germany requires 65% renewable energy use in the building code. In Japan, the policymaker needs to consider a higher multi-dwelling housing share (40%) in urban cities and the different climate conditions along the nation, so the municipals are leading the renewable energy deployment programs. Tokyo metropolitan government and Kyoto city are the initial municipals to implement mandatory roof-top PV in new construction.

(2) Housing and building retrofits

In both countries, the larger part of the existing building stock is still far away from modern energy efficiency standards, particularly for the building envelope, since they were built before the energy efficiency requirements for new buildings came into effect, or when these were still not as consequent in energy efficiency terms as they can be now. Retrofits of the envelope as well as HVAC systems are, therefore, an important lever for the energy transition and climate change mitigation.

German building retrofit policy focuses on energy efficiency and renewable heating system deployment, with financial support (subsidies/grants/low-rate loans) and professional advice. Energy cost savings and better market valuation with the efficiency labeling system (Energy Performance Certificates) can recover retrofit investments in less than twenty years.

In Japan, the building policymaker (MLIT: Ministry of Land, Infrastructure, Transportation and Tourism) targets retrofits in owned houses constructed after 1980. Pre-1980 housings may better get demolished and newly constructed. As housings get older, their residents are also becoming elderly. When such residents consider a housing retrofit, they usually have three choices: convenience/comfort, energy conservation, and barrier-free accessibility.

Most Japanese residents exchange a room air conditioning and a hot water boiler in a 10-15 year-cycle. There is less incentive to explore double/triple paned window replacement and better insulation in the wall/roof/floor. Policies aiming at incentivizing such retrofit measures potentially increase the number of residents willing to invest time and money for larger/less familiar measures.

One of the barriers in the energy conservation retrofit is the longer investment recovery time and less urgency as an individual. Such a barrier is not limited to housing retrofit but is frequently observed in the non-residential sector's higher equipment/industrial machine replacement.

4.2 Policies and strategies

Japan and Germany have a long history of implementing energy conservation laws aimed at improving energy efficiency and reducing energy waste. While Germany introduced its first building related legislation as early as 1977 with the *Heat Insulation Ordinance* with prescriptive values for the energy efficiency of building envelope components and heating systems, the Japanese policies had a more general focus on the energy performance of appliances with its *Top Runner Program* launched in 1998. This different approach can partly be understood by the fact that the share of energy used for heating is not as high in Japan compared to Germany, because of the warmer climate and the fact that most Japanese only heat or cool the room they are using at a certain time. Contrary to Japan, the energy used for heating is accounting for a large share of the overall energy consumption in a standard German household. Accordingly, measures and policies aiming at the improvement of the insulation of the building envelope are considered of utmost importance: From 2001, an overall building energy performance approach for new buildings was added, as well as component energy efficiency requirements in case of major renovation. In Japan, the newly introduced *Building Energy Conservation Law (2017* revised in 2022*)* applies the *Top Runner*

Program introduced in 1998 for appliances also to dwellings by imposing an average efficiency standard on owners of numerous housings.

Against the background of raising the ambition level to cope with the global warming, both countries have also intensified their efforts to increase the energy performance of the buildings. In Germany, after several rounds of improvement of the standard for new build, it will reach nearly zero-energy building standards in 2025. Importantly, German legislation is also often influenced/pushed by EU regulations that have been tightened following the launch of the Green Deal and the soon expected agreement on the fit for 55 program aiming, among others, at GHG emission reduction in the building sector.

Major points in common

The overall goal of both countries' policies is to reduce the energy consumed in the building sector. However, in Japan the focus is more on new buildings and the improvement of the energy performance of appliances and HVAC systems, while in Germany the improvement of the insulation (of the envelope) of both new and existing buildings is considered important.

Germany is now strongly promoting the use of heat pumps, as the electricity system is being converted to a very high share of renewable energy sources. Integration of renewable energies is also important for both countries (however to different degrees), with a focus on incorporating solar, wind, and other sustainable sources into new and existing buildings. Both Japan and Germany offer financial incentives for renovation and maintenance of high energy performance standards in buildings, including tax credits and subsidies. In terms of appliances, Japan has the *Top Runner* program to increase energy performance and efficiency, while the EU has implemented the *Ecodesign* program to promote environmentally-friendly design in products, which is immediately binding for all Member States, including Germany.

Furthermore, Japan and Germany both acknowledge the importance of increasing the share of wood among the construction material to reduce the GHG emissions in the construction process.

Major differences

Japan and Germany both prioritize energy efficiency and sustainability in their building sector policies and strategies, but there are some key differences between the two countries. Japan places a greater focus on appliances, such as air conditioning and lighting systems, as a means of improving energy efficiency, whereas Germany places more emphasis on improving the insulation and overall energy performance of its building stock, and on heating systems. This difference in focus may be a reason why the *Top Runner* standards for air conditioners are more advanced than the EU Ecodesign standards, while building code requirements for overall energy performance and many components are much closer to ZEB/ZEH performances in Germany than in Japan, even for similar climate zones, and are planned to reach ZEB/ZEH standards already in 2025, compared to 2030 in Japan. Germany has more specific goals for the integration of renewable energies in the building sector and offers a larger range of financial mechanisms to encourage building upgrades and renovations. This includes subsidies, tax credits, and low-interest loans, while Japanese policies rely more on mandatory regulations and building codes. Despite these differences, both countries are committed to reducing their carbon footprint and promoting sustainable building practices.

Table 4-1 summarizes the relevant policies and measures of both countries regarding (a) Energy Performance Requirements, (b) Energy Performance Certificates, (c) Performance standards for appliances and HVAC systems, (d) integration of renewable energies, (e) financial incentives, (f) energy advice, (g) energy management requirements and (h) Lifecycle Assessment.

Table 4-1: Comparative overview of policies aiming at improving the energy performance of the building sectors in Germany and Japan

	Type of policy	Germany	Japan
	Energy performance requirements	*Building Energy Act (2020):* • Compliance with energy performance for (a) new buildings and (b) existing buildings undergoing major renovation • integration of renewable energies	*Building Energy Conservation Law (2017, updated in 2019 and 2021)* • mandatory minimum envelope performance • standard average efficiency standard on housing builders • additional efficiency levels for ZEH/ZEB level with incentives
		Revisions of Building Energy Act (2022 to 2024): new or stronger efficiency standards • 2023: Efficiency House 55 Standard for new build • 2025: Efficiency House 40 Standard for new build • 2024: Efficiency House 70 Standard for renovation or extension of existing houses • 2024: at least 65% renewable energies in newly installed heating systems	*Revision of the Building Energy Conservation Law (2022) to comply with 'decarbonized society' plan* • improve energy efficiency • increase use of RE and use of wood Energy Conservation Law • specific targets for (a) appliances and (b) building material • compliance with energy conservation standards also for **new** medium- and large-scale residential buildings → building permit as certificate for meeting the standard • to be implemented by 2025 • Requirements for renovation (insulation/ high-level performance appliances)
	Energy performance certificates	*Energy Performance Certificate (EPC)* • ranging from A^+-H for residential buildings • obligation to present to interested parties at sale or lease • highlights deficiencies of the building and offers recommendations for energy renovation	Energy consumption performance label Insulation Performance label
	Performance standards for appliances	*Ecodesign* • necessity to ensure energy efficiency and recyclability • inform about possible environmental externalities • analyze product lifecycle	*Top-Runner (1998), revised 2022:* • increase energy efficiency of standard appliances • revised 2013 to also include e.g., (Non-residential) refrigerators,

	Type of policy	Germany	Japan
			electric water heaters, light-emitting diodes (LED) • 2015 revision expanded to building materials. • The government is trying to accelerate the standard updates onward.
	Integration of Renewable Energies	• certain percentage of overall energy performance of new buildings/ houses must be covered by renewables • 65% from 2024 in new heating systems (according to revised GEG)	• obligation for municipalities to increase the share of renewable energies by designating promotion area and by prepare promotion plans
	Financial incentives	• since 2005: loans and grants for energy efficiency renovation and integration of renewable energies • federal funding for efficient buildings including renewable energies: in 2022, 5 billion Euros • plans to increase volume to 12 to 14 billion Euros/yr from 2023 until 2026 • Worst-Performing-Building Bonus (WPB) • Serial Refurbishment Bonus (SerSan-bonus) • Efficient heating network program • Support for municipal heat plans (covering 90-100% of cost)	• Grants for energy efficiency renovation (Efficient Windows/doors replacement, Wall/Roof Insulation, Efficient Boiler Replacement, each replacement may receive 9,000JPY-48,000JPY, up to 300K per household) • 75% of the cost for the installation of a rooftop PV and battery storage
	Energy advice	Professional energy consulting (subsidized as well) as prerequisite for financial incentives for renovation measures	architects must be capable of informing about the integration of renewable energies for (new) buildings
	Energy management requirements	Following the EU's energy efficiency directive from 2012 (Art. 8), Germany introduced a requirement for companies defined as not being small and medium enterprises to either have a regular energy audit or an energy management system. This includes buildings.	*Energy Conservation Law (1979):* • obligation for regulated facilities to appoint an energy manager • necessity to report energy consumption and develop reduction plans
	Lifecycle Assessment	Increase of wooden material is an aim	Increase of wooden material is an aim

5 Conclusion: Learnings and Recommendations

This study has taken stock of building stock characteristics, energy intensity, and energy consumption in both countries, Germany and Japan, in chapter 2, and of existing policies and their recent and planned changes, as well as the strategies and factors towards carbon neutral targets in both countries in chapters 3.1 to 3.4. In chapter 3.5, we identified gaps in the existing and planned policies for achieving the carbon neutral targets and made some recommendations on how the policy mix could be enhanced further. Chapter 4 compared the findings for both, building stock characteristics and policies and strategies.

Based on these analyses and findings, this chapter draws some conclusions on potential mutual learnings between Germany and Japan (in chapter 5.1), summarizes the policy recommendations for both countries individually from chapter 3.5 (in chapter 5.2), adds recommendations on potential cooperation between both countries in terms of innovative technical solutions and policies (5.3), and ends with suggestions for further research needs (5.4).

5.1 Mutual Potential Learnings

Germany can learn from some aspects of Japan's approach to implementing energy-saving measures in the building sector. Japan places a strong emphasis on HVAC appliance energy efficiency, which is an area where Germany could potentially improve its policy efforts in addition to the EU's Ecodesign regulation and labelling. Additionally, Japan's experience with energy management systems and all-electric housing could provide valuable insights for Germany as it continues to promote electrification in the building sector. Finally, programs that promote wood construction in Japan are also very interesting for Germany. In this regard, the profound experience Japan has concerning wooden building construction and particularly the country's knowledge on how to reduce the risk of fire, is useful for Germany's building sector. By incorporating these approaches, Germany could potentially enhance its efforts to reduce its carbon footprint and promote sustainable building practices.

Japan, on the other hand, can learn from Germany's focus on the overall energy performance of the building stock. Germany places a strong emphasis on improving insulation, heat recovery ventilation, and incorporating renewable energies towards net-zero-energy buildings, which can have a significant impact on reducing energy waste and improving sustainability. Japan could benefit from adopting these approaches to strengthen or complement its existing measures, such as mandatory regulations and the *Top Runner* program, to drive systemic improvements in energy efficiency. Additionally, Germany's extensive system of financial mechanisms for investments and energy advice, such as grants, subsidized loans, and tax credits, can provide a model for Japan to incentivize building upgrades and renovations. By incorporating these strategies, Japan could potentially enhance its efforts to reduce its carbon footprint and promote sustainable building practices, while also increasing the comfort-level of Japanese housing and buildings.

5.2 Policy gaps and recommendations

From a German point of view, although major improvements of existing policies are already planned or on their way, both the recent as well as the planned policies are lacking operational targets (e.g., annual rate/depth of energy renovation, phase-out rates and pathway of oil and gas heating). Also, in addition to improving the energy performance of the building sector, it is also important to stop or at least reduce the increase in building floor area and by that also tackling embedded carbon emissions (protection of resources and land).

In order to make retrofit measures more attractive and the progress more transparent, it is recommended to (a) guide renovation efforts for each house and building by a *Building Renovation Passport,* (b) increase financial incentives, (c) ensure monitoring and (d) show the state of a building's renovation by introducing, for example, a *Digital Building Logbook*. Supportive structures, such as One-Stop-Shops, would also further facilitate the renovation process.

One major remaining problem in the Japanese building stock concerns the poor performance in both earthquake resistance and energy efficiency of many buildings and houses. Here, it is important to amend the regulations to equally incorporate both aspects into the building code. Appropriate valuation can be identified as another major challenge, because often the buyers cannot judge which buildings are suitable for retrofit. Moreover, the building code requires to comply with the newest regulation upon the retrofit work; regardless whether the work may not involve the non-fulfilling section. There are too many simple retrofit work opportunities, such as a simple additional façade modification and an external wall insulation, passed with excessive costs. A limitation of the requirement for compliance to the element of the building envelope that is retrofitted (e.g., wall or roof), as in the EU/Germany, may be worth considering. Closely connected to the problem is the lack of skilled workers to take care of the renovation measures. Communicating the health and comfort benefits of improved thermal insulation and shading may help to overcome the barrier that energy efficiency retrofits may not be cost-effective based on energy savings alone.

The increase of renewable energies at buildings also poses a problem because of height restrictions inscribed in the building code. However, this barrier could easily be adjusted by amending the regulations respectively.

There is also a logistical barrier. An effective retrofit program requires a good assessment and planning, associated with additional costs, which may become a problem for both the resident and the service provider. In Germany, these costs are subsidized with up to 80%.

In both countries, ESCO (Energy Service Company) and EaaS (Energy as a Service) models can be explored so that such additional logistic costs are minimized and levelized across a long service payment. The policy needs to show the long sustainable retrofit market with becoming the initial demands in the government/municipal buildings retrofits so that the service company can survive in the early stage. Such a government/municipal initial demand can also help boost renewable energy and EV charging business.

5.3 Potential for German-Japanese cooperation

Cooperation between Germany and Japan on energy efficiency in buildings and the policies and measures to support it is nothing new. A Memorandum of Cooperation has existed between the construction ministries of the two countries since 2013 and has also been extended to the research level between the BBSR in Bonn and Berlin and the Institute for Building Research in

Tsukuba. Within the framework of this cooperation, a basis of trust and a state of knowledge on the respective standards and developments has emerged, which seems to present a very fruitful basis for further exchange. Because Germany introduced some types of policies on energy efficiency in buildings earlier on, Japan has been able to gain inspiration for its own energy and environmental policies, inter alia, from Germany's set of policies in the past.

The principle of 'Inform, Support, Regulate based on Research' has established itself in German building energy policy. A similar approach seems to apply in Japan as well, so that an exchange on the respective political measures is possible along these lines and based on the policy recommendations outlined above and the prototypical policy package outlined in Rauschen et al. (2020). In all policy areas, parallels can already be seen in the work, even if the levels are still different. The aspects discussed above in chapter 5.1 on mutual potential learnings could provide ideas for exchange and cooperation.

The GJETC has already contributed to this exchange through a working group paper published in 2020 (Rauschen et al. 2020), and through discussing policy approaches and recommendations at the recent stakeholder dialogue on "Exchange on Policy Frameworks that support the Transition to a Carbon Neutral Building Sector in Japan and Germany", held on 3rd of March, 2023 in Tokyo and online.

A further approach to the exchange may build, e.g., on German experience with the work of energy and climate protection agencies. In Germany, the work of such agencies for the efficient implementation of political goals is important at the federal, state, and local levels. The agencies manage to build up competences and implement projects professionally over longer periods under public or partly public sponsorship.

The German side can particularly benefit from the Japanese experience of Smart City projects. In addition to heat pumps, which are highly developed in Japan, their use combined with photovoltaics in urban neighborhoods is a model for Germany, where heat supply will need to be electrified based on an electricity system with high shares of PV and wind energy, while using the potential of heat pump systems as a source of flexibility for this green electricity system.

Therefore, connecting German knowledge of and technology for building shell energy efficiency and Japanese knowledge of and technology for BEMS/HEMS and Smart Cities could provide even better energy performance in both countries, and opportunities for implementation in other countries too.

This is one potential topic for a future innovation roundtable by the GJETC. These innovation roundtables bring together experts from industry and research, to discuss possibilities for concrete cooperation projects in the development and testing of new technologies or solutions.

Another potential topic regarding building sector decarbonization for an innovation roundtable could be "Cost-efficient Refurbishment in Building Stock with Serial Components". It could combine German building design and envelope technologies with Japanese experiences in serial and prefabricated housing. Concrete objectives could be demonstration of industrial construction, digital design tools, and process optimization, while advancing the use of low embedded carbon designs and materials.

5.4 Further research needs

The goal of reducing the cost of energy renovation and accelerating it in times of shortage of skilled workforce through prefabrication, digital design tools, and process optimisation mentioned at the end of the last section is also one important area of further research needs. This has already been identified in a previous output paper by Rauschen et al. (2020).

Regarding the building stock and strategies towards decarbonization, questions include:

- What are the most appropriate building concepts and energy performance levels in different climate zones?
- What are even current energy performance levels for comparable buildings in comparable climate zones?
- How can cost-effectiveness of energy-efficient/low-carbon buildings and renovations be further improved?
- What does this mean for the energy standards of building components and installed systems?
- How much energy can be saved through HEMS/BEMS and energy sufficiency?
- How can buildings be made a source of flexibility for electricity supply?
- Which other benefits can be achieved, e.g., for health and productivity?
- How can embedded carbon be assessed and tackled?

In the field of policies, a more in-depth analysis seems also useful on how the policy packages for energy efficiency and decarbonization in buildings can be made more effective. This analysis could particularly address, whether the suggestions for new or enhanced policies and measures outlined in chapter 3.5 are applicable in both countries and beyond, albeit with adapted choices in case of policy alternatives and with country-specific adaptations of the typical instruments. What can be mutually learnt for making energy/material efficiency (and sufficiency) as well as renewable energy policies for new build and energy-efficient/low-carbon renovation more effective in both countries?

The complexity of restructuring the demand side of the energy market during the energy transition in Japan is comparable to that in Germany. This raises the question, whether especially the cooperation on a new (polycentric) governance structure, according to the principle “Efficiency First”, could be intensified? For example, do both countries need a central coordinating institution (agency) for energy efficiency (and sufficiency) policies with strong financial and staff resources?

6 Bibliography

Accounting rules of the QNG for non-residential buildings: Bilanzierungsregeln des QNG für Nichtwohngebäude.

Arimura, T.H., Matsumoto, S. (2020). *Carbon Pricing in Japan*. Springer. https://doi.org/10.1007/978-981-15-6964-7.

Bauhaus der Erde (n.d.). Retrieved on November 12, 2022, from https://www.bauhausdererde.org.

BBSR/BBR/Öko-Zentrum NRW GmbH (2022). Klimaschutz im Gebäudebereich. Darstellung und Untersuchung nationaler Methoden, Strategien und Instrumente. Synopse: Deutschland und Japan im Vergleich. 2021.

BBSR (2020). *Ökobilanzierung im Bauwesen*. In ÖKOBAUDAT. Retrieved on November 20 2022, from https://www.oekobaudat.de/fileadmin/downloads/2020-04_Flyer_Oekobilanzierung_im_Bauwesen_web.pdf.

BBSR (2019). *ÖKOBAUDAT - Grundlage für die Gebäudebilanzierung*. In Zukunft Bauen - Forschung für die Praxis, 09(2).

BBSR (2020). *Umweltfußabdruck von Gebäuden in Deutschland*. In BBSR-Online-Publikation Nr. 17/2020. Retrieved on December 10, 2022, from https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?__blob=publicationFile&v=3.

BDEW (Bundesverband der Energie- und Wasserwirtschaft e.V.) (2019). *Wie heizt Deutschland?* Retrieved on November 22, 2022, from https://www.bdew.de/energie/studie-wie-heizt-deutschland/.

BMEL (Bundesministerium für Ernährung und Landwirtschaft) (2021). Charta für Holz 2.0. 4te Auflage 2021. Bonn.

BNB (n.d.). Retrieved on May 30, 2023, from https://www.bnb-nachhaltigesbauen.de/en/.

BBSR (n.d.). *Calculation tool eLCA (component editor)*. Retrieved on December 15 2022, from https://www.bauteileditor.de/.

BMWK (2022): *Energy data*. Retrieved on October 26 2022, from: https://www.bmwk.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls-2022.pdf?__blob=publicationFile&v=3.

BMWSB (n.d.) Information on useful lives or renewal cycles of components. Retrieved on November 05, 2022, from https://www.nachhaltigesbauen.de/austausch/nutzungsdauern-von-bauteilen/

BMUV (2021). *Climate Change Act.* https://www.gesetze-im-internet.de/englisch_ksg/englisch_ksg.pdf.

Constitutional Court (2021). 1 BvR 2656/18. Retrieved on January 10, 2022, from: https://www.bundesverfassungsgericht.de/SharedDocs/Entscheidungen/EN/2021/03/rs20210324_1bvr265618en.html.

dena (2019). *dena-Gebäudereport 2019. Statistiken und Analysen zur Energieeffizienz im Gebäudebestand.* Retrieved on November 05, 2022, from https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2019/dena-GEBAEUDEREPORT_KOMPAKT_2019.pdf

dena (2022). *dena-Gebäudereport 2023. Zahlen, Daten, Fakten zum Klimaschutz im Gebäudebestand.* Retrieved on October 30 2022, from https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2022/dena_Gebaeudereport_2023.pdf

dena (n.d.). *Gebäude energetisch sanieren. Energetische Modernisierung. Seriell sanieren: schnell,* *günstig, hochwertig.* Retrieved on December 10, 2022, from https://www.dena.de/themen-projekte/energieeffizienz/gebaeude/bauen-und-sanieren/

Destatis (2022a). *Gebäude und Wohnungen. Bestand an Wohnungen und Wohngebäuden. Bauabgang von Wohnungen und Wohngebäuden.* Retrieved on January 10, 2023, from https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Wohnen/Publikationen/Downloads-Wohnen/fortschreibung-wohnungsbestand-pdf-5312301.pdf?__blob=publicationFile.

Destatis (2022b). *Bauen und Wohnen. Baufertigstellungen von Wohn- und Nichtwohngebäuden (Neubau) nach überwiegend verwendetem Baustoff.* Retrieved on January 15, 2023, from https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Bauen/Publikationen/Downloads-Bautaetigkeit/baufertigstellungen-baustoff-pdf-5311202.pdf;jsessionid=7810F72D385EF61A667426B5FB6C51C8.live722?__blob=publicationFile.

Destatis (2022c). *Baugenehmigungen / Baufertigstellungen von Wohn- und Nichtwohngebäuden (Neubau) nach Art der Beheizung und Art der verwendeten Heizenergie.* Retrieved on February 05, 2023, from https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Bauen/Publikationen/Downloads-Bautaetigkeit/baugenehmigungen-heizenergie-pdf-5311001.pdf?__blob=publicationFile.

Destatis (2023): Wohngebäude, Wohnungen, Wohnfläche: Deutschland, Stichtag, Anzahl der Wohnungen. Retrieved on November 26 2022, from: https://www-genesis.destatis.de/genesis/online?operation=abruftabelleBearbeiten&levelindex=1&levelid=1685476578307&auswahloperation=abruftabelleAuspraegungAuswaehlen&auswahlverzeichnis=ordnungsstruktur&auswahlziel=werteabruf&code=31231-0001&auswahltext=&werteabruf=starten#abreadcrumb.

DGNB (2023). Retrieved on November 15, 2022, from https://www.dgnb-system.de/en/.

Ea Energy Analyses & Viegand and Maagøe (2020). *Erfahrungen mit der Wärmeplanung in Dänemark—Input zur Entwicklung eines Leitfadens zur Wärmeplanung in Baden-Württemberg*. Retrieved on October 30 2022, from www.kea-bw.de/fileadmin/user_upload/Publikationen/Experience_with_heat_planning_in_Denmark_-_GermanSummary.pdf.

Hafner A. et al. (2017): Treibhausgasbilanzierung von Holzgebäuden – Umsetzung neuer Anforderungen an Ökobilanzen und Ermittlung empirischer Substitutionsfaktoren (THG-Holzbau). Forschungsprojekt: 28W-B-3-054-01 Waldklimafonds. BMEL/BMUB. ISBN: 978-3-00-055101-7.

Hörner, M., Bischof, J. (2022): *Typologie der Nichtwohngebäude in Deutschland – Methodik, Anwendung und Ausblick.* Institut Wohnen und Umwelt (IWU).

IWU (Institut Wohnen und Umwelt GmbH) (2018). Datenergebung Wohngebäudebestand 2016. Datenerhebung zu den energetischen Merkmalen und Modernisierungsraten im deutschen und hessischen Wohngebäudebestand.

Mantau, U., Döring, P., Glasenapp, S., Blanke, C. (2017). *Szenarien der stofflichen und energetischen Holzverwendung*. In AFZ-DerWald 13/2017. Forschungsprojekt WEHAM-Szenarien.

Obane, H., Gericke, N., Nawothnig, L., Bunge, F., Hennicke, P. (2022). *Key strategies towards Decarbonization of Energy Use and Supply in Japan and Germany: Insights from a Comparison Study on Long-term Scenario Analyses up to 2050.* Study for the GJETC. Wuppertal, Tokyo.

ÖKOBAUDAT (n.d.). Retrieved on October 27, 2022, from https://www.oekobaudat.de/.

Rauschen, M., Ikaga, T., Thomas, S. (2020). *Energy efficiency in buildings, particularly for heating and cooling.* Output paper of the GJETC. Wuppertal, Tokyo.

Rules for determining the requirement value for QNG non-residential buildings: Regeln zur Bestimmung des Anforderungswertes für QNG Nichtwohngebäude.

State of Green (2018). *Think Denmark—White papers for a green transition: Fernwärme und -Kälte Energieeffizienz für städtische Gegenden*. Retrieved on October 26 2022, from: www.stateofgreen.com/de/veroeffentlichungen/fernwaerme-und-kaelte.

Statista (2023): Electronic appliances in German households. Retrieved on February 25 2023, from: https://de.statista.com/statistik/daten/studie/171470/umfrage/im-haushalt-vorhandene-elektrogeraete/.

Holzbau Deutschland – Bund Deutscher Zimmermeister im Zentralverband des Deutschen Baugewerbes e. V. (2020): Lagebericht 2020. Zimmerer / Holzbau. Retrieved on May 31, 2023, from https://www.holzbau-deutschland.de/fileadmin/user_upload/Pressebereich/2020_04_27_Lagebericht_2020/Lagebericht_2020_mit_Statistiken.pdf

UBA (2022a): *Wohnfläche.* Retrieved on November 20 2022, from https://www.umweltbundesamt.de/daten/private-haushalte-konsum/wohnen/wohnflaeche#zahl-der-wohnungen-gestiegen.

UBA (2022b). *Treibhausgas-Emissionen in Deutschland.* Retrieved on February 10, 2023, from https://www.umweltbundesamt.de/daten/klima/treibhausgas-emissionen-in-deutschland#emissionsentwicklung.

VFF/BF (2017). *Mehr Energie sparen mit neuen Fenstern.* Aktualisierung September 2017 der Studie „Im neuen Licht: Energetische Modernisierung von alten Fenstern“. Studie_2017_VFF/BF_3.indd (window.de).

Wuppertal Institut (2022). *Zukunftsimpuls – Transformationslücke schließen – Handeln unter Hochdruck* (Zukunftsimpuls Nr. 24). (in German only)

7 Appendix

7.1 Supplements to chapter 3.1.1.5

7.1.1 Life-cycle Assessment and Grey Energy (non-renewable primary energy) – Existing Policies: System limits (using the example of QNG)

- The table shows which processes and phases are included in the system limit and therefore incorporated in the evaluation and which processes and phases are excluded. The designations and descriptive information from modules A to D refer to DIN EN 15978.

LIFE PHASES	A 1–3			A 4–5		B 1–7							C 1–4				D
	PRODUCTION PHASE			ERECTION PHASE		USE PHASE							END OF THE LIFE CYCLE				BENEFITS AND LIABILITIES OUTSIDE OF THE SYSTEM LIMITS
	RAW MATERIALS PROCUREMENT	TRANSPORT	PRODUCTION	TRANSPORT	ERECTION/INSTALLATION	USE 1	MAINTENANCE 2	REPAIR	REPLACEMENT 2	MODERNISATION	ENERGY CONSUMPTION DURING OPERATION	WATER CONSUMPTION DURING OPERATION	DISMANTLING/DEMOLITION	TRANSPORT	WASTE RECYCLING	DISPOSAL	POTENTIAL FOR REUSE, RECOVERY AND RECYCLING
Modules in accordance with DIN EN 15978	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D

Delimitation of the different regulations: Life cycle assessments must be prepared for the following building certifications, among others:

- DGNB, BNB: without inclusion of module D
- DGNB: with inclusion of module D

  → No direct comparability of the results of the different LCA calculations!

  When calculating a life cycle assessment, the following components are recorded and documented in a component catalog (KG – German cost categories)

  Complete building structure incl. unheated areas (basement, underground parking, etc.)

- KG 320 Foundation, substructure
- KG 330 Exterior walls/vertical building structures, exterior
- KG 340 Interior walls/vertical building structures, interior
- KG 350 Ceilings and horizontal building structures
- KG 360 Roofs

Building services, with the installations necessary for the use of the building

- KG 410 Sewage, water, gas installations
- KG 420 Heat supply systems
- KG 430 Air-conditioning systems
- KG 440 Electrical installations
- KG 450 Communication, safety and information technology systems

- KG 460 Conveyor systems

In the case of complete modernization, the materials and components that continue to be used are included with zero in the determination of the proportional balance sheet values of modules A1-A3. Newly installed materials and components are accounted for as in the case of new construction.

7.2 Supplements to chapter 3.1

7.2.1 Federal funding for efficient buildings

- Definition Building heating network up to 16 buildings and up to 100 WE published in October 2021.
  - 30 % subsidy if at least 55 % renewable energy and waste heat
  - 35 % subsidy if 75 % renewable energy and waste heat
  - heat network connections 30 % subsidy if 25 % renewable energy and waste heat in the network or primary energy factor max. 0.6
  - 35 % subsidy if at least 55 % renewable energy and waste heat or primary energy factor max. 0.25 or transformation plan is available
- Waste heat can be credited to reach the efficient house standard
- As of 01.02.2022, the subsidy from efficient house 55 was discontinued.
  - The renewable energy and sustainable classes were also discontinued for some time.
- In the case of selfmade work, material costs are to be eligible for grants funding again if an energy efficiency expert certifies that the measure has been carried out professionally.
- For municipalities, the maximum cumulation limit will be raised from 60% to 90%.
  - The requirement that at least three bids must be obtained for subsidized measures is softened by adding a note stating that this requirement may be waived in justified cases.
- The requirement to achieve the renewable energy class is increased from 55% to 65% of coverage from renewable energies or unavoidable waste heat.
  - Unlike before, heat recovery from a ventilation system and the use of green hydrogen will also be able to be counted in the renewable energy class.
  - The use of biogas, on the other hand, can no longer be counted.
  - When connecting to a heating network, it should always be possible in future to apply a flat-rate renewable energy share of the heating network of 65%.
  - A new requirement for achieving the renewable energy class is the use of a ventilation system with heat recovery.
- In the future, it will also be possible to apply the sustainable class for the renovation of residential buildings.
- With the exception of the efficiency house “Denkmal” (historic listed building), all efficiency houses must be low-temperature ready; a supply temperature of 55°C must not be exceeded during design and operation.
- Previously, power supply systems (e.g. photovoltaic systems) could be co-financed for efficiency houses and is now completely abolished.
- Biomass systems may only be used in subsidized efficiency houses if they do not exceed a fine dust emission of 2.5 mg/m³.
- As of 01.01.2024, requirements for noise emissions from the outdoor unit (at least 5 dB lower than specified in the Ecodesign Regulation) apply to subsidized efficiency houses with air-to-water heat pumps.
  - As of 01.01.2026, these requirements are to be tightened (at least 10 dB lower).
  - In addition, only natural refrigerants may be used in heat pumps from the beginning of 2030.

7.2.2 Individual measures in Federal funding for efficient buildings

- The lower limit of eligible costs (minimum investment volume) is raised from €2,000 to €5,000 and from €300 to €1,000 for heating optimization measures.
- The promotion of fuel cells powered by green hydrogen is newly included with a subsidy rate of 25% (plus 10% exchange bonus, if applicable).
- In the case of subsidies for heat pumps or biomass heating (also in addition to an existing or new fossil heating system), the building to be supplied must be powered by at least 65% renewable energy after the measure has been implemented.
- In the case of subsidies for heat generators, the rental costs for a temporary heating system after a heating system defect can be subsidized for a period of up to one year.
- When subsidizing heat generation systems, a heating load calculation and hydraulic balancing is always required.
- If an internet connection and a technical interface on the device are available, the connectivity of subsidized heating systems must be established.
- The subsidy for heating optimization is limited to small buildings (at least 5 residential units or up to 1,000 m² in case of non-residential buildings).
  - In addition, fossil heating systems older than 20 years will no longer be subsidized for heating optimization.
- Biomass heating systems can only be subsidized if they are combined with a solar thermal system and do not exceed a fine dust emission of 2.5 mg/m³.
  - The innovation bonus for biomass systems is cancelled.
- Biomass heating systems must have seasonal space heating utilization rates of 81% from 01.01.2023 (today: 78%).
  - In addition, the biomass used must comply with sustainability requirements.
- The subsidy rate for the construction of building networks will be increased from 25% to 30%.
  - At the same time, the subsidy rate for the construction of building networks using biomass will be reduced to 20%.
- Subsidized building networks must be operated with at least 65% (previously 55%) renewable energies or unavoidable waste heat.
  - Biomass systems in building networks are only eligible for funding in bivalent form in conjunction with other renewable energies or if there is no possibility of bivalent generation.
- In the future, the construction of building networks must always be accompanied by an energy efficiency expert.
- For the connection to a heating network, there are no longer any technical requirements for a renewable energy share or for the primary energy factor.
  - In addition, the subsidy rate for connection to a heating network will be increased from 25% to 30%.

7.2.3 The funding for efficient heating networks program is divided into four modules that build on each other:

- Eligible for funding in Module 1 are transformation plans and feasibility studies for the transformation or new construction of heat network systems.
  - These must be geared to supplying heat to more than 16 buildings or more than 100 residential units.

  - Systemic funding covers the new construction of heat grids that are fed by at least 75% renewable energies and waste heat, as well as the transformation of existing infrastructures into greenhouse gas-neutral heat grids.
  - A maximum investment subsidy of 50% is granted
- The funding in Module 2 basically covers all measures from the installation of the generation plants and heat distribution to the transfer of heat to the buildings supplied.
  - A maximum investment subsidy of 40% is granted for investments in generation plants and infrastructure.
- The systemic approach is supplemented by individual measures in module 3.
- In addition, Module 4 provides an operating cost subsidy for the generation of renewable heat from solar thermal systems and from electricity-driven heat pumps that feed into heating grids.
  - This subsidy applies both to new construction of heat grids and to transformed existing grids.

7.2.4 Municipal heat planning

Municipal heat planning is considered important to provide guidance to building owners and energy suppliers on which buildings would be served by either district heating or individual heating in the future. Denmark has a successful history of more than 40 years with this tool, and it was the basis for the very high share of both district heating and renewable energies in heating the country's homes and buildings.

With a revision of the municipal guideline, an impulse subsidy for municipal heat planning has been introduced as of November 1, 2022.

- In the new funding priority, the preparation of municipal heat plans by expert external service providers is funded.
- If applications are submitted by the end of 2023, the subsidy amounts to 90% of the total eligible expenditure; for financially weak municipalities and applicants from lignite regions, the subsidy amounts to 100%.
- After that, the grant rates are reduced to 60% and 80% respectively.
- The subsidy formulates content-related requirements for municipal heat planning, which are described in the Technical Annex to the Municipal Guidelines.
  - In addition to an analysis of the existing situation, the heating plan must also contain an energy and greenhouse gas balance, including a spatial representation.
  - This also includes a potential analysis to determine energy saving potentials or local potentials of renewable energies.
  - For two to three focus areas, which are to be prioritized in the short and medium term, concrete, spatially located implementation plans are also to be developed.
  - The participation of relevant administrative units, appropriate controlling and a continuation and communication strategy are also to be integrated into the planning.
- The federal government wants to legally obligate the states to have heat plans drawn up for a certain portion of the population and an associated space heating requirement (e.g. 75%).
  - A separate federal law will be created for this purpose, with different requirements depending on the density of the populated area.
  - For example, threshold values of 10,000 - 20,000 inhabitants are being discussed, above which municipal heat planning is to be implemented on a mandatory basis.

  - The federal states, which are obligated by the federal government, will transfer this task to the municipalities and districts.
- Methodological and content-related specifications as well as requirements are to be developed in parallel by the federal government together with the states, municipalities and stakeholders.
- So far, the following implementation steps are proposed for municipal heat planning:
  - Development of a heat plan (either by the municipality itself or by commissioning a service provider).
  - Public participation of the affected stakeholders (building owners, companies, energy suppliers, etc.)
  - Adoption of the heat plan as a legal act
  - Coordination of implementation
- In terms of content, four sections are mentioned in the preparation of the heat plan, which are to be spatially broken down for the entire municipal area:
  - The inventory analysis shows the current heat demand and the resulting GHG emissions, as well as information on building types, building age classes, and the current supply structure.
  - The potential analysis shows sinks (e.g. through renovation and an increase in energy efficiency) as well as potentials of renewable energies and waste heat.
  - In the target scenario, a climate-neutral target for heat supply in 2045 is shown, in which milestones for the years 2030, 2035 and 2040 also describe the future development of heat demand.
  - Finally, the heat transition strategy shows possible measures to achieve the goal of climate-neutral heat supply in 2045
- After the federal law for municipal heat planning comes into force, every obligated municipality should have drawn up a heat plan after three years at the latest.
- Municipalities in the "pioneer states" such as Baden-Württemberg, which have already drawn up a municipal heating plan, are to adapt their plans to the requirements of the federal law during this period - but there are not to be any major differences between previous and future requirements.
- Municipalities are entitled and obliged to collect and evaluate the necessary data from citizens, companies, and other government agencies.
- The heat plans are to be updated every five years.