Energy efficiency in buildings, particularly for heating and cooling

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1. Introduction: The role of energy efficiency in buildings for the energy transition

Buildings take a significant share in energy consumption and greenhouse gas emissions in both countries. For example in 2015, buildings consumed 42 % of the final energy in Germany and 32 % in Japan. This was 45 GJ/capita in Germany and 34 GJ/capita in Japan (Ecofys and IAE 2017). In addition, despite significant improvements in energy efficiency in the past, the potential for further energy savings still is very large. Consequently, energy efficiency in buildings plays a key role in most energy and climate scenarios and targets.

However, scenarios and targets are not sufficient to bring about the transformation of the building stock needed to implement the potential and achieve the targets. Although targets and clear policy roadmaps will provide clarity and guidance to market actors and stakeholders, there remains the importance of understanding in detail the potentials of building concepts and technologies as well as non-technical solutions and actions, the barriers to be tackled, and the effectiveness of policies. In addition to analysing this for each country, further conclusions and learnings can be drawn from also examining the differences and similarities between the two countries, Germany and Japan.

Against this background, this paper concentrates on three main subjects, making use of existing literature:

1. Energy performance of German and Japanese typical new buildings as well as advanced building concepts (eg Passive Houses, KfW40+ in Germany; ZEH/ZEB in Japan) in various climate zones
2. Potential overall energy savings targets for the building stock in 2030 and 2050
3. Policy analysis, including country-specific restrictions/barriers and policy packages that can mainstream the energy-efficient building concepts and technologies, also in the building stock.

The paper concludes with an outlook on possible areas of further cooperation between Germany and Japan.

2. Energy performance of new and refurbished buildings in Germany and Japan

This part of the paper aims to achieve a comparison of the energy performance of German and Japanese typical new and refurbished buildings (i.e., those that are just meeting the minimum energy performance standards – MEPS – as required by the building energy code) as well as advanced building concepts (eg Passive Houses and the energy performance level KfW40+ in Germany; Zero Energy Houses and Buildings – ZEH/ZEB in Japan) in various climate zones. It also discusses the influence of the various components and installed systems on this performance. It focuses on residential buildings but includes some information on non-residential buildings. This has entirely been based on existing literature. Cases, for which no (well-documented) example or simulation exists, had to remain void. Before discussing energy performance levels, some background information on building stock, climate, and the resulting energy uses is provided in chapter 2.1.

In order to make things comparable, the analysis will focus on legal requirements and resulting calculated energy performance; but the impact of different practices in using buildings and resulting actual energy consumption may be briefly discussed.

2.1 Background on the building stock, climate, and energy use today

Germany

Basic trends

Germany's population is expected to be slowly declining, but in contrast to this development the average household size is getting smaller and smaller and the number of total households is increasing. At the same time, the demand for more living space per person is growing.

Around 70% of existing buildings in Germany date from before the first Heat Insulation Ordinance, i.e., before 1979. The energetic quality of new buildings has gradually improved in recent years. Today, however, the proportion of new buildings added to the stock is around 0.5 % per year, and energy savings in existing buildings are becoming more important.

Climate

The annual average temperature, related to the normal period 1961-1990, is 8.2 °C in the nationwide average, with monthly average temperatures between -0.5 °C in January and 16.9 °C in July. These averages are quite similar throughout the country, resulting in average heating-degree days (HDD)[1] between 3500 Kd[2] and 4000 Kd, and cooling-degree days (CDD) between 10 Kd and 50 Kd (Source: https://ec.europa.eu/eurostat/de/web/products-datasets/product?code=nrg_chdd_a).

1 Heating degree days are defined as a function of a basic temperature, i.e. the outdoor temperature above which a building does not require heating. In this case, a base temperature of 15°C was set for unrenovated buildings. For energy-efficient new or renovated buildings, which only need a base temperature of 12°C, lower heating degree days are to be used.

2 Unit of measurement: Kelvin days

Dehumidification will normally not be needed. As a consequence of the low CDD values and insignificant dehumidification needs, air conditioning is still very uncommon in residential buildings but gaining importance in non-residential buildings. The average annual precipitation is 789 millimetres but varies significantly between and within regions. Average monthly precipitation ranges from 49 millimetres in February to 85 millimetres in June.

Building typology

In Germany, there are about 18.2 million residential buildings with approx. 40 million residential units (as of 2012). About 70% of these residential buildings were built before 1979, i.e. before the first Heat Insulation Ordinance. In addition, there are about 1.8 million non-residential buildings.

Of the 18.2 million residential buildings, approx. 63% are detached and semi-detached houses and approx. 37% multi-family houses. The one- and two-family houses are predominantly used by the owner him-/herself, only about 30% of these buildings are rented. The multi-family houses are predominantly rented residential units, only about 13% of the residential units in multi-family houses are used by the owners themselves, the remaining residential units are rented by private or public landlords and by co-operative housing associations.

The decline in new construction activity goes hand in hand with greater renovation of existing buildings. The annual renovation rate of existing buildings in Germany built before 1979 is around 1%. Efforts to provide thermal insulation for masonry structures were essentially only implemented after 1949 and in particular with the introduction of the 1st Thermal Insulation Ordinance in 1979. With the increasing thickness of insulation material and the entry into force of the second Thermal Insulation Ordinance in 1984, the first low-energy houses were established on the market. With these new demands on the quality of the building envelope, timber construction methods once again came to the fore. The prefabricated construction method has a market share of approx. 5 to 10 percent.

User behaviour

The majority of residential buildings in Germany are centrally heated and have no air conditioning. The boiler of the heating system also often produces the hot water, of which the average German consumes approx. 10 to 15 m^3/a or approx. 20 to 60 litres/day. When assessing the energy performance of buildings in accordance with the Energy Saving Ordinance, the building-related energy requirement is taken into account. This is done without considering the user influence, as it is not the user but the energetic quality of the building that is to be assessed.

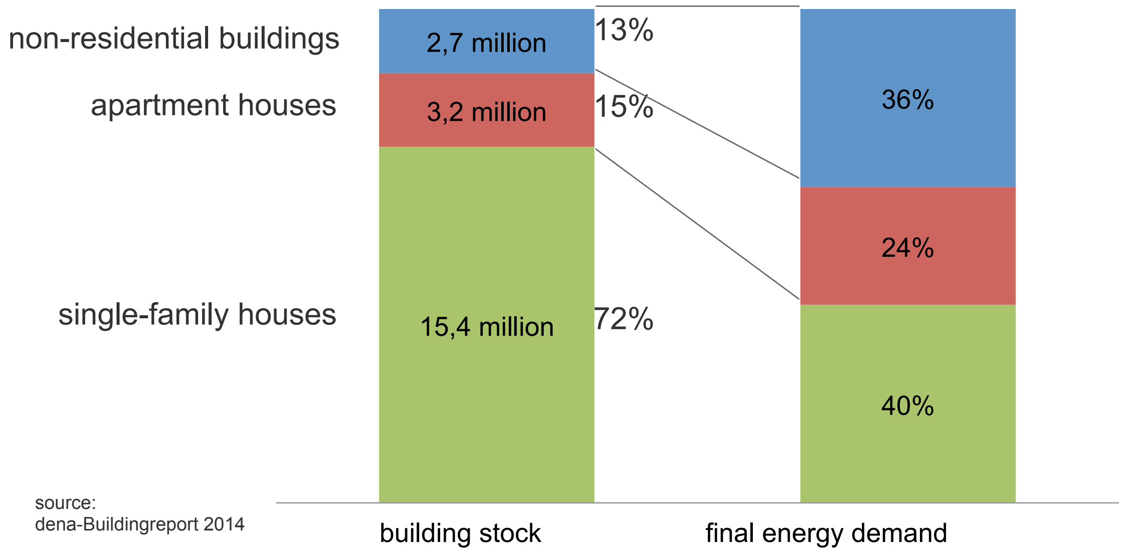
Energy consumption

Total final energy consumption in Germany has been relatively stable at around 2,500 TWh per year for several years. About 38% of this final energy consumption is accounted for by the building sector (space heating, hot water, cooling and lighting in residential and non-residential buildings). Residential buildings account for about two thirds of the energy consumption of the building sector. Put in relation to living space (currently ca. 3,600 million m^2, dena 2018), the residential buildings in Germany consume an average of approx. 150 kWh/(m^2*yr).

The distribution of energy sources in new buildings is significantly different. Here only 54% are heated with gas or oil. At the same time, the proportion of heat pumps has risen to around 30%. Around 28% of new buildings also have a solar thermal system.

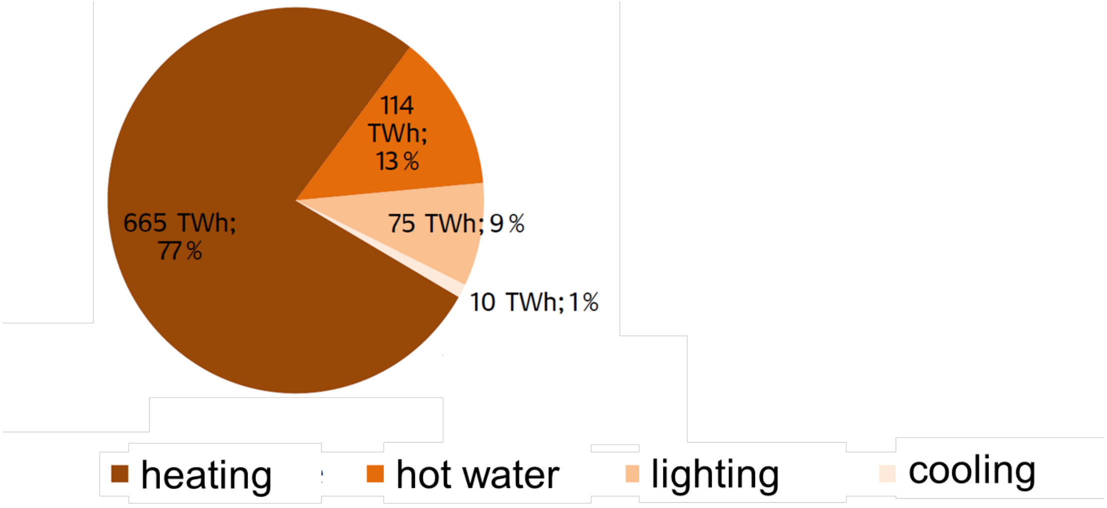
Non-residential buildings have an area of ca. 1,900 million m^2 (dena 2018), around 34.5 % of the total. This share is similar to their share in final energy consumption (Figure 1).

Figure 1: Shares of building types in Germany regarding stock numbers and energy demand for heating and hot water in all buildings, plus cooling and lighting in non-residential buildings



The consumption of final energy for heating, hot water preparation, cooling and lighting installations is around 864 terawatt hours (TWh). Around 35% of the total energy consumption in Germany are used for buildings. The following graph shows the energy consumption of all buildings (residential and non-residential). However, it only refers to building-related energy consumption. Industrial processes in buildings are not included.

Figure 2: Overall final energy consumption of existing buildings in Germany by end use



Source: dena Buildings report 2014

Japan

Basic trends

Japan's population has been slowly declining since 2009, but in contrast to this development the number of total households is increasing. At the same time, the demand for living space per person is growing.

Around 60% of existing buildings in Japan date from before the first Energy Saving Act, i.e., before 1979. The energetic quality of new buildings has gradually improved in recent years. Today, however, the proportion of new buildings is around 2.0 % per year, and energy savings in existing buildings are becoming more important.

Climate

The annual average temperature, related to the normal period 1981-2010, is 13.9 °C in the nationwide average, with monthly average temperatures between 3.9 °C in January and 23.8 °C in July. These averages are quite different from Climate Area 1(Severe cold: North latitude 45) to Climate Area 8(Subtropical: North latitude 25) in Japan. Therefore, heating-degree days (HDD)[3] are 5000 Kd in Climate Area 1 and 20 Kd in Climate Area 8, and cooling-degree days (CDD) are 0 Kd in Climate Area 1 and 700 Kd in Climate Area 8. (Source: https://www.jma.go.jp/jp/amedas/). Dehumidfication will normally be needed in Climate Area 3-8. In these climate areas, air conditioning

3 Heating degree days are defined as a function of a basic temperature, i.e. the outdoor temperature above which a building does not require heating. In this case, a base temperature of 18°C was set for unrenovated buildings. For energy-efficient new or renovated buildings, which only need a base temperature of 18°C, lower heating degree days are to be used.

is very common in residential and non-residential buildings. The average annual precipitation is 1720 millimetres but varies significantly between and within regions. Average monthly precipitation ranges from 85 millimetres in February to 214 millimetres in June.

Building typology

In Japan there are about 53 million residential units (as of 2018). About 20% of these residential buildings were built before 1979, i.e. before the first Energy Saving Act that has no mandatory requirements for houses until 1999.

Of the 53 million residential units, approx. 56% are detached and semi-detached houses and approx. 44% multi-family houses. The one- and two-family houses are predominantly used by the owner him-/herself, only about 8% of these buildings are rented. The multi-family houses are predominantly rented residential units, only about 24% of the residential units are used by the owners themselves, the remaining residential units are rented by private or public landlords and by co-operative housing associations.

The new construction activity is still large, and greater renovation of existing buildings is still few. The annual renovation rate of existing buildings in Japan is around 0.7%. But Insulation renovation is still very few in numbers.

The zero energy houses (ZEH) were gradually increasing since 2016 because of government financial support. ZEH is also promoting high performance window/insulation, photovoltaics and battery. The prefabricated construction method has a market share of approx. 14 percent.

User behaviour

The majority of residential buildings in Japan have individual heaters and air conditioners. The centralizing heating systems are mainly used in Climate Are 1-2(Cold climate). The energy performance labelling of residential and non-residential buildings are gradually promoted in accordance with the Energy Saving Act. This is done without considering the user influence, as it is not the user but the energetic quality of the building that is to be assessed.
However, heating energy use behaviour still differs from Germany in residential buildings, which normally do not heat all rooms as it is common in Germany, and using hot baths to warm the body is relatively more common than heating the room air compared to Germany.

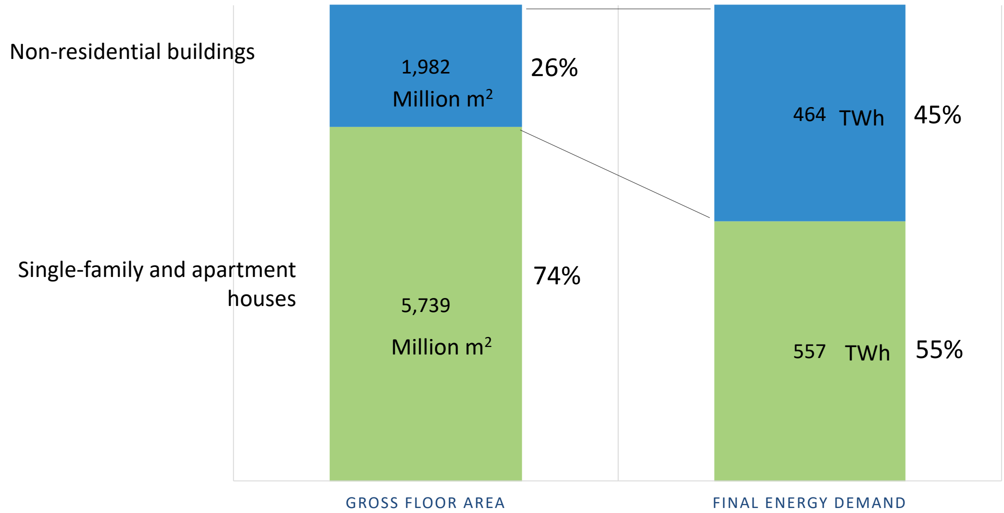
Energy consumption

Total final energy consumption in Japan has been relatively stable at around 3,600 TWh per year for several years. About 28% of this final energy consumption is accounted for by the building sector (space heating, space cooling, hot water, cooking, lighting and home/office electric appliances in residential and non-residential buildings). Residential buildings account for about half of the energy consumption of the building sector. Put in relation to living space, the residential buildings in Japan consume an average of approx. 100 kWh/m² a.

The distribution of energy sources in new buildings is significantly different. Here 85% are heated with gas or oil. At the same time, the proportion of heat pumps has risen to around 30%. Around 0.5% of new buildings also have a solar thermal system.

In Japan, the share of non-residential buildings in floor area is smaller (26 vs. 35 % in Germany), but it is higher in final energy demand than in Germany (45 vs. 36%; Figure 3 vs. Figure 1).

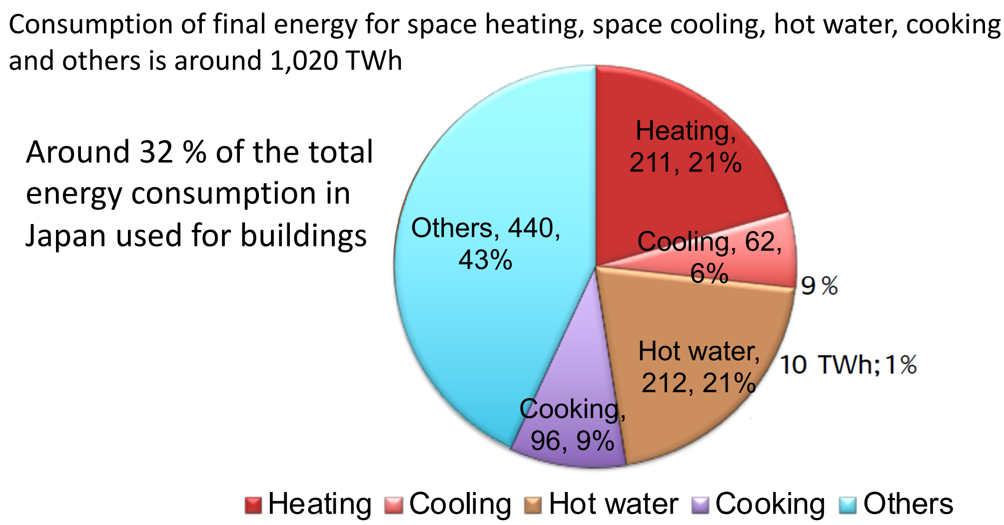
Figure 3: Shares of building types in Japan regarding stock numbers and energy demand for space heating, sapace cooling, hot water, cooking, lighting and home/office electric appliances in all buildings



Source: Handbook of Energy & Economic Statistics in Japan 2018; Building Stock Statistics 2017, Issued by the Construction Economic Statistics Research Office, General Policy Bureau, Ministry of Land, Infrastructure and Transport, 2017

The differences in climate and user behaviour between Japan and Germany also show in Figure 4: The share of energy demand for cooling and hot water is higher than in Germany, while energy demand for heating is much lower in Japan.

Figure 4: Overall final energy consumption of existing buildings in Japan by end use



Source: Handbook of Energy & Economic Statistics in Japan 2018

2.2 New Residential buildings

Germany

- **MEPS compliant – GEG (Gebäudeenergiegesetz – German Building Energy Act)**

New residential buildings must fulfill three main criteria for energy performance in Germany. Those criteria are defined by creating a reference building that is similar in the way it is build, but has defined u-values and a certain heating system. The table below shows an excerpt from the requirements of the reference building.

Table 1: Maximum allowed heat transmission coefficients (U-Value) for new residential buildings according to the German MEPS

Component	Maximum heat transmission coefficient (U-Value)
Exterior walls	0.28 W/m^2K
Roof	0.20 W/m^2K
Base plate / cellar ceiling	0.35 W/m^2K
Windows	1.3 W/m^2K
Doors	1.8 W/m^2K
Thermal bridges (adder)	0.05 W/m^2K

Note: 1) Stricter requirements will apply, if the heating system is based on fossil fuels.

2) W/m^2K means Watts per square metre of surface and per Kelvin of temperature difference. The mathematically correct way to write it would be $W/m^2/K$ or $W/(m^2K)$, but this way of writing is common practice in Germany.

The first criterion is the useful heat (or cold) energy input needed, defined by the heat transmission coefficient (H'_t). It describes how much energy may at maximum get lost over the construction parts (walls, roof, windows etc.) of the building. They should be better than those listed above, which are defined for the reference building.

The second criterion includes the total of all energy losses of the building by transmission, ventilation as well as losses caused by the efficiency level of the heating system, and above that, the upstream process chain. These requirements follow the principle of the primary energy approach (QP). The upstream processes are included by using a defined factor for the chosen energy source, e.g. natural gas or wood pellets, and must be 25% better than in the reference building, which is based on a defined heating system. This means that the use of renewable energy is rewarded by the law, and the maximum primary energy demand required is in fact only the part not provided from renewable energy. Both requests are statutory in the German Energy Conservation Act (EnEV).

The third requirement is the use of renewable energy. The GEG mandates a certain amount of renewable energy for each type of heating technology. For example if solar thermal collectors are used, at least 15% of the energy demand must be produced by those collectors. If geothermal energy is used, at least 50% of the energy demand must be produced with this.

Table 2: Required minimum shares of renewable energy for new buildings according to the German law

Renewable energy	**required minimum share**
Thermal solar energy	15%
gaseous biomass (biogas)	30% (with CHP system) 50% (with boiler)
liquid biomass (e.g. vegetable oils)	50%
solid biomass (e.g. wood)	50%
Geothermal energy or environmental heat (via heat pumps) or waste heat	50%

Since the last revision of the German Energy Conservation Act (EnEV), the predecessor to the GEG, the second requirement related to the primary energy demand is relatively strong. This leads to the fact that it is necessary to use a certain amount of renewable energy to comply with the act. Often the requirements for the use of renewable energies are already met.

- **KfW 40+ (advanced standard)**

A KfW Efficiency House 40+ refers to the same reference building as the MEPS (GEG), but must comply with significantly better energy performance values. If a building is erected in this way, the German Development Bank (KfW) will offer a grant of 30% of the construction cost. The requirement for the KfW 40 Standard is that the primary energy use must be at maximum 40% and the overall transmission coefficient no more than 55% of the levels required for the reference building by the MEPS. The plus (+) is an additional criterion to produce energy within or near by the building with renewable energies like photovoltaics or cogeneration units.

- **Passive House (advanced standard)**

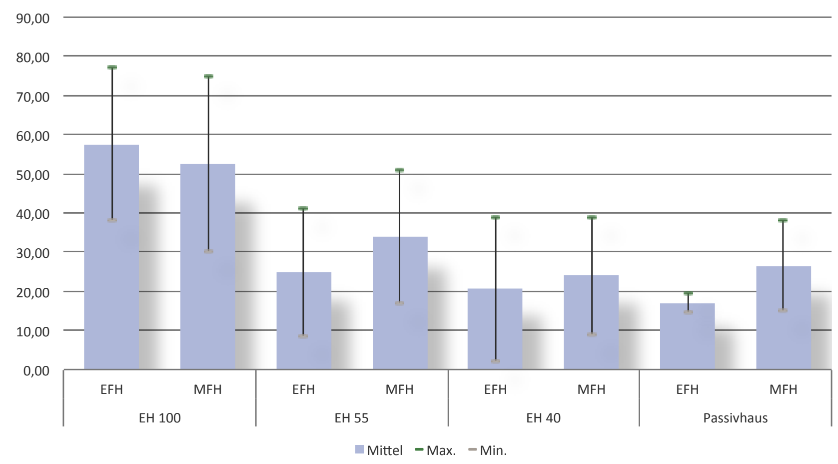
A “Passive House" is a clearly defined standard created by the Passive House Institute. However, there are different classes: "Passive House Classic", "Passive House Plus" and "Passive House Premium", which differ in the permissible proportion of primary energy demand and the required renewable energy production.

Requirements are placed on a very low energy requirement for heating the building. There are two alternative requirement criteria to prove the very good building shell: either through the heating load of the building (max. 10 W/m²) - or through a very low heat energy requirement (max. 15 kWh/m²a). It describes the requirement of heating, in which the solar and internal heat gains are taken into account in addition to the energy performance of the building envelope.
In addition, there are a number of other requirements for the frequency of excess temperature, excess humidity, air tightness and primary energy demand.

Requirements for a Passive House "Classic":
Heating demand ≤ 15 kWh/(m²a) or Heating load ≤ 10 W/m²
Excessive temperature frequency (>25°C) ≤ 10 %
Frequency of excessive humidity (>12g/kg) ≤ 20 %
Air tightness n_{50} ≤ 0,6 1/h
Maximum primary energy demand (PE) ≤ 120 kWh/(m²a) incl. hot water, ventilation, and user's electricity for lighting, eventual elevators, and plug loads
(higher requirements for primary energy demand and additional requirements for renewable energy generation with Passive House Plus and Passive House Premium).

Very high demands are placed on the design with regard to the thermal quality of the building shell. The insulation thickness can be assumed very roughly as double compared to the MEPS (EnEV).

Figure 5: Resulting final energy performance of new residential buildings in Germany for different energy efficiency concepts



Values: kWh/m²/yr

Source: Wuppertal Institut

EFH = single family home

MFH = multi-family house

EH = efficiency house

EH 100 equals legal requirement

EH 55 supposed to need 55% of energy compared to EH 100; analoguous for EH 40

Passivhaus = passive house

Mittel = average

Japan

- **MEPS compliant**

Japan introduced MEPS for new buildings with gross floor areas larger than or equal to 2,000 m^2 in 2015, and has extended their application to new non-residential buildings with gross floor areas larger than or equal to 300 m^2 since 2019 in order to comply with the Paris Agreement.

However, there is no mandatory compliance to MEPS for new residential buildings yet. Instead, for large and medium residential buildings larger than or equal to 300 m^2, it is mandatory to notify the calculated energy consumption. For residential buildings smaller than that, the revision of the act in November 2019 installed a duty of effort to comply with MEPS (see Table 3). This means that from 2021, architects designing new residential or non-residential buildings with a total floor area of less than 300 m^2 are required to explain the MEPS compliance status to building owners.

The values of energy performance that will typically be achieved in Japan's different climate zones under this regulation can be found in

Table 4 below.

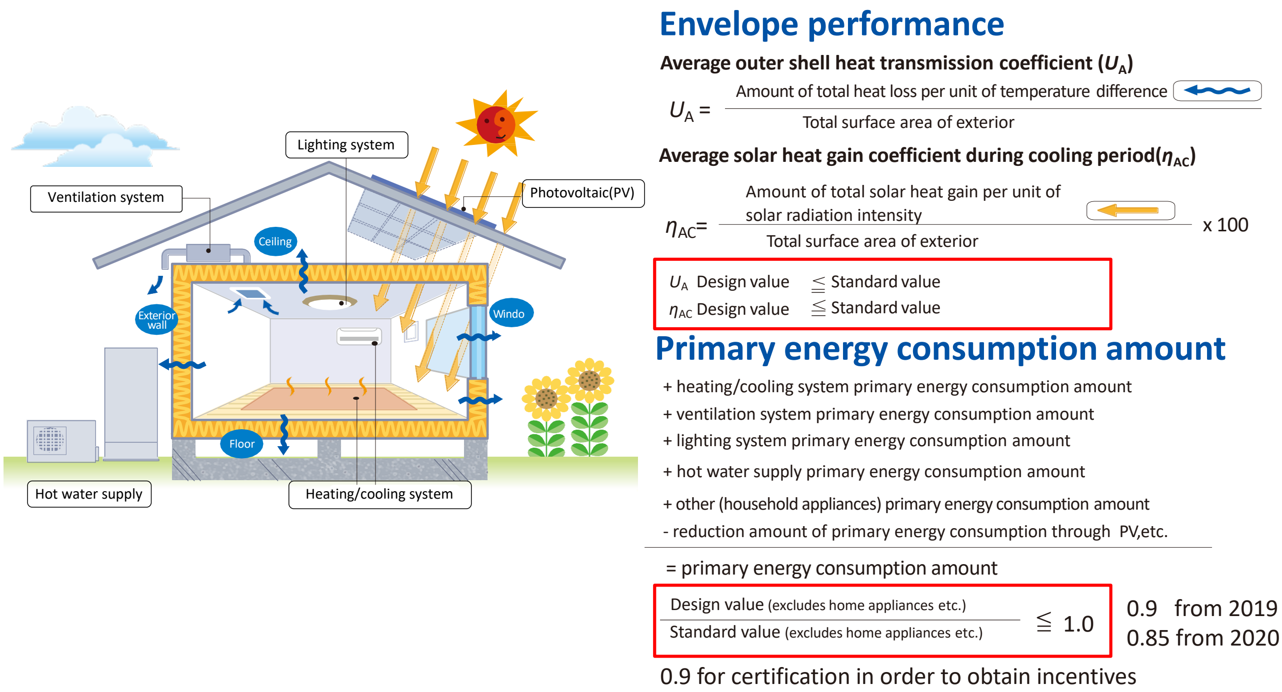
Table 3: Revision Act that was promulgated to achieve the Paris Agreement in 17 March 2019

	Enforced from April 2017	Enforced from Nov 2019/April 2021
Large scale 2000m^2 or more **Medium scale** 300m^2 or more and less than 2000m^2	**Mandatory notification** to administrative agencies with jurisdiction of plan for new construction /extension/renovations	Mandatory notification to administrative agencies with jurisdiction of plan for new construction /extension/renovations[*2]
Small scale Less than 300m^2	**Duty of effort** to improve energy efficiency	Duty of effort to MEPS and Mandatory description from architect to building owner
	Mandatory compliance with energy efficiency standards・Mandatory certification only for ready-made houses[*1] <Housing Top-Runner Program>	Mandatory compliance with energy efficiency standards・Mandatory certification only for ready-made, order-made and apartment houses[*1,*2]

*1: applied for home builders who supplies 150 or more houses per year

*2: Enforced from Nov 2019 *3: Enforced from April 2021

Figure 6: Energy requirements for residential buildings in Japan



Source: Building energy saving leaflet supervised by: Ministry of Land Infrastructure and Transport and issued by: Institute for Building Environment and Energy Conservation (IBEC) , 2017

Table 4: Maximum allowed heat transmission coefficients (UA-value) and solar heat gain coefficient during cooling period (η-value) according to the Japanese MEPS

Climate area		Area1	Area2	Area3	Area4	Area5	Area6	Area7	Area8
Average heat transmission coefficient UA(W/(m^2•K)		0.46		0.56	0.75	0.87			-
Average solar heat gain coefficient during cooling period η(-)		-	-	-	-	3.0	2.8	2.7	3.2
Typical U-value by component	Exterior walls	0.35		0.53					
	Roof/Ceiling	0.17		0.24					
	Floor/ Base plate	0.34			0.48				-
	Windows/ Doors	2.33			3.49	4.65			

Figure 7: Climate area in Building Energy Conservation Act

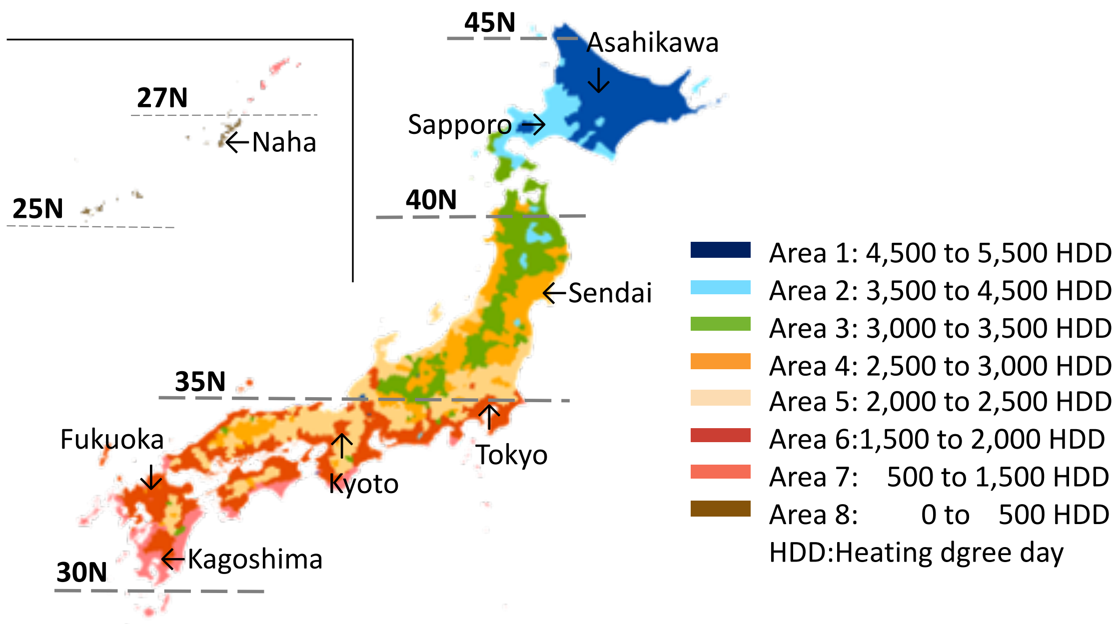


Table 5: Maximum allowed Typical primary energy according to the Japanese MEPS

Climate area	Area1	Area2	Area3	Area4	Area5	Area6	Area7	Area8
Typical primary energy for all rooms 24 hours operation (kWh/(m^2*yr))	305	270	242	253	233	228	192	189-
Typical primary energy for partial intermittent operation (kWh/(m^2*yr))	-	-	156	153	143	136	117	103

Primary energy (heating, cooling, ventilating, lighting, hot water supply and home electric appliances primary energy consumption amount minus primary energy supply by PV) for all rooms 24 hours operation (for partial intermittent operation) kWh/(m^2*yr)

- **Zero-Energy Houses (ZEH; advanced standard)**

Ministry of Economy, Trade and Industry/ Ministry of Land, Infrastructure and Transport/ Ministry of Environment are promoting ZEB with subsidies and other incentives to achieve the target of Paris Agreement.

Table 6: Maximum allowed heat transmission coefficients (UA-value) according to the Japanese MEPS and ZEH standard

Climate area	Area1	Area2	Area3	Area4	Area5	Area6	Area7	Area8
MEPS in 2018	0.46		0.56	0.75	0.87			-
ZEH (Zero Energy House)	0.40		0.50	0.60				-
ZEH+ (Zero Energy House plus)	0.30		0.40			0.50		-

Comparative Analysis between Germany and Japan

The building concepts described above for both countries will yield the following energy performances for single-family buildings in various climates:

Table 7: Energy performance of new single family homes in Germany and Japan in different climate zones

	Germany			**Japan**
Building standard	useful energy heating /cooling kWh/(m^2*yr)	solar PV generation kWh/(m^2*yr)	(fossil fuel) primary energy kWh/(m^2*yr)	primary energy (heating, cooling, ventilating, lighting and hot water supply primary energy consumption amount minus primary energy supply by PV) for all rooms 24 hours operation (values in brackets: for partial intermittent operation) kWh/(m^2*yr)
MEPS	typically: **70**	**0**	typically: **45**	typically: **305** (-) in Area 1 (4,500 to 5,500 HDD) typically: **270** (-) in Area 2 (3,500 to 4,500 HDD) typically: **242** (156) in Area 3 (3,000 to 3,500 HDD) typically: **253** (153) in Area 4 (2,500 to 3,000 HDD) typically: **233** (143) in Area 5 (2,000 to 2,500 HDD) typically: **228** (136) in Area 6 (1,500 to 2,000 HDD) typically: **192** (117) in Area 7 (500 to 1,500 HDD) typically: **189** (103) in Area 8 (0 to 500 HDD)
KfW 40+	typically: **40**	**14**	typically: **18**	-
Passive House	maximum: **30** (15 for heating plus 15 for cooling)	**0**	maximum: **120** (incl. hot water, ventilation, and user's electricity for lighting, eventual elevators, and plug loads)	
ZEH	-	-	-	0 for Net Zero Energy House

Climate characteristics:
Germany: 3,500 to 4,000 HDD, 10 to 50 CDD incl. zero dehumidification needs
Japan: 10 to 5,500 HDD, 0 to 600 CDD incl. zero dehumidification needs

As Table 7 indicates, the typical energy demand of new Japanese homes in a climate comparable to Germany (area 2) seems to be much higher (270 kWh/(m^2*yr)) compared to new homes complying with the minimum energy performance standard in Germany (70 kWh/(m^2*yr)), when assuming all rooms in 24 hours operation of heating systems.

Building concepts and energy performance values for **multi-family buildings and non-residential buildings** are similar. However, a net energy demand of 0 kWh/(m^2*yr) will be much more difficult to achieve for ZEH concepts, since the available space for PV power generation on the roofs in comparison to living floor area is much smaller. This will be similar for KfW40+ houses in Germany.

Influence of building design, components, and materials on differences in energy performance between Germany and Japan

The architecture of buildings and the materials and elements used in their construction also have an influence on energy efficiency and potential savings.

Japanese residential buildings in particular have a tendency towards more complex shapes, bay windows, dormers and thus a deterioration in the ratio of surface to usable space.

In Japan, wood is the dominant material in owner-occupied construction, in Germany solid construction is very strong with over 80% of the market. Both construction methods can be implemented with high energy efficiency. In Germany, timber is strongly represented in prefabricated construction and the timber houses of the prefabricated house industry account for a considerable proportion of the houses in Effizienzhaus 40 or Effizienzhaus Plus (KfW 40+) construction.

A significant influence on the energy efficiency of Japanese buildings is the shortage of space and the high land prices. Insulation requires space and if, unlike in Germany, you build on very small plots of land with extremely small distances between them, the insulation is at the cost of the usable space.

Solutions at the level of quarters

With regard to quarters, the significantly higher density of buildings in Japan offers advantages for local and district heating supply. Although the specific heating requirements of Japanese houses in most climate zones are somewhat lower than in Germany, the lower costs of the heating network compared with the number of buildings that can be connected offer an advantage in terms of cost-effectiveness.

2.3 New non-residential buildings

Germany

The following standards apply to all non-residential buildings regardless of their type. By the calculation standard of DIN V 18599 it is possible to take the usage of the building into account. The defined usage also applies to the reference building, which specifies the target values to be met.

- **MEPS compliant - GEG**

In a similar way to residential buildings, the approach for the valuation of non-residential buildings is a comparison with a reference building. Nevertheless, the requirements for the building and the design of the reference building are partly different. The main difference between those calculation methods is that non-residential buildings are created with multi-zone models. This means for each type of usage e.g. office, classroom, or kitchen, a zone is created. These zones differ in the user behavior like time of usage, requirement of air ventilation or demand on light quality. All requirements of a zone are standardized and fix, so that a typical building can be compared with another of its kind.

On the one hand, as in the residential homes, the primary energy demand is a main requirement. However, instead of the transmission heat coefficient (H'T), which includes losses through the exterior surface as well as through a certain amount of thermal bridges, a different form of requirement exists for non-residential buildings. To limit the heat flow over the exterior surfaces, three average U-values are given for specific building components like the exterior walls, the roofs or windows. The given U-values are for opaque and transparent components as well as for glass roofs and skylight domes, since they are not as efficient as usual windows.

Table 8: Maximum allowed heat transmission coefficients (U-Value) for non-residential buildings according to the German MEPS

Component	Maximum values of the thermal transmittance in relation to the mean value of the respective components	
	Building zones ≥ 19°C	Building zones 12 to < 19°C
opaque exterior components	$\bar{U}$ = 0.28 W/m²K	$\bar{U}$ = 0.50 W/m²K
transparent exterior components	$\bar{U}$ = 1.5 W/m²K	$\bar{U}$ = 2.8 W/m²K
curtain wall	$\bar{U}$ = 1.5 W/m²K	$\bar{U}$ = 3.0 W/m²K
glas roofs, light domes	$\bar{U}$ = 2.5 W/m²K	$\bar{U}$ = 3.1 W/m²K

This shows that the requirement values for non-residential buildings are significantly weaker than for residential buildings. However, in contrast to residential buildings, the electricity for lighting, ventilation and cooling of the building is included in the calculation, since for example cooling is not usual in residential houses in Germany but it is often used in non-residential buildings. However, other energies, used for example in production processes, are to be neglected.

- **KfW 55 (advanced standard)**

Like the KfW-40 standard, the KfW-55 standard refers to the requirement values of the EnEV, but for nonresidential buildings: Annual primary energy demand and thermal insulation – for the latter, however, not H't for as residential buildings, but $\bar{U}$ values for non-residential buildings, cf. Table 8 above . The requirement for the KfW-55 standard is that the primary energy must be only 55% of that of the reference building, and certain average U-values are given that must not be exceed. The requirement parameters for this efficiency standard of non-residential buildings are still significantly weaker than for residential buildings.

- **Passive house (advanced standard)**

The calculation of a passive house exists on different procedure and boundary conditions, which is not based on the DIN V 18599 (EnEV). In doing so, much more precise conditions, such as the real location of the building or its thermal bridges, are taken into account. The total electricity consumption is also forecasted and counted. The way of calculating is mainly the same as it is for residential buildings. The requirements are also the same (see 2.2)

Japan

- **MEPS compliant**

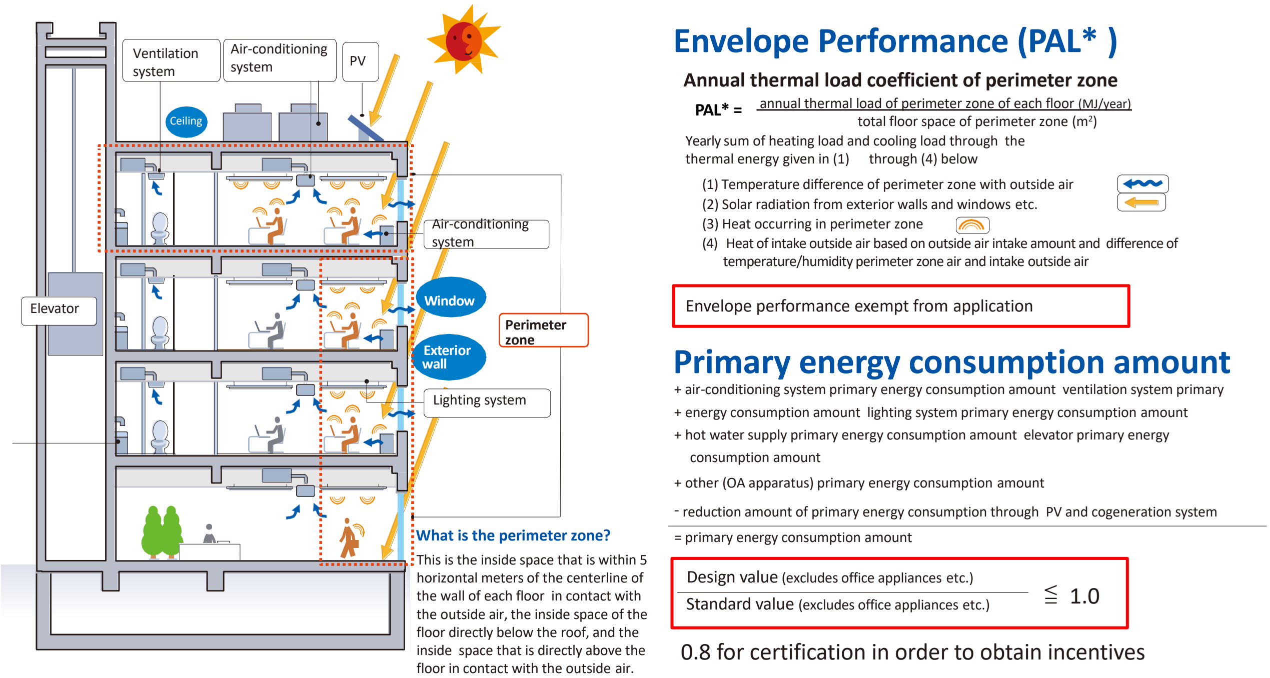
Japan has introduced MEPS for new non-residential buildings with gross floor areas larger than or equal to 2,000 m2 since 2015, and expanded them for new non-residential buildings that their gross floor areas are larger than or equal to 300 m^2 since 2019 to achieve the Paris Agreement. Furthermore, since 2021, architects designing new non-residential buildings with a total floor area of less than 300 m^2 are required to explain the MEPS compliance status to building owners.

Table 9: Revision Act was promulgated to achieve Paris Agreement in 17 March 2019

	Enforced from April 2017	Enforced from Nov 2019/April 2021
Large scale 2000m^2 or more	**Mandatory compliance** with energy efficiency standards and Mandatory certification	**Mandatory compliance** with energy efficiency standards and Mandatory certification
Medium scale 300m^2 or more and less than 2000m^2	**Mandatory notification** to administrative agencies with jurisdiction of plan for new construction /extension/renovations	**Mandatory compliance** with energy efficiency standards and Mandatory certification*1
Small scale Less than 300m^2	**Duty of effort** to improve energy efficiency	Duty of effort to MEPS & Mandatory description from architect to building owner*1

*1: Enforced from April 2021

Figure 8: Energy requirements for non-residential buildings in Japan



Source: Building energy saving leaflet supervised by: Ministry of Land Infrastructure and Transport and issued by: Institute for Building Environment and Energy Conservation (IBEC) , 2017

- **Zero-Energy Buildings (ZEB; advanced standard)**

Ministry of Economy, Trade and Industry/ Ministry of Land, Infrastructure and Transport/ Ministry of Environment are promoting ZEB with subsidies and other incentives to achieve the target of the Paris Agreement.

Comparative Analysis between Germany and Japan

Regarding the Influence of building design, components, and materials on differences in energy performance between Germany and Japan, the same applies as has been said above for new residential buildings. An exception is that wooden buildings are less important for non-residential buildings so far, so that in fact, non-residential buildings are probably more similar between Germany and Japan than residential buildings.

Since non-residential buildings are more diverse and complex than residential buildings, no comparison of the energy performances resulting from the different standards is possible.

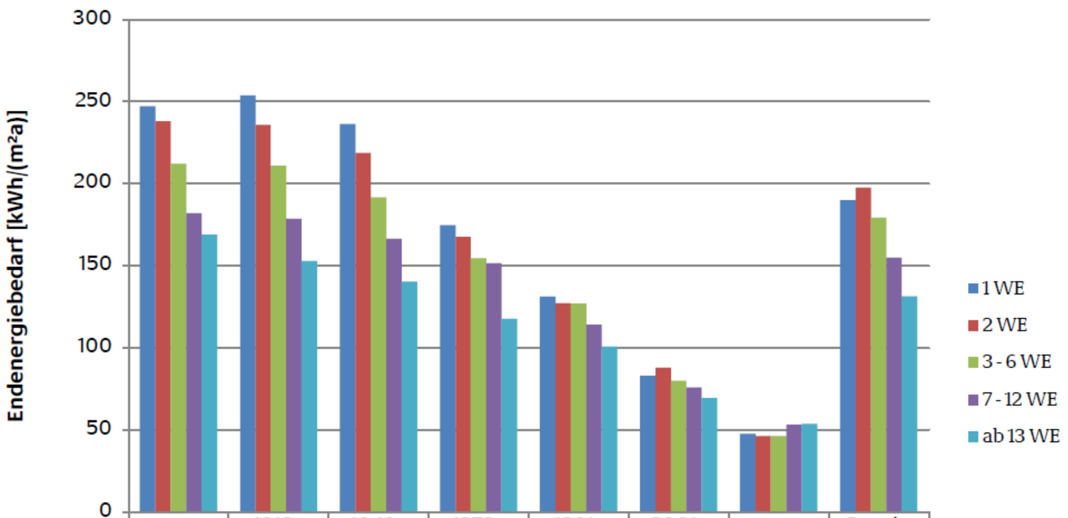
2.4 Energy savings in renovation of buildings in Germany and Japan

Germany

- **Performance of building stock**

The following figure shows the final space and water heating energy demand of existing residential buildings in Germany in kWh/m²a depending on the age class and the number of residential units.

Figure 9: Energy demand for space heating and hot water of existing residential buildings by age class and size in Germany



	bis 1918	1919 - 1948	1949 - 1978	1979 - 1990	1991 - 2000	2001 - 2008	ab 2009	Durch-schnitt
1 WE	247	254	236	175	131	83	48	190
2 WE	238	236	219	168	127	88	46	198
3 - 6 WE	212	211	192	155	127	80	46	179
7 - 12 WE	182	178	166	152	114	76	53	155
ab 13 WE	169	153	140	118	101	69	54	131

Source: dena 2016

WE = Wohneinheit (dwelling unit); Endenergiebedarf = final energy demand

The figure shows that the specific energy demand per square metre is greater for small detached and semi-detached houses than for large apartment buildings. This is due to the fact that larger buildings generally have a more favorable ratio between heated volume and heat-transferring building envelope. In addition, the heat losses of the central system technology occur equally in small and large buildings. Large buildings can therefore be heated more efficiently.

For residential buildings built before 1978, the typical energy demand is between 150 and 250 kWh/m²/yr, depending on the size of the building. After the introduction of the first Thermal Insulation Ordinance in 1978, the energy demand of newly constructed buildings fell continuously (see also Figure 16 on the development of legal requirements in Germany). Since the Energy Saving

Ordinance (EnEV) of 2009, it has been below 50 kWh/m²/yr. With energy-efficient buildings, the size of the building does not have such a strong effect on the specific energy demand per square metre.

However, around 80% of the residential building stock was built before 1978 (left three families of columns in Figure 9), which demonstrates the challenge to improve energy efficiency in the existing building stock in Germany. In addition, the rate of energy efficiency renovation of this stock has only been around 1 % per year for the last 10 to 15 years.

The energy performance of the stock of non-residential buildings by age class is similar.

- **Mandatory renovations for existing buildings**

In Germany it is mandatory to improve two things on existing buildings. Old standard boilers without control unit that are older than 30 years must be replaced. The top floor ceiling must also be insulated if it is uninsulated and adjoins an unheated attic. This law is based on the finding that these kinds of renovations will usually be cost-effective. N.B.: Such a regulation is unusual in Germany, because it abolishes the so-called protection of existing property (Bestandsschutz), which normally applies. The cost-effectiveness made it possible to deviate from the normal rule of protection of existing property.

- **Requirements for renovation during voluntary restoration work**

In principle, the same procedure as for new buildings applies to rate the efficiency of the renovation work, but it is allowed that the requirement to the primary energy consumption of the renovated buildings can by 40% higher than the reference building (instead of 25% lower). It is also legal for the transmission heat requirement to be 75% higher than that of the reference building.

Since it is necessary to do a relatively complex calculation of the entire building in order to determine these values, there is an alternative verification procedure, which requires the building components to meet specific requirements. In this case, requirements on the U-value for every construction element as shown in the table below must be fulfilled.

Table 10: Excerpt of requirements of U-values to certain construction elements

Construction element	Residential and non-residential buildings with an internal temperature with at least 19 °C	Non-residential buildings or zones of them with an internal temperature between 12 °C and 19 °C
	max. coefficient of heat transmission (U_{max} [W/m²K])	
external walls	0,24	0,35
windows, glazed doors	1,30	1,90
garret window	1,40	1,90
curtain wall	1,50	1,90
glass roof	2,00	2,70
roofage, ceiling to attic	0,24	0,35
roofage with seal (flat roof)	0,20	0,35
external walls adjacent to ground	0,30	-
floor adjacent to external air below	0,24	0,35

This regulation means that the previously mentioned protection of existing property is also revoked if an owner wants to renovate his building voluntarily. Again, this is jusified by the fact that the incremental investment in energy efficiency on top of the normal renovation cost is usually cost-effective.

In order to obtain financial support from KfW or other programs (subsidized loans or grants), it is necessary to surpass the efficiency of above listed criteria. It is therefore possible either to demonstrate a significantly better efficiency standard for the entire building or to meet improved U-values.

It is difficult to provide typical heating energy savings from GEG-compliant renovations (in % and in kWh/m2/yr), since there is no systematic evaluation. There are evaluations of the buildings receiving financial support from the KfW programs. They show that deep renovations according the KfW's 'Effizienzhaus' (efficiency house) standard can achieve energy performance levels better than those currently required for new buildings (Diefenbach et al. 2018). In addition, many cost-effective demonstration projects (such as 'NEH im Bestand', Köln-Bilderstöckchen) have achieved energy savings of 80 % or even higher.

Japan

In Japan, there are no mandatory requirements for renovations for existing buildings. But, there are requirements for voluntary renovation to obtain subsidies from the government.

3. Energy efficiency policy targets for buildings

In this chapter, existing overall energy savings targets for the building stock in 2030 and 2050 in both countries are briefly presented and discussed. Where such targets do not yet exist, the possibility for setting them is discussed.

3.1 Germany

In 2010, the German Government – then a conservative coalition of Christian Democrats (CDU) and Liberals (FDP) under Chancelor Angela Merkel - decided on the mid- and long-term targets of the „Energiewende“. These „revolutionary targets“ (Angela Merkel) up to 2050 were based on a far-reaching consensus of the German scenario analysis community.

The targets for energy efficiency increase and for an absolute reduction of primary energy consumption might still be among the most ambitious in the world (see below Table 11). Buildings take a prominent role among these targets, with a short-term target of reducing heating energy consumption in buildings by 20% by 2020, and a long-term target for an “almost climate-neutral building stock”, using ca. 80% less non-renewable primary energy, in 2050. However, the latter would not only be achieved through reducing energy consumption by energy efficiency: it is understood as *non-renewable* primary energy, so the increased use of renewable energy directly in buildings (solar thermal; biomass; ambient heat used through heat pumps; solar PV power used to drive heat pumps) will also contribute to achieving this target.

Table 11: Energy saving targets of the German Energiewende and status of implementation

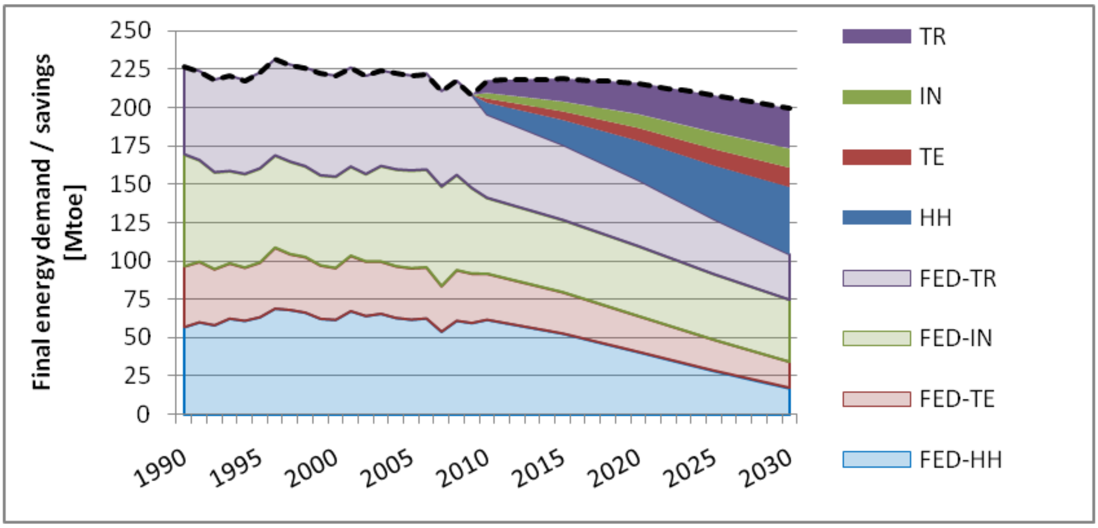
Indicator	Target 2020	Target 2050	Level of Implementation 2017
Primary energy consumption (compared to 2008)	**- 20 %**	**- 50 %**	**- 5.5 %**
Gross electicity consumption (compared to 2008)	**- 10 %**	**- 25 %**	**- 3.3 %**
Final energy productivity		**2.1 % per annum (2008 – 2050)**	**1.0 % per annum (2008 – 2017)**
Primary energy consumption in buildings (compared to 2008)	**–**	**in the order of - 80 %**	**-18.8 %**
Heat consumption in buildings (compared to 2008)	**- 20 %**	**–**	**- 6.9 %**
Final energy consumption in transport (compared to 2008)	**- 10 %**	**- 40 %**	**+ 6.5 %**

Source: Federal Ministry for Economic Affairs and Energy, BMWi. (2019). The Energy of the Future, Second “Energy Transition” Progress Report. (in German)

The following graph from BMU/FhG-ISI (2012) shows that the technical potential exists in Germany to reach the targets: already in 2030, almost 50 % savings are possible even in final energy demand.

In addition, around 80% of this potential is cost-effective when doing a life-cycle cost calculation. The sectors HH (private households) and TE (tertiary, i.e. commercial and public) include most of the energy consumption in buildings and show the biggest potential in per cent, particularly the HH sector (darker wedges at the top of the graph).

Figure 10: Technical energy saving potentials in Germany, by sector



Source: Fraunhofer ISI 2012, p. 182

In addition to energy savings, energy efficiency in buildings brings **multiple other benefits** (IEA, 2014). The EU project COMBI quantified around 30 different impacts of energy efficiency for an improvement of energy efficiency in 2030 that is equivalent to achieving the new EU energy efficiency target vs. the baseline scenario for 2030. For the buildings-related measures in Germany, findings include (https://combi-project.eu/charts/):

- Energy savings of ca. 83 TWh/yr are calculated to be worth ca. 7.65 bn €/yr.
- Health and labour productivity improvements, an increase in active days through healthier buildings, reductions in mortality and greenhouse gas emissions (25 mn tons/year) add another almost 5.0 bn €/yr or 65% to the direct energy cost savings.
- The additional investment needed is ca. 5.45 bn €/yr. Hence, the additional impacts improve net benefits of building energy efficiency from ca. 2.2 to ca. 7.2 bn €/yr.

Is Germany on track to meet these targets?

As the right column of Table 11 shows, Germany has been lagging behind its energy efficiency targets in recent years. For most of these indicators, 2017 actual values are further away from the targets for 2020 than 2014 actual values. A reason may have been the strong economic growth in these years. Preliminary values for 2018 show considerable progress towards the targets but trends are still too slow to make the 2020 targets appear achievable.

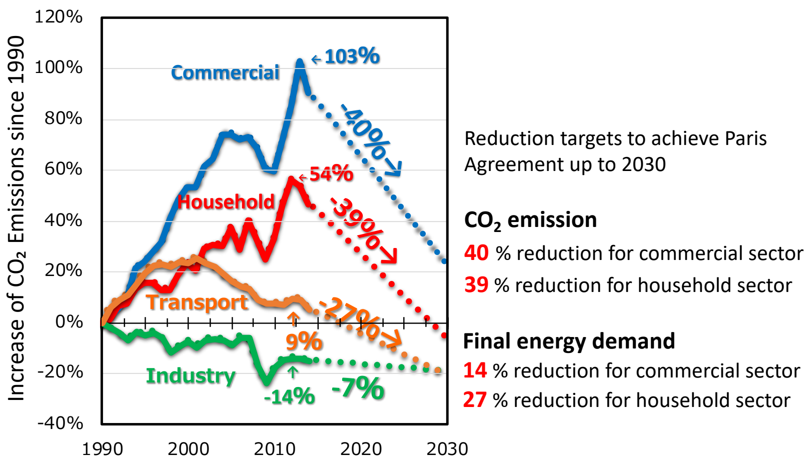
In recent years and hence in the short run (up to 2020), the decrease of energy consumption in the buildings sector is not on track either. While in 2014, heating energy consumption in buildings was 12.4 % lower than in 2008 (BMWi 2015), it rose to 2017 due to weather effects and increase in population, which inhabited new dwellings but also previously unoccupied dwellings, and remained only 6.9 % lower than in 2008 (BMWi 2019). Although the heating energy consumption per m^2 of *residential* buildings was ca. 13 % lower in 2016 than in 2008 (BMWi 2018), the increase in building floor area, also in non-residential buildings, and in population reduced the overall energy savings to the said 6.9 %. In contrast to this, primary energy consumption in the buildings sector continued to decrease and reached a level 18.8 % below that of 2008 in 2017, as compared to 14.8 % in 2014. However, as said above, this excludes the use of renewable energies, and also includes energy savings in non-residential lighting. This may explain the diverging trends between the two indicators between 2014 and 2017.

One of the latest reports (BMWi 2018) also estimated whether the long-term target may be achieved if past trends since 2008 prevail. The result was that non-renewable primary energy consumption in the building sector would be reduced by 60 % by 2050, which would be good but obviously not sufficient to reach the 80 % target, let alone a complete decarbonisation. This is why the German Government comments, already in its latest Green Paper on Energy Efficiency (BMWi, 2016), correctly by writing “energy saving in Germany: much achieved but still much to do”.

3.2 Japan

In 2016, the Japanese Cabinet decided CO_2 reduction targets and final energy demand reduction targets to achieve Paris Agreement in Japan, by sector up to 2030 as shown in Figure 11. Reduction targets of CO_2 emissions are 39% and for final energy demand are 14% for the household (residential building) sector and 40% and 27%, respectively, for the commercial (non-residential building) sector in 2030 compared to 2013.

Figure 11: Reduction Targets to achieve Paris Agreement in Japan, by sector



Source: Long-Term Energy Supply and Demand Outlook Source created by the Agency for Natural Resources and Energy (July, 2015)

Source : National Institute of Environmental Science, 2016

However, Japan has not yet set a policy target for the building sector for 2050.

According to the analysis performed by the GJETC's Working Group on Climate & Energy Policy Targets, Plans and Strategies – The Role of Monitoring and Evaluation Mechanisms, Japan is on track to achieve its overall energy savings target for 2030 (Matthes et al. 2020). This may indicate that it is also on track to achieve the policy targets for building energy consumption.

4. Effective energy efficiency policies for buildings

This chapter particularly addresses the following questions:

1. What are country specific restrictions/barriers for an energy-efficient, climate-neutral new build and refurbishment strategy of the building stock?
2. Which policies can mainstream the energy-efficient building concepts and technologies, also in the building stock, and for typical forms of ownership and use of buildings?
3. Which policies already exist in both countries, and what could they learn from each other?
4. How could policies be improved in both countries?

4.1 Barriers and market failures

Although many market actors have incentives to save energy or to offer energy-efficient technologies and services, the barriers to energy efficiency action are often stronger. If only one actor in the market chain for buildings decides against the energy-efficient solution, it will not happen.

Such barriers include:

- Lack of awareness on the existence of more energy-efficient solutions and their benefits: energy efficiency is often hidden in many items, and not the primary purpose of a building or its components
- Lack of information and market transparency, leading to high search and transaction costs, compared to sometimes small individual gains
- Lack of skilled designers contractors for energy efficiency works or of supply of energy-efficient buildings in general
- Little consideration of life-cycle costs instead of purchase costs only
- Other priorities in consumption or production to spend/invest money on
- Expectation of short payback times (few years), equivalent to implicit internal rates of return of 10 to 30 % over the much longer life times of the energy-efficient technologies, fuelled e.g. by uncertainty or mistrust in the savings that can be made or the increase in value of an energy-efficient building, or the priority in investment in core businesses
- The principal-agent dilemma (e.g. split incentives between landlords and tenants in all rental buildings)
- Maybe unavailability of the energy-efficient technology from the "usual" supplier, risk aversion regarding new solutions on both supply and demand side

- Subsidies to energy supply will reduce cost-effectiveness, as will a lack of energy taxation, so that external costs are not sufficiently internalized.
- Specifically in Japan, energy consumption for heating is low in many regions, because only few rooms in dwellings are heated or only to relatively low indoor temperatures. Better insulation will therefore increase thermal comfort, in both heating and cooling season, and improve the health situation, but to save a lot of energy compared to today's situation. These comfort and health benefits are very important but much less tangible and quantifiable than energy cost savings, so the economic attractiveness of building energy efficiency may be less obvious than in Germany.

Therefore, energy efficiency policies must support all market actors in overcoming these barriers.

In addition, in many liberalized energy markets, the perspective of suppliers does not coincide with the perspective of consumers. As long as utilities make more profit from the sales of energy, they have little interest in increased efficiency on the demand side. Only if the framework conditions are adapted in a way that the supply of energy services results both in a cost degression for the consumer and in appropriate profits for the supplier, the market for energy efficiency and energy services can flourish (cf., e.g., Pagliano et al. 2001). This type of incentive regulation is practiced in several countries, but not yet in Germany nor in Japan.

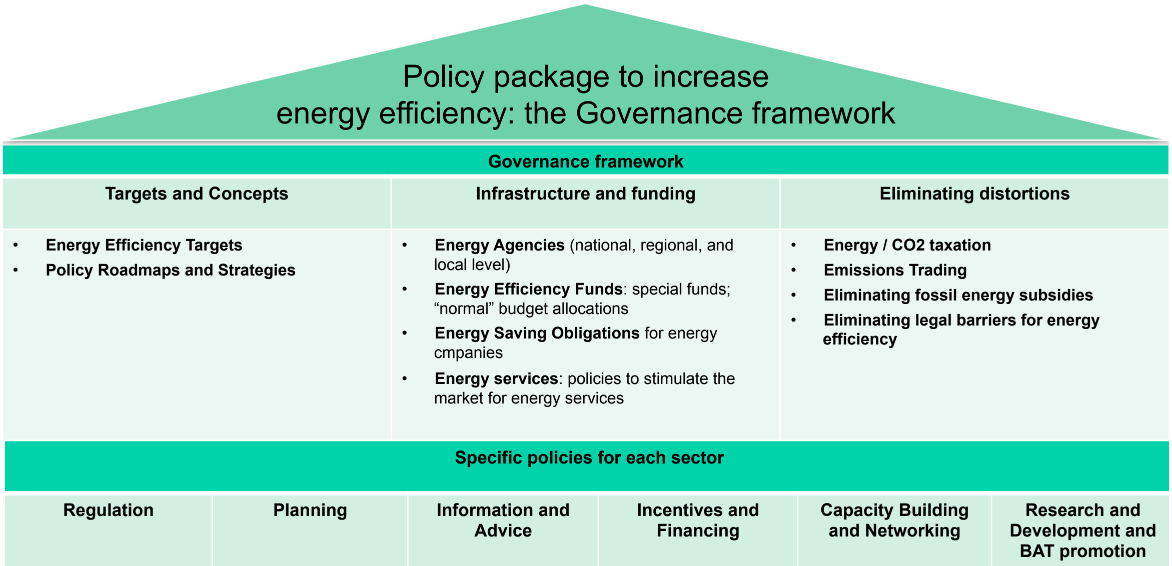
4.2 Overcoming barriers with ambitious, targeted packages of policy instruments

Due to the complexity of the market and the numerous actor-specific barriers (see Chapter #4.1), policy is needed to overcome the barriers and to harness the (cost-effective) potential of energy efficiency measures. For buildings just as for any other sector, a consistent and synergetic package of policies needs to be in place to improve information and market transparency, to overcome financial barriers, and to make at least a minimum level of energy efficiency, which is cost-effective for most consumers, the standard. Professional training and certification of suppliers, instruments of local planning, or special instruments to foster innovation towards new or improved technologies with even higher levels of energy efficiency are also needed. The sectoral policy package discussed in literature for buildings (cf. Thomas et al. 2015) will be provided below. Later on, we will discuss to which extent and how Germany's and Japan's energy efficiency policies implement these policy packages.

In addition to the sectoral instruments, a set of overarching policies we call the governance framework serves to guide and enable implementation of the sector-specific policies (Thomas et al. 2015). These include strategic targets and concepts such as those presented in chapter 3, the infrastructure and funding for implementing the sectoral policies, and energy or GHG taxation, reform of eventual energy subsidies, and removal of legal barriers for energy efficiency.

The following figure presents the typical instruments of the governance framework. It should be noted that Energy Saving Obligations for energy companies are an alternative to the combination of government's Energy Agencies and Energy Efficiency Funds.

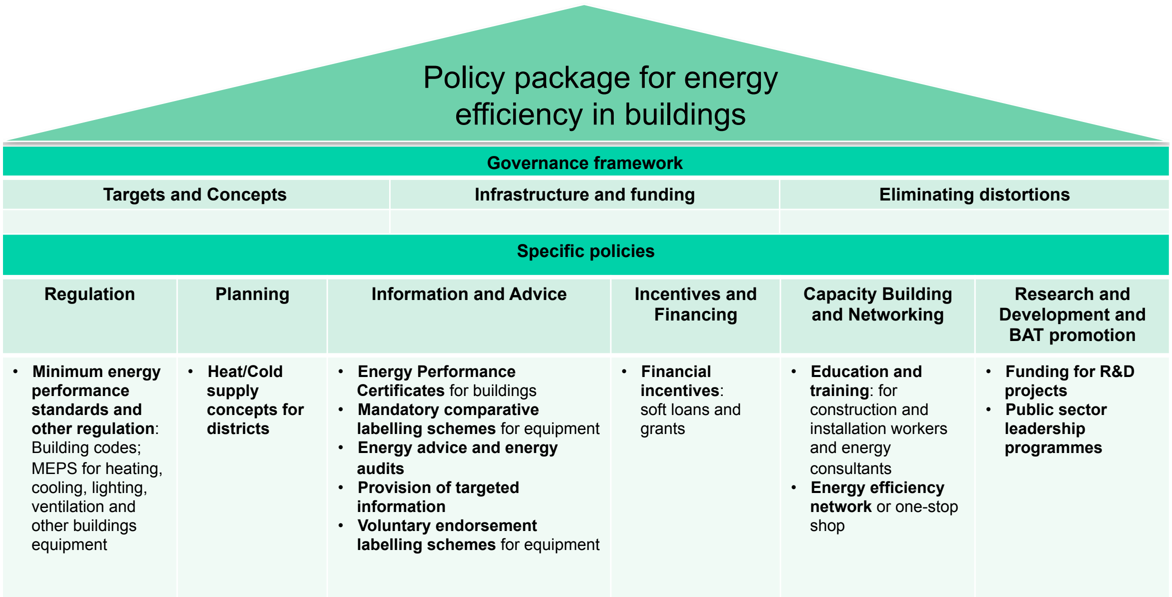
Figure 12: Prototypical energy efficiency policy package: the governance framework



Source: based on Thomas et al. (2015).

Next, Figure 13 presents the prototypical energy efficiency policy package for buildings and installed equipment.

Figure 13: Prototypical energy efficiency policy package for buildings

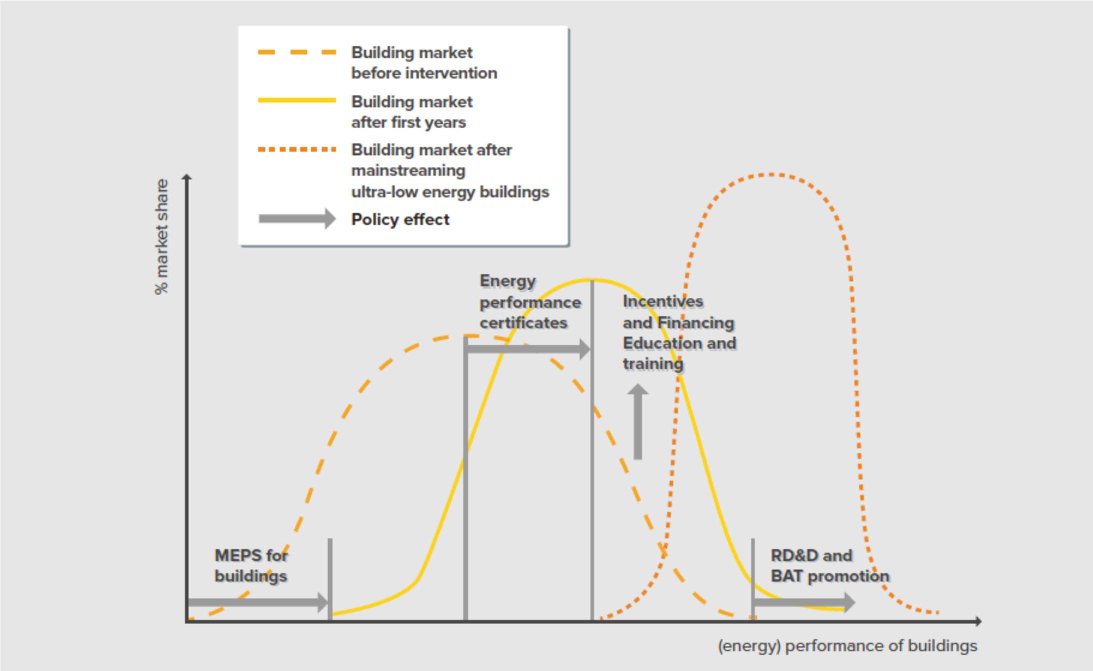


Source: based on Thomas et al. (2015).

Interaction of the policy instruments in the package

In the remainder of this subchapter, we will discuss how the specific policies for energy efficiency in buildings need to **interact as a policy package**. This will need to distinguish between new and existing buildings.

Figure 14: Purposes of instruments in the energy efficiency policy package for new buildings



Source: Thomas et al. (2015)

- Mandatory **minimum energy performance standards (MEPS)** for all new buildings (and building components where useful) are *the most important policy for energy efficiency in new buildings*. They should be created by law and then strengthened step by step every three to five years, to finally require very high energy efficiency levels. MEPS reduce transaction costs as well as the landlord-tenant and developer-buyer dilemma by removing the least energy-efficient building practices and concepts from the market.
  They should, however, always be at least as stringent as the energy performance level leading to least life-cycle costs. In order to be effective, compliance with MEPS must be controlled at the local level in both the design stage and after construction. Preferably, **other statutory requirements** such as individual metering, energy management for larger buildings and building portfolios, or regular inspections of heating, ventilation, and air conditioning systems would complement the legal framework.
- **Education and training** of building professionals (architects, planners, developers, builders, building and installation contractors, financiers and other relevant market actors) is essential to prepare introduction and further strengthening of MEPS regulation. Easy-to-use tools for energy-efficient building design and for life-cycle cost calculation are important for the training. **Certification** of successful participation to the training can make it more attractive for both the qualified market actors and their customers.

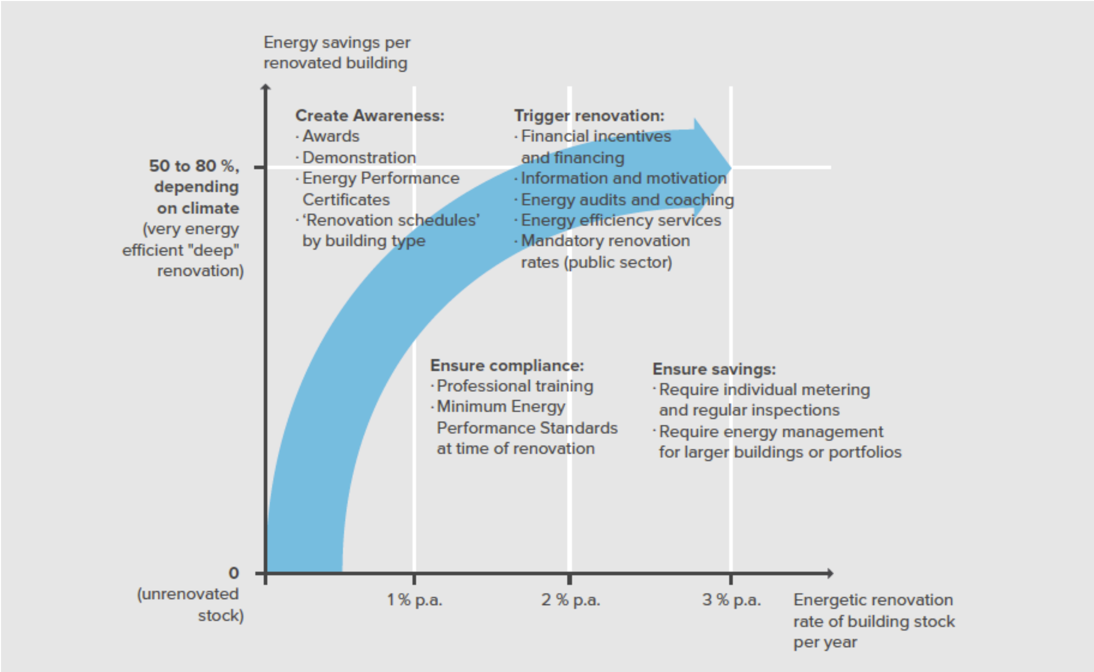
- The markets should, furthermore, be *prepared for the next step(s) of MEPS regulation* through policies tackling the substantial information deficits and financing barriers. These include building **energy performance certificates** (and energy labels for components where useful), **showcasing** of demonstrated good practice buildings, **advice** and **financing support** for investors, and **financial incentives** – such as grants and tax incentives – for broad market introduction of ULEB. It is mainly for such information and financial programmes that energy efficiency funds or energy companies must contribute.
  Promotion of energy services for energy savings and voluntary agreements with large developers to build more energy-efficiently than required by MEPS may also support market breakthrough.
- Once a certain market share of (Ultra-) Low-Energy Buildings of a specific energy performance level is reached, the professionals are trained and used to the required practices, and the cost-effectiveness of this energy performance level step is proven, this level can then be mandated by the regulation to become the new MEPS level.
- Future steps of MEPS regulation towards very high energy efficiency levels should be prepared by innovation support through **R&D funding, demonstration** (including in public buildings), **award competitions**, and maybe also already by financial incentives for broad market introduction. The **public sector** should **lead by example** through energy-efficient public procurement and ambitious targets for its own buildings, thereby paving the way for the other sectors to follow.

The **existing building stock** provides larger potential for cost-effective energy savings than new construction, at least in Germany. It is also the bigger challenge to retrofit the walls, roofs, windows, and heating and cooling systems of existing buildings to highest energy performance levels in an integrated way. The operational goal for energy efficiency in existing buildings thus has two dimensions:

- **Achieving very energy-efficient and comprehensive, "deep" retrofits whenever a building is renovated,** and
- **increasing the rate at which buildings undergo such "deep" energetic renovations.**

Figure 15 and the text following it present an advisable combination of policy instruments for achieving this two-dimensional goal.

Figure 15: The interactions of policy instruments for energy efficiency in building renovation and operation



Source: Thomas et al. (2015)

- Every year, many existing buildings undergo renovation for maintenance or beautification anyway. These opportunities should be harnessed to improve energy efficiency by adding thermal insulation or shading and using more energy-efficient windows, heating, and cooling systems, instead of just replacing paint, tyles, or windows as they were before. The reason for this recommendation is that it is very often cost-effective to add the incremental energy efficiency investment at the time of renovation but not cost-effective to repay the full renovation cost from energy savings. Renovation without improving energy efficiency therefore means a lost opportunity and will likely lock in high energy consumption until the next renovation.
- Mandatory **minimum energy performance standards (MEPS)** for existing buildings undergoing major renovation (e.g. more than 10 or 20% of the building shell or of the walls, windows, or roofs) as well as for building components and heating and cooling systems *are therefore an important policy for energy efficiency in existing buildings, too*. They should be created by law and then strengthened step by step every three to five years, to finally require very energy efficiency levels also for existing buildings when the technology is mature and cost-effective enough. MEPS reduce transaction costs as well as the landlord-tenant and seller-buyer dilemmata by removing the least energy-efficient building practices and components from the market. They should, however, always be at least as stringent as the energy performance level leading to least life-cycle costs. In order to be effective, compliance with MEPS must be controlled at the local level in cases of major renovation. However, for existing buildings it is much more important to accompany MEPS with individual advice as well as financial incentives or financing for meeting the MEPS requirements, since otherwise building owners may wait with major renovation. A possibility may be to mandate the rate at

which the portfolio of large building owners has to undergo energy-efficient renovation each year, as the European Union has required for national government buildings in its Member States.

- Preferably, **other statutory requirements** such as individual metering, energy management for larger buildings and building portfolios, or regular inspections of heating, ventilation, and air conditioning systems would complement the legal framework to ensure energy-efficient operation of buildings.
- *The most important policies and measures for energy efficiency in existing buildings are those tackling the substantial information deficits and financing barriers, in order to first move markets towards very energy-efficient retrofit levels („deep renovation") and then to trigger energy-efficient renovation at all, to increase retrofit rates.*
- These instruments include building **energy performance certificates** (and energy labels for components where useful) with mandatory display upon advertisement, rental or sale, **showcasing** of demonstrated good practice building renovations, and **award competitions** for very energy-efficient renovations, combined with **information and motivation programs** to disseminate the results, to *raise awareness* for energy efficiency opportunities in renovation and to develop more energy-efficient and cost-effective technologies and concepts for building renovation. In addition to these instruments, **individual advice**, such as **energy audits** need to show building owners what they (or their tenants) can save and what is cost-effective, and **coaching** can be essential to assist investors in implementing the retrofits. Still, due to long pay-back times and/or lack of finance, **financing support** for investors, and **financial incentives** – such as grants and tax incentives – are essential for broad market breakthrough of very energy-efficient retrofits. It is mainly for such information and financial programs that energy efficiency funds or energy companies must contribute. Promotion of **energy efficiency services** for guaranteed energy savings and voluntary agreements with large developers to renovate energy-efficiently at an increased rate may also support market breakthrough.
- Only all of these instruments together are likely to achieve the double goal of very energy-efficient retrofits at increased rates.
- In addition, there must also be a sufficient number of skilled providers willing and able to perform the energy-efficient renovation tasks. **Education and training** of building professionals (architects, planners, portfolio managers, builders, building and installation contractors, financiers and other relevant market actors) is essential *to increase renovation rates and ensure high quality and very energy-efficient retrofit.* Easy-to-use **tools** for energy-efficient building design and for life-cycle cost calculation are important for the training. **Certification** of successful participation to the training can make it more attractive for both the qualified market actors and their customers.
- Once a certain market share of retrofits to a specific energy performance level is reached, the professionals are trained and used to the required practices, and the cost-effectiveness of this energy performance level step is proven, this level can then be mandated by the

regulation to become the new MEPS level for major renovations. This would be *one step of MEPS regulation* towards very high energy efficiency levels in existing buildings.

- *Future steps of MEPS regulation* towards energy efficiency levels equivalent or close to ULEB should be prepared by innovation support through **R&D funding, demonstration** (including in public buildings), **award competitions**, and maybe also already by financial incentives for broad market introduction. The **public sector** should **lead by example** through very energy-efficient renovations and ambitious energy savings targets for its own buildings, thereby paving the way for the other sectors to follow.

4.3 Comparison of existing policies for buildings in both countries

The following text is taken from chapter III.2 of the Ecofys/IAE (2017) report on energy efficiency for the GJETC, updated to the current situation, and augmented by additional information.

About 35% of the Japanese residential building stock was built in or before 1980 according to the Statistics Bureau (Statistics Bureau 2016b). In Germany, even 65% of residential buildings were built before 1980 (Landesamt für Statistik Niedersachsen 2014). Hence, in addition to standards for newly constructed buildings, incentives for energy-efficient renovation measures are of great importance in order to tap the efficiency potential of the entire building stock. In particular, the building envelope has a high potential for improvements in both countries. In Germany, it is estimated that in the next 20 years, 50% of residential houses will have to be renovated (BMWi 2017a).

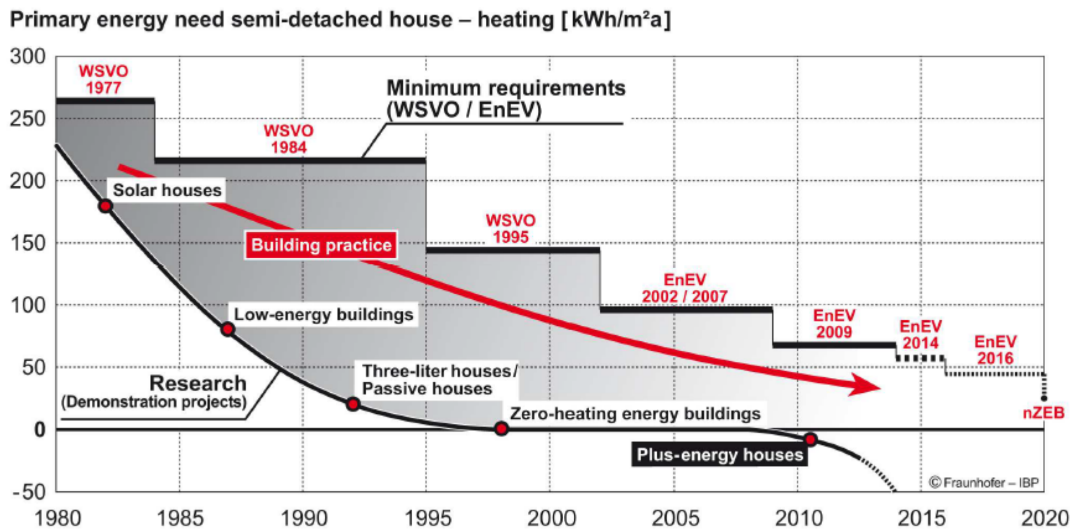
The amount of living space in Germany has increased steadily since 1990. Between 2000 and 2014, the living space per capita has increased from 39.5 to 46.5 m^2, due to an increase in one-person households and the tendency to remain in larger homes at old age (Eurostat 2016). In Japan, a similar development took place. Between 1968 and 2013, the living space per house has increased from 73.68 to 94.42 m^2 (Statistics Bureau 2016b). The average household size has decreased from about 3.5 to about 2.5 persons while floor space per capita has increased from 36 (2003) to 39.4 m^2 (2013) (Statistics Bureau 2016b). In addition, the Nationally Determined Contribution of Japan has a challenging target of 40% GHG reduction for buildings relative to 2013.

Regulatory instruments

In Germany, there are push and pull measures for energy efficiency in buildings, i.e. regulations (push) and support programs and informational measures (pull). The programs support building efficiency levels and renewable energy technology applications going beyond the regulations. Germany has a long history of building regulations, dating back to the seventies, which have continuously been updated.

For **new buildings in Germany**, the Building Energy Law (Gebäudeenergiegesetz - GEG) requires a maximum primary energy demand of the building in question to not surpass the primary energy demand of the reference building. The requirements have been strengthened continuously in the past, following progress in RD&D (cf. Figure 16). Since 2016 this requirement has been tightened by 25% in order to follow a stepwise approach to *nearly zero energy buildings (NZEB)*, which should be achieved by 2021 (public buildings: 2019). However, no further steps were taken but the 2016 requirements were, except for minor adjustments in detail, simply interpreted by the government to conform with the NZEB standard. The primary energy demand calculation comprises requirements for heat transition coefficients of the building shell and for technical building systems (HVAC). The building shell requirements for residential and non-residential buildings are in the same range for residential and non-residential buildings, whereas the requirements for technical building systems differ significantly (cf. chapter 2). Mandatory energy certificates indicate the building's energy performance.

Figure 16: Development of building MEPS and front-runner RD&D building performance in Germany over time



Source: Fraunhofer – IBP (no date; before 2016)

In Germany, the efficiency of buildings got recognized since 1977. The main cause that led to a rethink towards taking energy needs into account was the oil price crisis in the 1970s. The chart shows the development of the minimum requirements on building standard compared to the actual building practice and the buildings that became possible due to current research at that time.

As for new buildings, renovation measures in **existing buildings in Germany**- required if a share of more than 10% of a building component is renovated - have to meet certain heat transition coefficients that are in the same range for residential and non-residential buildings (cf. chapter 2.4). Alternatively, building owners are also allowed to prove the conformity with component requirements with a whole building requirement, which is 140% of the energy performance level for new buildings.

For **non-residential buildings in Germany**, the standard to evaluate envelope performance is calculated according to the annual thermal load coefficient of perimeter zone[4]. For standards to evaluate the primary energy consumption of equipment and office automation devices (i.e. air-

4 The perimeter zone is defined by the interior space that is within 5 horizontal meters of all walls that are in contact with the outside air, the interior space of the floor directly below the roof, and the interior space that is directly above the floor in contact with the outside air.

conditioning, ventilation, lighting, hot water, elevators, etc.), energy produced in the building is subtracted from total energy consumption.

In Japan, in contrast to the large number of specific instruments in Germany, **one comprehensive regulatory instrument**, namely the Building Energy Conservation Act was introduced. Incentive measures defined by the act became effective from April 2016 and regulatory measures from April 2017. **Regulatory measures** target new construction, extensions and renovation measures of buildings at or over a certain size. This means that certification is mandatory for 2,000 m^2 or larger non-residential buildings and for 300 m^2 or larger residential buildings. Since the implementation of the regulatory measures in 2017, large-scale non-residential buildings that are not compliant with energy efficiency standards have become ineligible for certification.

Financial incentives and financing

Incentive measures in Japan are in place for all **newly constructed buildings**, extensions, renovations, improvements, remodelling and pre-installation or repairs of cooling system equipment that contribute to the improvement of overall energy performance. If plans for such measures are compliant with certification standards, they may receive certification from the administrative agency with jurisdiction in the construction area. By acquiring certification for the performance improvement plan, construction clients are eligible to receive benefits. Additionally, pre-existing buildings can receive certification of conformity with energy efficiency standards.

In **Germany, the KfW Programmes** are the main financial incentive and soft loan programmes. They link the amount of financial support available for energy efficiency refurbishments or new built houses to the *improvement of the energy performance level in comparison to* the Minimum Energy Performance Standard. The higher the energy performance level, the higher the susidy rate, up to the maximum of 30% allowed in the EU. In this way, at least half of new dwellings built in recent years achieved a higher energy performance than the minimum required, but the energy efficiency renovation rate remained at around 1 % per year until 2019, so the programmes were not able to increase it. Since 2020, the grant rates were increased, and tax deductions were introduced as an alternative. First evidence seems to indicate that this increased the renovation rates by 50% or more.

Information and Advice

In Japan, there are two types of **labelling systems** in place. (1) For **new buildings**, labelling for the energy efficiency performance of buildings works as an incentive for building owners and emphasizes the energy efficiency performance as being at or higher than standards during new construction of residential and non-residential buildings. (2) **For existing buildings**, the labelling system to display compliance with energy efficiency standards lets owners emphasize the compliance of an existing residential or non-residential building with energy efficiency standards during renovations. Floor space energy intensity is implicitly evaluated when calculating primary equivalent net energy consumption of the buildings. Standard software is open to the public for standard building energy consumption estimates. Builders should comply with the energy performance at their design stage to obtain approval. Small residential building with less than 300m^2 are exempted from the regulation. In contrast to the German energy performance certificate, labelling for new and existing buildings is encouraged, but in most cases not mandatory in Japan.

Energy performance certificates in Germany declare the energy efficiency standard of any given building or apartment and are a prerequisite for selling, buying or renting a property.

Other instruments

In Germany, there are **long-distance heating and cogeneration units/systems**, whereas in Japan this is not widely spread because it is not economical in most regions. Further, in accordance with the German heating pump replacement scheme, since August 2016, 30% of investment costs for heating system circulators, hydraulic balancing and other low-expenditure measures are covered by subsidies.

Table 12: Overview of energy efficiency-related policy instruments in buildings sector in Germany and Japan

	Regulation	Planning	Information & Advice	Incentives & Financing	Capacity Building & Networking	Research and Development & BAT promotion
DEU	• Building Energy Law (GEG); this has mainly combined and substituted two previous regulations: • *Energy Conservation Act (EnEG) / Energy Conservation Ordinance (EnEV)* • *Renewable Energies Heat Act (EEWärmeG)* • Heating Cost Ordinance • Tenancy law (rent increases allowed following modernisation) • Energy Consumption-Relevant Products Act (EPPG), Energy efficiency Labelling Act	• Individual Buildig Renovatio n Roadmaps	• Energy Performance Certificates • National heating label • Subsidies for targeted advice: On-site advice, energy check, with database of advisors • "energy-saving meters" pilot programme • Information campaigns: e.g. "Deutschland macht's effizient" (Germany makes it efficient) • Top-Runner Initiative	• Energy efficient buildings: CO_2-Building Renovation and New Build Programme – KfW support programmes and "Renewable energy" Market Incentive Programme • "Energy Efficiency" and renewable energy in buildings Market Incentive Programme • Tax deductibility of craftsmen's bills • Heating circulator replacement scheme	• ZEB guidelines and harmonized database for good practices by REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations) • Some local actor networks on energy efficiency in buildings • Private energy advisor training and certification providers	• The "Energy in buildings and neighbourhoods" research network • The Energy-Optimised Building (EnOB) research initiative • The EnEff:Stadt/Wärm e (energy-efficient city/heat) research initiative
JPN	• Building Energy Conservation Act • Energy Conservation Act		• Energy efficiency labelling system for buildings • Information on the rational use of energy (best efforts) • Appliance labelling	• Subsidy system for ZEH (net zero energy houses) demonstration or ZEB (net zero energy buildings) construction • Subsidies for home energy management systems • Subsidies for high performance building related products during renovation • Tax reduction or credit for retrofitting residential buildings	• ZEH builder registration program. • ZEB/ZEH guidelines	• Demonstration program in operation for energy efficient new and retrofitted buildings (ZEB/ZEH)

Source: Ecofys&IAE (2017), updated

Recent changes in policies

Germany

The recent combination of the energy efficiency and renewable energy regulations to the Building Energy Act (GEG) has already been mentioned in chapter 2.2. But there have been further policy developments in Germany. At the end of 2019, the German government released the so-called Climate Package (Klimapaket), a policy agenda to combat climate change and to achieve the 2030 climate and energy targets (cf. chapter 3.1). This happened due to great public pressure i.a. from the Fridays for Future movement, which demand the fulfilment of the clmate targets the government set itself within the terms of the Paris Climate Convention. To achieve these targets, it became necessary to implement additional, effective activities. The basis for this is a mix of increased funding, information and advice, and a new pricing of CO_2. Contents of the Climate Package that are relevant for the building sector are listed below.

Government funding of energy-efficient buildings and technologies

The German government's climate protection program decided, among other things, to increase the support for energy-efficient construction and renovation (cf. Table 12 above) by 10 %. In addition, they introduced a new tax deductibility of 20% of the costs for energy-related renovation work. In the residential building sector, the maximum amounts of subsidized loans per housing unit will additionally be raised. The conditions are as described below; the ranges indicate that the percentage of subsidies increases with the energy efficiency level achieved (KfW Efficiency House standard).

- Renovation of residential buildings: 20%-40% of max. 120,000 EUR per housing unit
- Renovation non-residential buildings: 17.5%-27.5% of max. 275 EUR per square metre
- New efficient residential buildings: 15% - 25% of max. 120,000 EUR per residential unit
- New efficient non-residential buildings: 5% of max. 50 EUR per square meter

The following technologies will also be funded at the rates as described below, if the replacement is not a part of a complete renovation of the building.

- 35 % for biomass systems or heat pump systems
- 30 % for solar collector systems
- 35 % for renewable energies Hybrid heating systems (EE hybrids)
- 30 % for gas hybrid heating systems with at least 25% renewable heat production
- 20 % for gas hybrid heating systems with subsequent integration of renewable heat generation (Renewable Ready)

When oil heating systems are replaced, the subsidies increase by 10 percentage points to 40% and 45% respectively. Subsidies for purely fossil heating systems have been discontinued. In addition, inefficient oil heating systems got banned.

The industrial prefabrication of facade and roof elements and a standardized installation of facility technology, including the supply of self-generated electricity, are also to be promoted.

As a part of the economic recovery package against the Coronavirus crisis, the German government decided in June 2020 to increase the funding for the building energy efficiency programs by € 1bn for 2020 and 2021, an increase of ca. 25 %.

CO_2 pricing

The planned introduction of CO_2 pricing from 2021 will also have an impact on the building sector. The planned steady increase in fixed certificate prices from an initial 25 EURO per ton to 60 Euro per ton in 2025 will also increase the energy prices for operating buildings. This will have an impact on the economic profitability of energy-related renovations and new construction projects, especially when comparing fossil and renewable energy sources.

Information and advice

To inform and advice the public, energy consultancy becomes obligatory in certain cases, for example in the event of a change in ownership. In addition, the Federal Government will continue the information campaign "Germany does it efficient". This will provide information that is more specialized and more targeted at specific groups.

Japan

The recent combination of the energy efficiency and renewable energy regulations to the Building Energy Conservation Act enacted in2015 has already been mentioned in chapter 2.2. But there have been further policy developments in Japan. The Japanese government provides incentives such as volume incentive, low interest loan, property tax exemption and subsides to combat climate change and to achieve the 2030 climate and energy targets (cf. chapter 3.1). This happened due to great public pressure, which demands fulfilment of the climate targets the government set itself within the terms of the Paris Climate Convention. To achieve these targets, it became necessary to implement additional, effective activities. The basis for this is a mix of increased funding, information and advice, and a new pricing of CO_2. Contents of the Climate Package that are relevant for the building sector are listed below.

Government funding of energy-efficient buildings and technologies

The Japanese government provides volume incentives, low interest loans, subsidies. In the residential building sector, the maximum amounts of subsidized loans, property tax exemption, and subsidies for residential and non-residential buildings is as below.

- Subsidies for energy efficient renovation of residential and non-residential buildings
- Subsidies for new efficient residential and non-residential buildings

  Such as ZEH, ZEH+, LCCM(Life Cycle Carbon Minus) House, Low Carbon Program.

CO_2 pricing

The planned introduction of CO_2 pricing from 2021 will also have an impact on the building sector. But, it will be postpond to the future because of COVID-19 issue.

Information and advice

To inform and advice the public, energy consultancy becomes obligatory in certain cases, for example in the event of a change in ownership.

Mutual learning opportunities

The following text was adopted from Ecofys&IAE (2017), because in our opinion it is still valid.

Japan may have more to learn regarding building energy policy from Germany than vice versa, although the Japanese residential energy consumption per household may be smaller than that of Germany. Some sources say that heating demand is about one-fifth compared to German household (Jyukankyo Research Institute 2013). On the other hand, statistics seem to indicate that per capita energy demand for buildings in all sectors overall is only around 25 % lower in Japan than in Germany (ecofys and IAE, 2017). Heating equipment is operated in parts of a dwelling and intermitted over time in Japan, while German buildings employ central heating systems in most cases; Germany could save energy by adopting the intermittent heating practices as in Japan, which were also traditional in Germany in the past. Japan can learn from Germany in terms of long-history large scale building envelope insulation policy and its mandated characteristics and high energy performance levels. The same may be true for policies to stimulate energy-efficient refurbishment of existing buildings. Both countries are strong in development of energy management systems for buildings and homes (BEMS/HEMS), but Japan may be more advanced in this respect and in implementation. Connecting German knowledge and technology for building shell energy efficiency and Japanese knowledge and technology in BEMS/HEMS could provide even better energy performance in both countries and opportunities for implementation in other countries too.

4.4 Options for improvement of building energy efficiency policies

Assessment of existing energy efficiency policies in Germany

The **implementation** of building regulation and the many other policy instruments in Germany is relatively successful, as the absolute energy consumption of commercial and residential buildings is decreasing. EU level policy instruments play a role (with the Ecodesign minimum efficiency regulation and labelling for energy-relevant equipment directly applying in Germany too), and further policies have been introduced under the National Action Plan Energy Efficiency (NAPE) of 2014. Still, neither the policy spending nor the impact has reached the levels estimated necessary (cf., eg, Thomas et al., 2013). For example, there is an operational target to achieve energy-efficient renovation of 2 % of the building stock per year, but recent rates remained around 1 % only, although they may rise during 2020. And although staff preparing, implementing, and evaluating energy efficiency policies and programs in the federal administration and agencies was increased significantly, there still is not a central coordinating institution with strong financial and staff resources (Wuppertal Institut, 2013). Therefore, targets for 2030 are still in reach but stronger efforts are needed. Remaining **barriers** include the landlord/tenant barrier which refers to the share of 60% of the population renting rather than owning houses. As the legal rights of tenants are quite strong in Germany, renovation measures have to be coordinated carefully. Further barriers are of financial and informational nature.

Assessment of existing building energy efficiency policies in Japan

In the case of Japan, mandatory building performance standard regulation has just recently come into effect so that it remains to be seen to what extent implementation will be successful.

What could be improved in building energy efficiency policies in Germany?

The study on energy efficiency for the GJETC (Ecofys/IAE 2017) summarized the policy needs for the building sector and some recommendations. These have been updated for the present text.

In order to reach the *of 80 % of primary energy savings by 2050*), renovation rates, which are currently about 1%, need to at least double. The efforts of the German government to improve energy efficiency in buildings were, until recently, mainly focused on residential buildings as data on non-residential buildings is still weaker. Yet in the last years, various programmes and research projects were implemented to overcome this gap. The German building stock is quite old, which contributes to the fact that out of the 19 million residential buildings with ca. 40 million apartments, 50% must be renovated in the next 20 years (BMWi 2017b). In the buildings sector, financial and informational barriers present a large obstacle for realizing energy efficiency.

For years, the government has followed the three-pronged policy approach of 'Inform, Support, Regulate' and is likely to continue this approach in the future.

As said in chapter 4.2, regulation is the basis for most of the other policies. However, a revision of the building codes for new build with very energy efficient nearly zero energy building (nZEB) requirements, as required by EU legislation to enter into force on 1 January 2021, was not implemented with the new GEG law. The energy performance level for new buildings that we consider adequate for a sustainable next generation building code is equivalent to the KfW40+ standard. Standards that apply in case of major renovation should also be strengthened again, at least to component requirements equivalent to those needed for KfW 55 overall performance levels.

However, increasing the renovation rate to around 2 % per year and the energy savings levels in each renovation at the same time will require more than legal standards. First, ensuring a high-quality qualification of a larger number of building experts and workers is key. Currently, the building market in Germany is suffering from severe capacity constraints. These concern both the detailed advice on which action to take, the coaching of building owers through the renovation process, and particularly the insulation, installation, and construction work to implement the renovation itself. Targeted training of the workforce needed is therefore essential, along with improved support for energy advice and coaching. All of this can be better organised and coordinated at local level through local or regional energy agencies, acting as a one-stop shop on energy-efficient renovation and renewable energies for building owners. A financial support programme for such agencies will therefore also be needed.

Strengthened financial incentives for investing deep renovations are crucial too, especially with respect to the long-term targets. The KfW provides a considerable amount of funding for building renovations and has been very effective in doing so. However, there is the need to more than double KfW funding to around 5 bn €/yr and increase incentive rates accordingly to achieve the 2 % per year renovation target. Grant rates for single actions (e.g. insulating only the roof or the walls) should be increased, if the actions are coherent with an individual building renovation roadmap towards nearly zero energy building standards. Transaction costs for funding programs for non-residential buildings should be further reduced. KfW programmes will also need to be expanded to consider sector coupling and demand response opportunities when refurbishing buildings.

Stricter qualification requirements are also needed in order to overcome the barrier of lacking trust in energy efficiency auditors and energy consultants. Additionally, stricter laws are necessary to assist with the verification of the correct presentation of energy certificates and, if necessary, implement sanctions consistently. Currently, policies to incentivise the energy efficient refurbishment of the existing building stock are primarily of financial and informational nature, but regulation to refurbish old and inefficient building stock should now be considered in addition. It may be needed to require higher energy performance levels – as proposed by the European Commission in its October 2020 communication on a 'renovation wave' – or energy-efficient renovation of building parts without a renovation happening anyway. Along with improved financial incentives, this may overcome the split incentive barrier.

Furthermore, there is also the need to bring down renovation costs through industrial construction, digital design tools, and process optimisation, also in renovation. Examples for such concepts include the Dutch Energiesprong and a number of EU projects showing potential savings in renovation costs and time of up to 40% (BPIE 2019). Financial support could also be provided for agencies bundling renovation projects together, in order to reduce costs.

Finally, further aspects for the construction and renovation of buildings should also be considered in the future. In addition to the current focus on energy consumption including its upstream production chain, energies for the construction and demolition of the building must be taken into account. The cradle-to-cradle principle can be used to calculate the so-called grey energy. The grey energy gains more and more importance, the lower the direct energy consumption of a building becomes.

Improving the governance framework: The need for a coordination agency in a polycentric energy efficiency governance

One main problem we identified is that in Germany there are **neither an institutionalized steering responsibility nor sufficient capacities for coordination and bundling of the overall energy efficiency packages to fulfil the official energy savings targets -** quite opposite to designing and guiding the green power sector. When the development of renewable electricity is not on track in relation to official targets, intervention will follow soon, but to date nothing comparable happens on the demand side.

The human resources in the departments responsible for energy efficiency policy in the Ministry of Economic Affairs and Energy and its subsidiary institutions (BAFA/BfEE, dena) still do not have the budget and the competencies for target-driven interventions. Their human power is much too weak compared to the huge number of experts supervising the supply side of the energy market, e.g. in the energy regulation agency (BNetzA).

The **Federal Agency for Energy Efficiency and Energy Saving Funds** (BAEff) as a "national care-taker" would be given a comprehensive mandate, the necessary personnel resources and an ambitious budget. The competences of all existing governmental energy saving actors would be bundled, while additional personnel is recruited, and would be linked with the numerous regional efficiency actors. On a legal basis, the process responsibility for achieving the energy saving goals of the EU Directive on Energy Efficiency (EED) as well as of the long-term energy concept of the federal government, would be transferred to the BAEff. Insofar, the BAEff would perform its duties a) in framework of a "polycentric governance structure" of the German energy efficiency policy and b) as far as possible via competitive processes (e.g. Bidding for the implementation of energy saving programs). The BAEff would coordinate and evaluate program implementations and resource allocations by the KfW and involved banks as well as regional and local energy agencies, consumer advice centres, energy companies, local network nodes for building refurbishment and other program partners.[5] It thereby ensures these activities are congruent with the overall policy targets. Insofar, the BAEff would be a consequent further development of existing building blocks of energy efficiency governance in Germany. Whether it would be a new institution or whether the duties and resources of BAFA/BfEE and dena would be enhanced, is open to policy debate.

Above that, further aspects for the construction and renovation of buildings should also be considered in the future. In addition to the current focus on energy consumption including its upstream production chain, energies for the construction and demolition of the building must be taken into account. The cradle-to-cradle principle can be used to calculate the so-called grey energy. The grey energy gains more and more importance the lower the direct energy consumption of a building becomes. What could be improved in building energy efficiency policies in Japan?

The building energy performance requirements, under the Building Energy Conservation Act, are applied to new construction/extensions/renovations of buildings with a floor space area over certain thresholds. Additional supporting measures should be provided for buildings with small floor space and old vintage housing stocks. However, it is based on the design phase evaluation before the completion of the building.

Policies on energy monitoring with advice during the utilisation phase are recommended because the building performance would be degraded compared to the initial condition in the long-run.

In certain cases, energy performance certificates should be required in order to raise awareness of the energy consumption of the building considered. As in Germany, this obligation can be fulfilled

5 Further detail is provided in: A proposal for a Federal Agency for Energy Efficiency and Energy Saving Funds (BAEff) by the Wuppertal Institute (Thomas et al. 2013).

when selling, renting or leasing property, as well as for buildings with a publicly accessible area of a size that needs to be defined for Japanese conditions.

In addition to that, mandatory energy consultancy especially for people who are willing to buy or build a house could be added. This targeted advice can show which potentials exsist to reduce the energy consumption of the building.

5. Outlook on the cooperation between Germany and Japan

5.1 Outlook on the cooperation between Germany and Japan

Since the Meiji Restoration, Germany and Japan have been cooperating in many subject areas, and this has been developing quite strongly in the environmental field in recent years.

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. This applies to the Energy Saving Ordinance, the Renewable Energy Sources Act and the DIN 18599 balancing system for non-residential buildings, which have largely been copied for the Japanese regulation.

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.

A further approach to the exchange may build 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 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 prototypical policy package outlined above. In all policy areas, parallels can already be seen in the work, even if the levels are still different.

The German side in particular can benefit from the Japanese experience of Smart City projects. In addition to fuel cells, which are much more highly developed in Japan, their use combined with photovoltaics in such settlements is a model for Germany, where urban neighborhoods are still very heat-oriented.

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.

5.2 Further research needs

This paper has provided some insights in the similarities and differences in energy use in homes and buildings, in building energy performance, design, and technologies, as well as in policy targets and packages of instruments implemented. Still, there remains considerable need for further in-depth comparable research to better understand what both countries could learn from each other, and what they could jointly offer to other countries for advancing the energy transition in cities and buildings.

For example, 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 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? Which other benefits can be achieved, e.g. for health and productivity?

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

A more in-depth analysis seems also useful on whether the prototypical policy packages outlined in chapter 4 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 efficiency (and sufficiency) policies for new build and energy-efficient 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?

Further research needs in Germany

As said in chapter 4.4, there is the need to bring down renovation costs through industrial construction, digital design tools, and process optimisation, also in renovation. This will be important to make building renovation more attractive, but there is also the continued need to evaluate the existing policies in order to make them more effective in achieving the necessary increase in both renovation rates and depth.

In addition, further aspects for the construction and renovation of buildings should also be considered in the future. In addition to the current focus on energy consumption including its upstream production chain, energies for the construction and demolition of the building must be taken into account. The cradle-to-cradle principle can be used to calculate the so-called grey energy.

The grey energy gains more and more importance, the lower the direct energy consumption of a building becomes.

Further research needs in Japan

In the first place, it seems most important to convince not only the Japanese population, but first and foremost the Japanese government of the advantages of energy-efficient renovations. This requires further research, which can be submitted to the relevant ministries. It is therefore appropriate that sample renovation roadmaps be drawn up to demonstrate the advantages of energetic renovations.

A considerable amount of research is still needed to develop targeted and successful policy measures to promote the energy-efficient refurbishment of the Japanese building stock. As in the past in Germany, all types of buildings in the stock will need be analyzed for their refurbishment potential in order to derive refurbishment variants, energy saving potentials and statements on costs and economic efficiency. In contrast to Germany, where clear advantages of refurbishment can be derived from economic efficiency alone, in Japan there are other motivations for upgrading the energy efficiency of residential buildings. In particular, coziness and living comfort increase, e.g. through improved thermal insulation, which is a good argument for many Japanese to invest in old buildings. Promotional strategies and information campaigns can be developed from the mix of building information on renovation and the arguments from the point of view of the building owners.

This strategy needs include increasing the level of expertise among architects, tradespeople, construction companies and other parties involved in construction. Competence for the modernization of existing buildings, in particular for energy-related refurbishment, must be anchored in the building world in order to be able to provide an adequate offer to clients with refurbishment requirements.

Furthermore, the creation of a component catalogue that lists typical components for different regions of Japan according to the age/era of construction can significantly simplify the analysis of all existing buildings.

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