Innovation in housing decarbonisation: Germany

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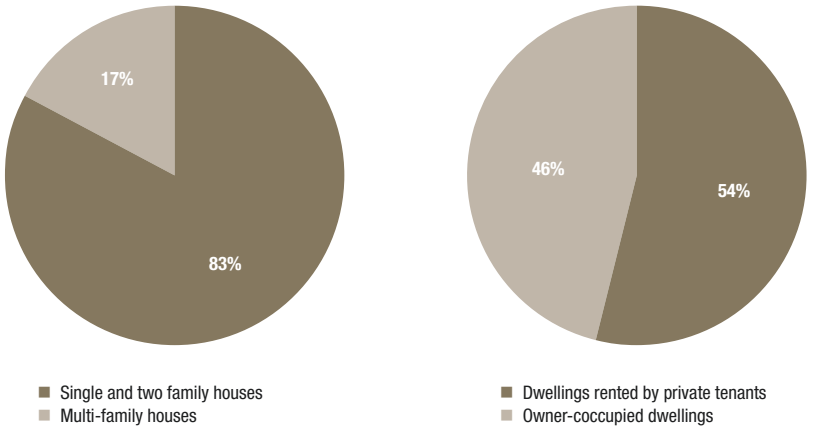
1. Structure of the stock

The total residential building stock in Germany comprises 18.95 million buildings, with a total of 3.7 billion m² of heated space (as of 2018) (dena 2019: 10). 3.2 million (or 17%) of these buildings are apartment buildings and a total of 15.75 million (or 83%) are detached and semi-detached houses (cf. Figure 1). Detached and semi-detached houses therefore make up the largest share of the number of residential buildings (dena 2019: 10). With 2.2 billion m², detached and semi-detached houses also make up the larger share of total residential heated floor area (ca. 60%), while the remaining 1.5 billion m² are located in apartment buildings (dena 2016: 14). Non-residential buildings, totalling 2.7 million (with a heated net floor area of 1.35 million m²), account for one seventh of the total stock. More than half of all dwellings in Germany are rented to private tenants (Bienge et al 2018: 17). In this respect, Germany differs from other developed countries (Bienge et al 2018: 17).

Driven in particular by the rising demand for housing, investment in housing construction is increasing. In the past, there has been an annual increase in construction investments in multi-family houses of 5.8% (measurement period: 2005 to 2015) (Bienge et al. 2018: 22). According to the Federal Statistical Office, there has been an increase in the housing stock in Germany within the last few years: At the end of 2019, the growth comprises a total of 0.7% or 277,400 dwellings (compared to 2018), resulting in a total of 3.9 billion m² of floor space. In addition, both living space per dwelling (by 1 m² compared to 2010) and per inhabitant (by 2 m² compared to 2010) increased (Federal Statistical Office 2020a). The current average flat size in Germany as of 2019 is 91.9 m² (ibid.).

FIGURE 1 **Share of single and two family and multi-family houses and share of dwellings rented or owner-occupied in the German residential building stock**



Data: Dena Building Report compact 2019: 10 and Bienge et al 2018:17

While demand for affordable housing is increasing, the share of the social housing stock is decreasing (Bienge et al. 2018: 17; 25). The number of social housing dwellings has significantly declined over recent decades, from 2.87 million in 1990 to an estimated 1.07 million in 2020 (Statista n.d.[1]). This decline is a result of market based strategy, which strongly relies on providing financial incentives linked to capped rents for a specific period of time instead of setting regulatory requirements. However, in the light of increasing demand particularly in metropolitan areas (cf. section 2), corresponding increasies in rents and low market interest rates, housing developers are looking for higher ROI than enabled by the conditions for state promotional programmes. In addition, more and more of the social housing stock is no longer subject to rent control after expiration of the commitment period.

2. Socio-demographic issues

With a population of 83.2 million people (with a slight upward trend), Germany is the most populous country in the EU (Federal Statistical Office 2020b).

As are many other countries, Germany is experiencing a rise in immigration and urbanisation. The increasing urban boom in major German cities, caused in particular by the migration of young people and immigration from abroad, is increasing the demand for affordable living space (Federal Statistical Office 2019a). As a result, the average living space per person in the seven largest German cities (Berlin, Hamburg, Munich, Cologne, Frankfurt, Stuttgart and Düsseldorf) is decreasing (currently at 39 m²) (ibid.) while overall it has increased over time from ca. 35 m² in 1991 to ca. 47 m² in 2019 (Statista n.d.[2]). In contrast, outside the

[1] https://de.statista.com/infografik/12473/immer-weniger-sozialwohnungen-in-deutschland/

[2] https://de.statista.com/statistik/daten/studie/36495/umfrage/wohnflaeche-je-einwohner-in-deutschland-von-1989-bis-2004/

metropolitan areas the population is declining. The result of this development is an increasing vacancy rate, especially in rural areas (Bienge et al. 2018: 24).

The rising demand for housing in German cities has led to a significant upward trend in property prices and rents since 2010 (Bienge et al. 2018: 24). This rise and corresponding strong increases in basic rents since 2015 have resulted in an average rent burden of around 27.2 % (as a share of disposable income) in 2018 (Federal Statistical Office 2019b), which is increasingly becoming a problem for many households. Households in metropolitan areas as well as families are particularly affected (Federal Statistical Office 2019). According to a national representative survey in 2018, 13.3% of people perceive the monthly housing costs as a major burden and as many as 57.2% still as somewhat of a burden (Federal Statistical Office 2019c: 168).

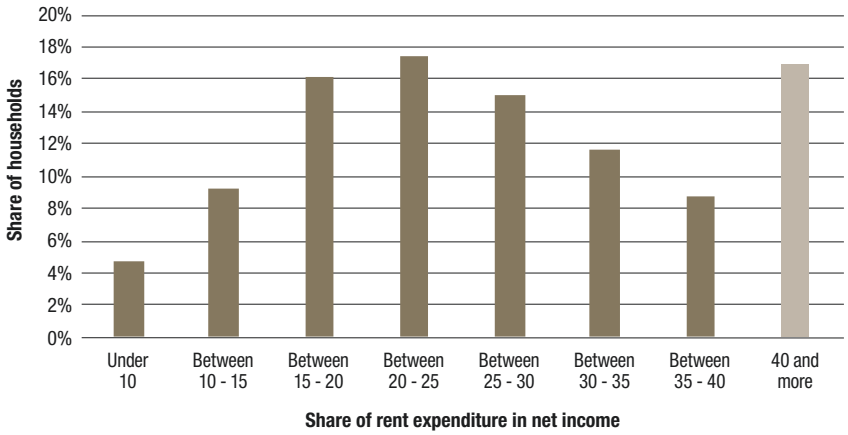
The problem of rising rent burdens is further illustrated by the fact that around 17% of German households have to spend more than 40% of their monthly disposable income on rent alone (cf. Figure 2).

According to the Federal Statistical Office, the majority (around 48%) of people receiving housing benefits are pensioners followed by dependent employees with a share of 37% (Figure 3). The data collection revealed that the housing benefit needs of employees increase significantly with the number people living in the household. Only about 2% of the self-employed receive housing allowances in Germany.

3. Governmental targets on housing decarbonisation

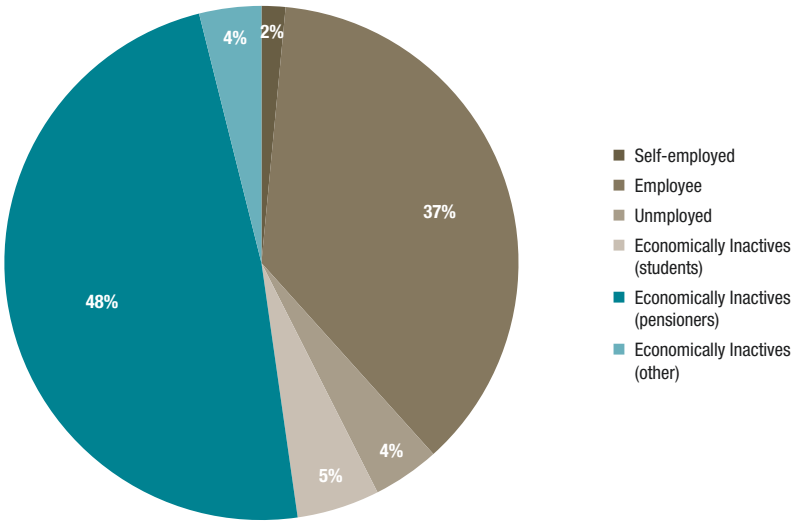
The German government's targets for decarbonising the building sector are derived from international climate targets, i.e., the goals of the Paris Climate Accord and the corresponding European climate targets. Overall, Germany aims to reduce greenhouse gases (GHG) by at least 55%[3] by 2030 and by 80-95% by 2050 (compared to 1990) (BMWi 2020: 29). Sectoral emission reduction targets in Germany are set out in the Climate Protection Plan 2050 and specified in the Climate Protection Programme 2030. According to the latter, annual greenhouse budgets of the sectors and respective reduction targets are to be defined by law and

FIGURE 2 Relative frequency of tenant households regarding their share of rent expenditure in disposable income in 2014



Source: own graph based on data from Federal Statistical Office 2019c: 167 (data from 2014)

FIGURE 3 Share of households receiving housing benefits by employment status



Source: own graph based on data from Federal Statistical Office 2019c: 169 (data from 2017)

TABLE 1 Sectoral emission reduction targets of Germany by 2030

FIELD OF ACTION	**1990** (in million tonnes CO_2-eq.)	**2014** (in million tonnes CO_2-eq.)	**2030** (in million tonnes CO_2-eq.)	**2030** (reduction in % compared to 1990)
Energy Sector	466	358	175 – 183	62 – 61 %
Buildings	209	119	70 – 72	67 – 66%
Transport	163	160	95 – 98	42 – 40%
Industry	283	181	140 – 143	51 – 49%
Agriculture	88	72	58 – 61	34 – 31%
Subtotal	1.209	890	538 – 557	56 - 54%
Other	39	12	5	87%

Source: BMU 2016: 33

[3] An adjustment of the national targets to account for the recently (December 2020) tightened EU emission reduction target to 55% compared to 1990 is yet to be implemented.

achievement of the targets to be reviewed annually (German Federal Parliament 2019: 13).

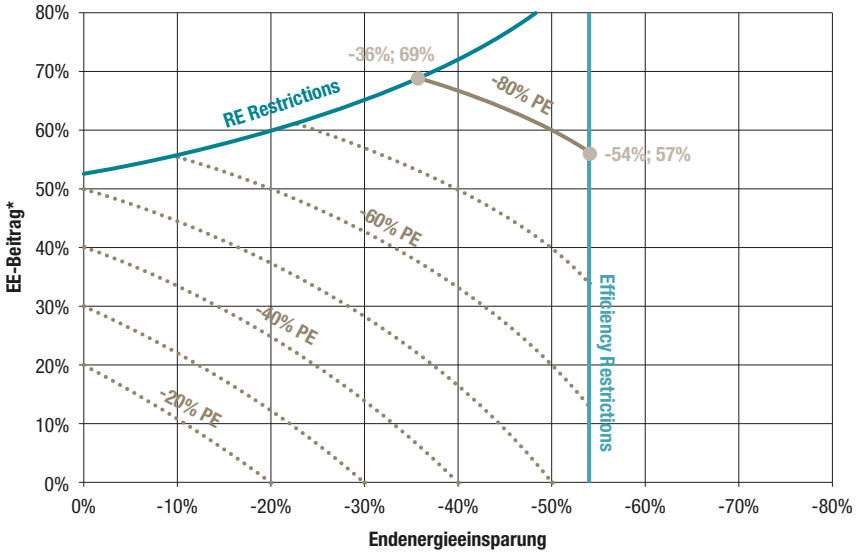
The German building sector directly causes 14% of total national GHG emissions and is indirectly responsible for as much as about a quarter of Germany's total GHG emissions (considering upstream emissions in the energy sector) (German Federal Parliament 2019: 39). In combination with a share of about a quarter (27%) of total primary energy consumption and 35% of final energy consumption, the building sector plays a significant role in the German climate protection accord (Dena 2018: 19). The residential sector accounts for 63% of final energy consumption of the total building stock (Dena 2018: 17 f.).

The climate-friendly transformation of the building stock is thus essential to achieve Germany's climate targets. The Federal Government therefore aims to reduce CO_2 emissions in the building sector by 66-67% (compared to 1990) by 2030 (cf. Table 1). This corresponds to a maximum amount of 72 million t CO_2 eq. to be emitted by the building sector in 2030 (German Federal Parliament 2019: 40).

The central document outlining the energy transition in the German building sector is the Energy Efficiency Strategy (ESG), which pursues the goal of achieving a "nearly climate-neutral" building stock by 2050 by increasing energy efficiency on the one hand and the share of renewable energies for heat and other end uses on the other (BMWi 2019a: 51 f.). The Federal Government aims to reduce non-renewable primary energy consumption of the building sector by 50% in 2030 and by 80% by 2050 compared to 2008 (BMWi 2015a). To this end, a target corridor delimited by the maximum potential for building energy efficiency (estimated at 54%) and use of renewable energies (1,800 PJ) has been defined, which translates into different scenarios with variations of the two pillars (cf. Figure 4).

In terms of achieving the target, by 2018 GHG emissions in the building sector have fallen by around 44% since 1990, from 210 m t CO_2 eq. to an estimated 117 m t (German Federal Parliament 2019: 40).

FIGURE 4 **Result of the target corridor taking into account the modelled restrictions:** Reduction of primary energy demand by 80% compared to 2008 – remaining corridor due to the restrictions in the area of renewable energies and in the area of energy efficiency / energy savings.



Note: EE-Beitrag = Contribution of renewable energies towards the decarbonisation of energy supply in %; Endenergieeinsparung = Final energy savings in %

Source: BMWi 2015a, based on data by Prognos et al. 2015

TABLE 2 **Refurbishment rates related to different measures and data bases in % of the stock**

MEASURE	Measure / data base	IWU/BEI Building stock data base 2010	IWU Building stock data base 2016	IÖW 2010 ENEF Haus (only detached and semi-detached houses)
Heating system replacement	3.17	2.8 - 3.5	3.05	2.6
Installation solar heating system	1.02	0.85 - 1.21	0.87	0.6
Facade insulation	0.87	0.82 - 1.06*	0.79*	0.9
Roof/upper ceiling insulation	1.43	1.32 - 1.65	1.69	1.7
Basement ceiling insulation	0.49	0.34 - 0.42	0.46	0.3
Window replacement	1.56*	1.34 - 1.80*	1.82*	1.6

* Area weighted, i.e., partial refurbishments are considered

Source: Metzger et al. 2019: 41

4. Refurbishment rate

There is no official definition in Germany with regard to what is considered the refurbishment rate. Due to this lack of consensus regarding the qualitative features to be considered and practical issues, there is no continuous and systematic data collection to monitor refurbishment activities over time. In a survey of 7,500 residential buildings in 2010, an annual refurbishment rate of 0.8% regarding thermal insulation measures has been identified for the years 2005-2008 (Diefenbach et al. 2010). A reliance on these findings as a basis for political strategies has however been questioned due to the small sample representing a mere 0.5‰ of the residential building stock (BBSR 2016). An updated survey in 2016 covering ca. 17,000 residential buildings found an annual refurbishment rate of 1% regarding thermal insulation measures for the period 2010-2016 (Cischinsky/Diefenbach 2018), which has since then informed both public discourse and political strategies for the residential building sector.

The same study measure identified measure-specific refurbishment rates, which have been compared (Metzger et al. 2019) with data from other sources in a recent publication (cf. Table 2)

However, data on the implementation of deep renovations is scarce. Based on a representative survey on the implementation of energy-related refurbishment measures, the German Institute for Economic Research (DIW) has estimated the share of comprehensive refurbishments (defined as four or more measures implemented) in 2014 at 0.2% (BBSR 2016a). A study by IPSOS/Navigant (2019) used expert survey and market data to estimate refurbishment rates differentiated by depth (i.e., primary energy saving levels), finding a range from 3.5 % of "Light" renovations (from 3% ≤ 30%), 0.9 % of "Medium" renovations (from 30% ≤ 60%) to 0.1 % of "Deep" renovations (> 60%).

4.1. Targets

Regarding the refurbishment of the building stock as a means to achieve the formulated sectoral target (see section 3), the Federal Government has formulated the target in its 2010 Energy Concept (Federal Government of Germany 2010) and revisited it in its Energy Efficiency Strategy 2050 (BMWi 2019b) to double the yearly renovation rate from "currently" 1% to 2%.

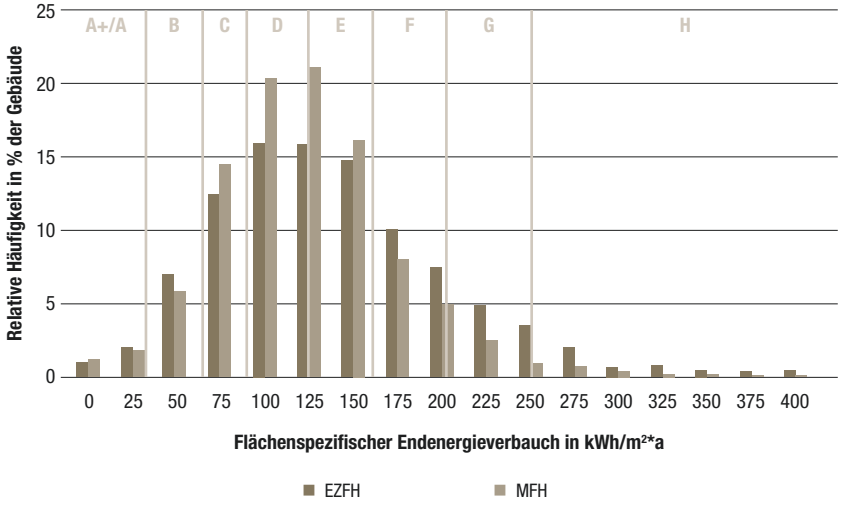
5. Energy efficiency standards

5.1. Current situation in the stock

The information base on the current energy efficiency of the German building stock is limited. Due to data protection concerns and associated costs, there is no central building cadastre systematically collecting and updating data on building energy efficiency in Germany (BBSR 2016b)[4]. Accordingly, available information is based on irregularly implemented (representative) surveys among building owners or professionals or online databases (e.g., Cischinsky/Diefenbach 2018; Metzger et al. 2019).

The following Figure 5 shows the relative frequency of the various energy building classes in Germany differentiated by detached and semi-detached houses or apartment buildings based on an assessment by dena, the German Energy Agency.

FIGURE 5 Relative frequency of the various energy building classes in Germany differentiated by detached and semi-detached houses (EFZH) or apartment buildings (MFH)



Note: relative Häufigkeit in % der Gebäude = relative frequency in % of all buildings; flächenspezifischer Endenergie-verbrauch in kWh/m²*a = floor area specific final energy demand in kWh/m²*a ; EZFH = detached and semi-detached houses; MFH = apartment buildings; Durchschnitt = Average

Source: Steuwer et al. 2018, based on data from dena (2016)

5.2. Legal requirements for new construction and refurbishment (building codes)

The Building Energy Act (GEG) is the main instrument for building energy regulation. Passed in November 2020, it transposes the additional provisions from the modified EU Directive on the energy performance of buildings (2018/844/EU) into national law and bundles the preceding legislation (i.e., Energy Saving Act (EnEG), Energy Saving Ordinance (EnEV), Renewable Energies Heat Act (EEWärmeG)) into an integrated regulatory framework. It sets minimum requirements for the energy performance of the building shell and the system technology for new buildings, and also for larger renovations of existing buildings.

5.21. NEW CONSTRUCTION

Newly erected residential buildings have to fulfil three main criteria related to heat transmission loss, primary energy demand and the share of renewable energy, that are defined by creating a reference building that is similar in the way it is built but has defined uvalues and a certain type of heating system. Based on the defined reference building standard ("Effizienzhaus 100") representing the statutory minimum energy performance requirements[5], several advanced building standards are defined, which serve as reference for the federal building energy efficiency promotion programme (see section 4.4). For example, the "Effizienzhaus 40" standard refers to a building, whose primary energy demand may not exceed 40% of that of the reference building and 55% of its heat transmission loss. In addition, the Passive House Standard is a well established though non-state standard with very low energy requirements to be proven either through the heating load of the building (max. 10 W/m²) – or through a very low heat energy requirement (max. 15 kWh/m²a of useful energy). The Heating Costs Order exempts buildings reaching the Passive House standards from billing requirements, thus creating an incentive for deep renovations of multi-family buildings.

5.22. REFURBISHMENTS

For existing buildings, the GEG only specifies a few mandatory energy efficiency requirements to be met by building owners. First, from 2015 onwards, fossil fuel based 'constant temperature' boilers have to be decommissioned after 30 years of use. Second, new heating pipes leading through unheated rooms must be insulated and third, the top floor ceiling

[4] https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/analysen-kompakt/2016/ak-09-2016-dl.pdf?__blob=publicationFile&v=2

[5] Confusingly, the current minimum requirements for new buildings as defined by the Building Energy Act (GEG) are 75% of primary energy demand compared to the standard set in the previous revision of building energy regulation in 2014, effectively making them "Effizienzhaus 75".

must also be insulated if it is uninsulated and adjoins an unheated attic. Although considered cost-effective, the requirements are watered down by a number of exemptions (grandfathering clause, cost-effectiveness proviso) that significantly reduce the number of affected buildings and thus their impact (BBSR 2015).

In case of voluntary restoration works such as renewing the plaster, insulation of the building shell or the replacement of windows, minimum standards defined by the GEG have to be met. If only single measures are implemented or (more than 10% of specific) building parts renewed, their heat transmission coefficients have to meet the respective standards. For comprehensive renovations, an overall assessment of the energy balance compared to a reference building comparable to new construction is required. However, the primary energy demand and transmission heat losses may in this case be up to 40% and 75% respectively higher than that of the reference building.

5.3. EE standards in other regulations (e.g., subsidy schemes)

Within the BEG WG promotion programme (see section 6), the loan conditions are linked to the fulfilment of energy efficiency standards that exceed the legal requirements. The lower the proposed primary energy demand and transmission heat loss is compared to a reference building ("Effizienzhaus 100") the higher the maximum redemption subsidy levels are. From July 2021, additional promotion products with higher credit / redemption subsidy levels will be offered that require additional conditions to be fulfilled in terms of the share of renewable heat (55% of total heat demand) or a specific sustainability certification of buildings, which also considers life-cycle aspects in the production of building components.

5.4. Enforcement of EE standards in refurbishment, challenges

Monitoring compliance with EE standards is the responsibility of the federal states, which can designate a competent supervisory authority by executive order. In most cases, the lower building supervisory authorities (municipal building offices) were entrusted with this task. Due to an increasing lack of personnel (cf. Brand & Steinbrecher 2016) and a shift in priorities motivated by the housing shortage in metropolitan areas, verification of evidence is only carried out on a random basis if at all, or on an ad hoc basis if there are specific indications. Accordingly, in some cases it is assumed that the authorities will fail to enforce the requirements effectively. (Hertle et al. 2006). While there is little data on the extent of this failure to enforce effectively, a survey among state officials on the enforcement of building energy certificate regulations found varying levels of recognition, processes and/or capacities to implement enforcement requirements on the part of the responsible authorities (DUH 2015)[6].

The Building Energy Act (GEG) aims to improve enforcement by introducing additional mandatory reporting requirements for building owners. Accordingly, they are now obligated to issue a compliance statement to the responsible authorities after completion of the construction or refurbishment, in which they confirm compliance with the legal requirements (§92, 93 GEG).

6. Financing tools

Germany has a wide range of financial instruments to incentivise deep energy renovation and decarbonisation of buildings, comprising funding schemes, subsidy programmes and feed-in tariffs.

6.1. Funding schemes

In 2021, the different existing funding schemes have been merged in the Federal funding for energy-efficient buildings programme (BEG) in order to increase transparency and to facilitate access for building owners. The BEG has three components providing funding for residential buildings (BEG WG), non-residential buildings (BEG NWG) and single measures (BEG EM) offering either investment grants or low-interest loans with redemption subsidies.[7] The BEG is administered in part by the Federal Office for Economic Affairs and Export Control (BAFA) and the state owned KfW Bank with a plan to divide the task for all promotional products along the lines of the provision of investment grants (BAFA) or low-interest loans (KfW) by 2023. For renovating an existing building up to an "Effizienzhaus" standard, loans up to 120.000€ are provided (150.000€ if the share of renewable heat is 55%) with differing levels of redemption subsidies or alternatively investment grants depending on the targeted energy efficiency standard ranging from 30.000€ to 48.000€ (and 45.000€ to 75.000€ respectively). The provision is conditional on the inclusion of certified energy efficiency experts providing professional energy advice. Grants or redemption subsidies may further increase by 5%, if owners develop and follow an individual renovation roadmap (see section 7.2). In terms of single measures, insulation of walls, roof, basement and storey ceilings, replacement of windows and doors, and installation of summer thermal protection, mechanical ventilation with heat recovery (MVHR) or digital systems that optimise energy consumption or make technical equipment smartly controllable are promoted with a loan of up to 60,000€ and a 20% redemption subsidy or alternatively by offering an investment grant. Furthermore, the exchange of heating systems with hybrid, "renewable ready" fossil (i.e., gas based) or renewable systems is promoted with different subsidy / grant rates between 20 -45% (again of a maximum of 60.000 € investment costs) depending on the technologies to be implemented and replaced. Lastly, optimisation of existing heating systems by means of hydraulic balancing and the replacement of inefficient heating and hot water circulation pumps with high-efficiency pumps is promoted with 20%.

6.2. Tax Bonus

Alternatively, owners of buildings with a minimum age of 10 years can benefit from a tax deduction of up to 20% of investment costs (max. 40,000€ per dwelling) in respect of single refurbishment measures, spread over a period of three years. Costs for construction supervision and technical planning are deductible up to 50%.

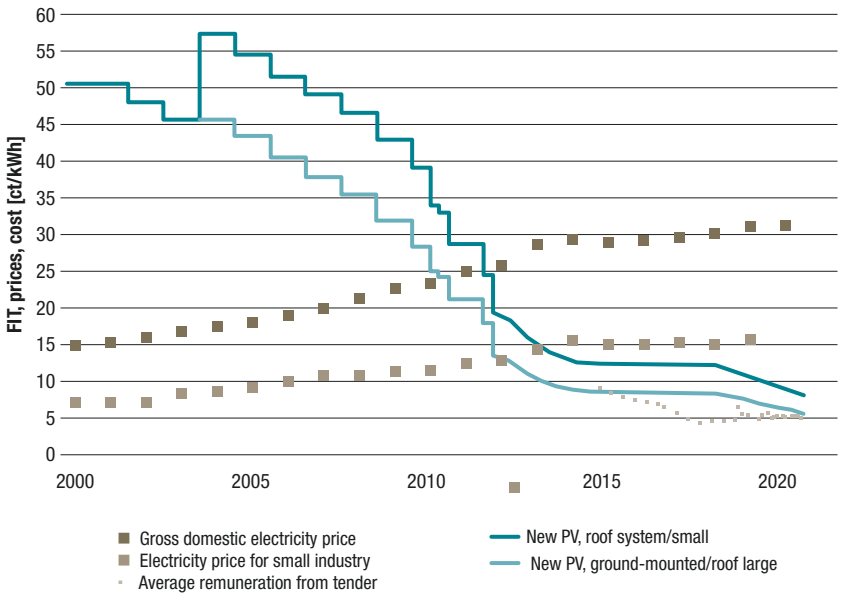
6.3. Feed-in tariffs

Additional, financial incentives for the installation of building based renewable energy plants for electricity are provided via a Feed-in-Tariff funded through an electricity surcharge under the Renewable Energy Sources Act (EEG). In order to control the increasing financial burden on end consumers due to expanding deployment of renewables, the tariff rate per kWh has been increasingly decreased from almost 60 ct/kWh in 2004 to currently 8.16 ct/kWh (as of January 2021) (cf. Figure 7). In addition, in 2014 an "expansion corridor" for different renewable power generation technologies was introduced (translating into 5 GW/a for PV) which is basically a cap after which investors receive further lowered rates per kWh. The Landlord-to-Tenant Electricity Act has extended the financial incentive for rental buildings by providing a supplement (between 2.37 and 3.79 ct/kWh depending on the size of the plant) for electricity that is generated on site and then sold to tenants.

[6] https://www.duh.de/uploads/media/Hintergrund_Regelungs_Vollzugsdefizite_270415_02.pdf

[7] https://www.kfw.de/inlandsfoerderung/Bundesf%C3%B6rderung-f%C3%BCr-effiziente-Geb%C3%A4ude/

FIGURE 6 **Feed-in tariff for PV power as a function of commissioning date, average remunera-tion of the bidding rounds of the Federal Network Agency, electricity prices and average compensation for PV power**



Source: Wirth 2020

The efficient provision of heat and electricity is incentivised by a combined heat and power (CHP) surcharge, which is paid for the electricity produced by cogeneration plants (16 ct/kWh when feeding into the grid and 8 ct/kWh for own consumption or provision to third parties).

7. Policy tools

There are several policy tools in Germany, that can be considered good practice for achieving a just transition towards a decarbonised residential building stock. They focus on different relevant aspects that need to be addressed to effectively promote this target.

7.1. Federal funding for energy-efficient buildings programme (BEG)

The most important and effective is probably the Federal funding for the energy-efficient buildings programme (BEG) that was presented in section 6. However, they are embedded in a number of other policies making them more effective, from several programmes on energy advice, offering free initial advice and 80% of subsidy for an in-depth advice, to the energy efficiency standards discussed in section 5, to energy performance certificates, and professional training of experts. We would like to present two more tools, one innovative tool and one addressing low-income households.

7.2. Individual Renovation Plan (IRP)

In the context of energy advice for residential buildings, a qualified energy consultant inspects the building and produces a comprehensive energy-consultancy report. This report includes guidance on funding-support programmes and an overview of the individual possibilities to improve the energy performance of the building. Since 2017 the Individual Renovation Plan (IRP) is available as a tool for consultation purposes. This software-supported tool helps building-energy consultants to produce a comprehensible overview of the renovation measures to be taken in a building, with a particular focus on the order in which measures should be implemented, to avoid technical or financial lock-in. This roadmap has the objective to allow the owner staged renovations taking the age of different parts of the building and system into account, as well as the availability of the owner's funds, while still achieving deep renovation in the end. Alongside energy-saving potential, opportunities to use renewable energies and the needed investments are assessed. In addition, the calculated reduction in heating costs and CO_2 emissions are highlighted. The IRP provides owners with both advice on concrete short-term measures as well as a long-term strategy and aims to set a quality standard for building energy consultation. The IRP has been one model for the Building Renovation Roadmap tool now proposed by the European commission.

7.3. State coverage of rent/heating expenses and free energy advice for low-income households

Household energy prices in Germany are among the highest in Europe (European Commission 2020). In combination with rising rent levels (see section 2), the financial burden of basic living expenses for many households particularly in metropolitan areas has considerably increased. In order to cushion against energy and rent-related financial hardship for economically vulnerable households (such as long-term unemployed), the German Federal Government largely relies on social policy. According to social security statute book II and XII, eligible persons (i.e., long-term unemployed or those unable to work) receive a basic income to cover their living expenses (including a dedicated budget for electricity). In addition, rent and heating expenses of welfare recipients up to an "adequate level" are fully covered by the state. Accordingly, though not contributing to the achievement of energy saving targets in the residential sector, heating related energy poverty is largely addressed by this approach. In addition, low-income households or those receiving welfare transfers can benefit from state funded free energy advice offers (see section 8.3).

8. Related measures

8.1. Greening

While the German Federal Government has acknowledged the positive contribution of urban greening towards more sustainable and liveable cities in a white paper (BMU 2017), the greening of buildings is largely promoted at community level via grants and reduced precipitation water fees[8]. In its yearly market report, the Federal association for building greening (BuGG) reports an increase of 7.2 million m^2 additional roof area greening in 2019 adding to a total of 120 million m^2 (BuGG 2020). Facade greening has increased significantly

[8] The precipitation water fee is a fee for the disposal of rainwater that enters the sewer system via built-up or sealed surfaces. Both private households and businesses must pay this fee if their paved properties are connected to the sewer system.

less by 90,000 m² in 2019. Roughly a quarter of all cities with more than 50,000 inhabitants promote roof and / or facade greening by means of grants and 72% by means of reduced precipitated water fees (ibid.). In addition, many of these cities have specified respective requirements in their land-use plans.

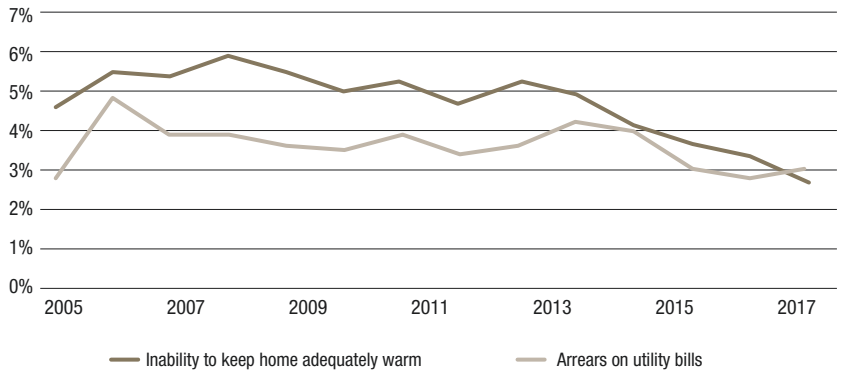
8.2. Prevention of heat islands

The National Climate Adaptation Strategy provides a political framework for adaptation strategies in different (cross-cutting) areas (Federal Government of Germany 2008). To prevent urban heat islands, German municipalities are legally authorized within the building code (§9) to consider climate adaptation measures within their urban land-use planning. Apart from greening buildings and inner-city areas, the German Environment Agency defines maintenance and creation of cold-air corridors within the built environment as a central strategy for action. This can represent a conflict with energy efficiency strategies and urban building policy targets, which aim at further densification.

8.3. Measures against energy poverty

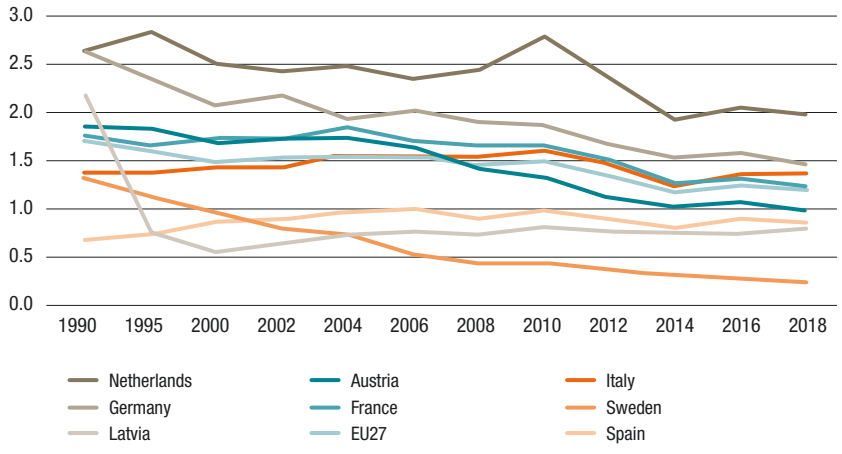
The German Federal Government does not consider energy poverty as an isolated problem but rather treats it within its wider approach of poverty alleviation via welfare state measures (BMWi 2020). Heating expenses of welfare recipients are fully covered by the state as long as they are considered reasonable, as outlined in 7.2. In contrast, allowances for electricity costs are included within the basic income, though an analysis by the Consumer Association has shown that dedicated budgets are insufficient (particularly with electric water heating) (Verbraucherzentrale NRW 2018). Also, households above the eligibility threshold (i.e., the working poor) do not have access to these benefits. As a consequence, in 2017 around 344,000 households have experienced power cuts (Federal Government of Germany 2019). Nevertheless, with regard to the development of energy poverty, the situation of households has improved over time (cf. Figure 7).

FIGURE 7 Development of energy poverty in Germany based on two consensual (i.e., subjective) indicators used by the EU Energy Poverty Observatory (www.energypoverty.eu): share of households being unable to keep their home adequately warm or having arrears on utility bills (2005-2018)



Source: EPOV 2020, based on data from the EU Survey on Income and Living Conditions (EU-SILC)

FIGURE 8 Development of emissions in tonnes CO2 eq. per capita in the EU27 and several of its member states



Source: Eurostat Emission Inventory, IIBW

While there is no Federal programme to tackle energy poverty, the Government financially supports non-state actors to provide energy saving advice to low-income households. The most prominent are the "Energy Saving Check" administered by the charitable organisation Caritas and the Energy Saving programme administered by the Consumer Association. The former trains long-term unemployed people to provide energy saving advice and low-cost technical devices free of charge to welfare recipients and low-income households.[9] The latter also provides free energy advice to low-income households. In addition, welfare recipients with arrears on energy bills can receive an interest-free loan, which is then repaid via a reduction of up to 10% of the basic income.

8.4. Planning issues

In addition to improved thermal insulation and reduction of ventilation heat loss via MVHR, the decarbonisation of heat supply systems is crucial to achieve climate neutrality of the residential building stock. While building (or district) based technologies such as heat pumps, solar heat, biomass heating and (micro) CHP will have to be deployed at larger scale, where possible (or otherwise impossible) district heating / cooling should be expanded as a more efficient way for heat / cold supply, particularly in dense urban areas. To this end, comprehensive spatial heating plans on a community level need to guide the development of district heating infrastructure. However, apart from single states (Baden-Württemberg), there is no regulatory framework governing this process of systemic energy planning.

[9] https://www.klimaschutz.de/en/projects/energy-saving-check

9. Conclusion: challenges, limitations, realism of plans for decarbonisation

Since 1990, Germany has made some progress towards decarbonising the building sector and reduced emissions by 40% (by 2018), which also translates into an overall decrease in tonnes CO_2 eq. per capita emitted (cf. Figure 8). It has done so by means of steadily increasing energy efficiency standards and providing substantial financial incentives to building owners and developers conditional on their adherence to these standards, both in new build and renovation. However, in order to create a sustainable building sector in Germany in the long term and to implement the transformation of the sector, the German government still faces numerous challenges (German Federal Parliament 2019: 40). Firstly, it has to effectively address the conflict between the need for increased private investment into building refurbishments on the one hand and increasing rents and dwelling shortage in metropolitan areas on the other. Furthermore, in order to increase the refurbishment rate of the existing housing stock to the level needed (i.e., 2% or more), additional mandatory energy performance requirements in combination with effective enforcement mechanisms seem necessary; and they should be combined with financial incentives covering the incremental costs – it is time to leave behind us the paradigm to either mandate or subsidize action. A potential approach for the private rented sector could be to link the permission for renting out a dwelling to the achievement of a certain energy efficiency standard, which is continuously tightened over time as implemented in Scotland (Scottish Government 2019). However, this must not lead to suboptimal refurbishments, so it should be coupled with a Building Renovation Roadmap. Therefore, it may be better to link mandatory energy performance requirements to the age of walls, roofs, windows, and heating systems rather than aiming to achieve a certain standard by year x. Also, structural barriers such as insufficient capacities and alternative priorities in the construction sector and training needs of crafts have to be addressed by targeted financial or legal incentives and training and information measures respectively.

In addition, further measures and short-term targets are needed, such as increasing tax incentives, targeted energy advisory services and public awareness campaigns (German Federal Parliament 2019: 40-44). One-stop shops and practical support for managing renovations should also be funded as policy tools, in order to both refurbish existing buildings in an energy-efficient manner and to construct new buildings in an energy-efficient and climate-neutral manner.

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