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Energy Efficiency Policy in Germany

Sino-German Energy Partnership

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Imprint

The report “Energy Efficiency Policy in Germany” introduces the importance of energy efficiency in the frame of climate neutrality and the best practice measures and policies for energy efficiency in Germany. The report is published in the framework of the Sino-German Energy Partnership between the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and the National Development and Reform Commission of the People’s Republic of China (NDRC). As the central dialogue platform on energy between two countries, the main objective of the partnership is to foster and advance the far-reaching and profound energy transitions ongoing in both countries by exchanging views, best practices and knowledge on the development of a sustainable energy system, primarily centered on improving energy efficiency and expanding the use of renewable energy. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implements the project under commission of BMWK.

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Abbreviation

CBAM	Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Use
CO_2	Carbondioxide
$CO_{2\ eq.}$	Carbondioxide-equivalent
EE	Energy efficiency
EED	Energy Efficiency Directive
EffSTRA	Energy Efficiency Strategy
EMS	Energy Management System
GHG	Greenhouse gases
GJ	Giga Joule (10^9 Joule)
H2	Hydrogen
kWh	Kilowatt hour
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
NAPE	Nationaler Aktionsplan Energieeffizienz
NECP	National Energy and Climate Plan
NEDC	New European Driving Cycle
PJ	Petajoule (10^{15} Joule)
PtG	Power-to-Gas
PtL	Power-to-Liquid
SUV	Sports Utility Vehicle
SWOT	Strengths - Weaknesses - Opportunities - Threats
TWh	Terawatt hour (10^{12} Watt)
ZLEV	Zero- and low-emission vehicles
WLTP	Worldwide Harmonised Light vehicles Test Procedure
KSG	Climate Change Act
GEG	Building Energy Act / Building code Germany

Preface

In times when Climate neutrality towards the middle of this century, or in the decade after, in many countries worldwide, energy efficiency policy is more than just a pillar in climate neutrality but the essential ingredient to make other policies more powerful and acceptable such as renewables policies, the hydrogen economy as well as a sustainable bioeconomy or carbon-capture and storage (CCS/CCU). All supply-side low-carbon solutions lead to larger environmental and socio-economic impacts such as resource use, (new) import dependencies, distributional effects among consumer groups and possible acceptance issues.

It is for this reason that the key role of energy efficiency is supported in the European Union by the Energy Efficiency First Principle. It is recognised as a guiding principle of the Union energy policy and should be taken into account across all sectors, going beyond the energy system, at all levels, including in the financial sector. Energy efficiency solutions should be considered as the first option in planning and investment decisions, when setting new rules for the supply side and other policy areas.

This Book addresses the important role of energy efficiency policies in Germany and investigates in 3 Parts its main mechanisms:

- Part 1 establishes the **frame for energy efficiency** (in terms of climate neutrality, supply security, competitiveness)
- Part 2 takes a **sectoral view** on energy efficiency polices in Germany (cross-cutting policies with a strong focus on pricing and trading policies, buildings, appliances, industry and transport. Policy case studies illustrate more in detail successes and failures of energy efficiency policies. A specific focus is given on monitoring and analysis approaches to the transformation of the energy system in Germany, as well as on the analysis facilities provided by the Odyssee-MURE project at European level.
- Part 3 finally points out the strong role of **local level** energy efficiency policies, the importance of policies **addressing vulnerable consumer groups** and enhancing **acceptance** of energy efficiency policies, notably of pricing and trading schemes.

All three parts are accompanied with SWOT analyses (Strengths-Weaknesses-Opportunities-Threats) which cover the frame policies, as well as sectoral policies and the detailed policy case studies.

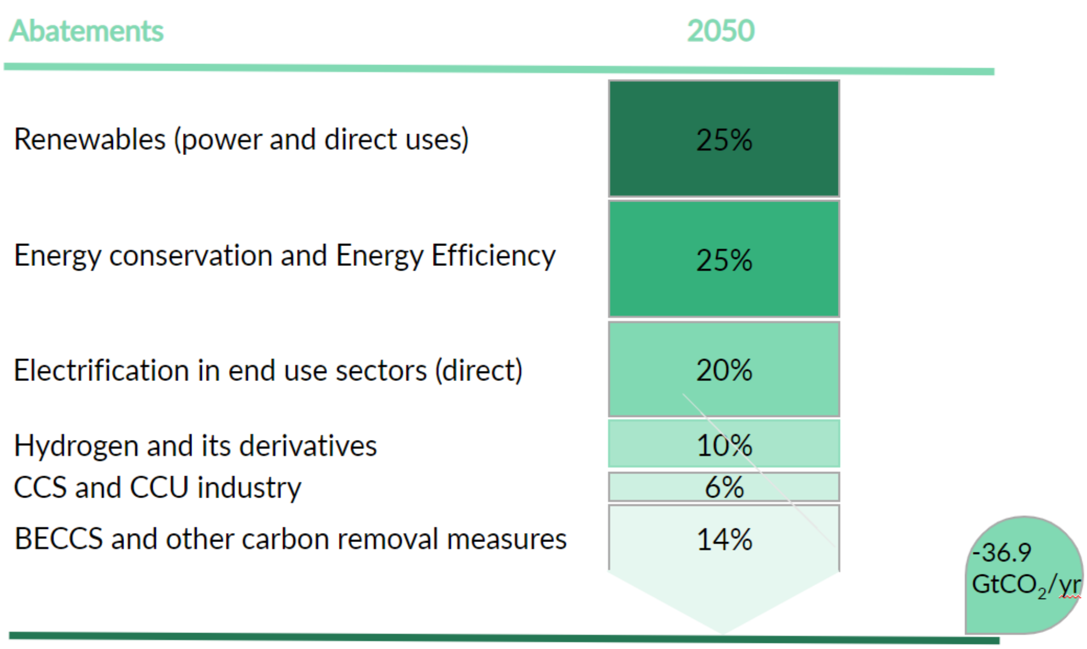
The strong arising European frame of the Fit-for-55 Packages proposed by the European Commission in 2021 as well as the high-level objectives brought forward by the new German Government Coalition in November 2021 will provide ample opportunities to implement the Energy Efficiency First principle strongly into policy practice. It can build on the policy strengths and weaknesses identified in this book while taking advantages of the opportunities provided in this new frame.

1. Introduction: The Importance of Energy Efficiency in the Frame of Climate Neutrality

Climate neutrality has emerged in recent year as a main objective for the whole world, in order to keep the global temperature rise of this century below 1.5°C. China has stated its objective to achieve a stabilisation of carbon emissions still in this decade, while aiming to achieve carbon neutrality by 2060. In its Fit-for-55-Climate Package put forward in July 2021z (European Commission 2021a), the European Union has reiterated its objective to reach greenhouse gases (GHG) neutrality by 2050, with an intermediate reduction of 55 % by 2030 compared to 1990.

Energy efficiency is seen by all actors as a major contributor to climate neutrality. This is illustrated on the global level by the World Energy Transition Outlook, published by International Renewable Energy Agency (IRENA 2021) as seen in Figure 1. According to their analysis, energy efficiency and renewable energy sources will contribute to half of the required reduction in GHG emissions while further contributions are necessary from direct electrification. GHG emissions can be further reduced when combined with a renewable energy-based hydrogen economy. Additionally, Carbon Capture Storage and Use (CCS/CCU) in industry, as well as CCS in bioenergy can achieve negative emissions to compensate for remaining CO2-emissions.

Figure 1 Main policy components contributing to carbon emissions abatements in the IRENA 1.5°C Scenario

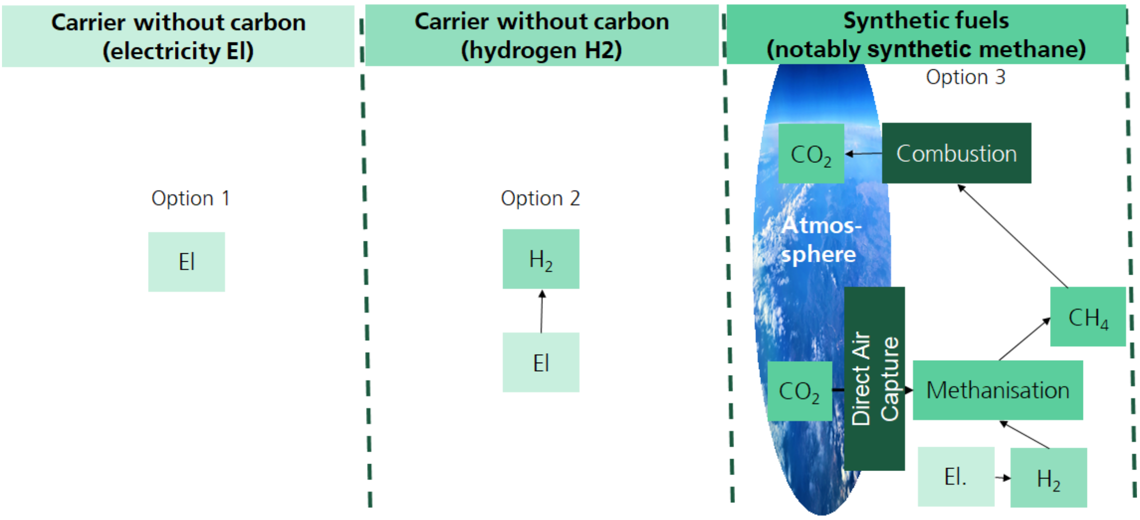


Source: IRENA (2021)

The most recent Long-term Scenarios published in 2021 confirm this assertion at a very detailed sectoral level for Germany. The aim of these scenarios was to investigate different paths[1] to climate neutrality in detail, notably [2] (Figure 2):

- Option 1 (Scenario TN-Electricity) with strong reliance on electricity
- Option 2 (Scenario TN-H2), based strongly on hydrogen
- Option 3 (Scenario TN-PtG/PtL), based to a large degree on synthetic fuels (generated from hydrogen), including CO_2 recycling from the atmosphere

Figure 2 Main decarbonisation paths to climate neutrality in Germany



Source: (Fraunhofer ISI et al. 2021)

The analysis shows that **final energy demand**[3] **needs to be reduced by 28-37%** at least, compared to today (Fraunhofer ISI et al. 2021). Especially **buildings and transport,** which consumed 35 and 29% of total energy respectively, require a high demand reduction of 41-50% (Table 1 and Figure 3). Also, the industry sector and the appliances sector, which consumed 22 and 14 %, need to reduce demand substantially.

[1] The scenario paths also investigate an Option 4, which includes CO2 storage to compensate for the continued use of fossil methane. However, there are many reasons, not to continue with fossil fuels, even combined with CO2 storage, notably the resource availability for oil and natural gas, as well as the environmental damage linked to their extraction and import dependencies.

[2] Take note that the sectors concerning energy consumption are buildings, industry, transport and appliances. Energy targets are given for the sectors buildings, industry, transport and appliances, while the emission targets are given for the sectors buildings, industry, transport, energy, agriculture and waste and others.

[3] In principle, one has to distinguish energy efficiency improvement from the reduction in energy demand. In European countries, this is mostly the same, as energy demand is not increasing any more. That may be different in countries with still raising energy demand as in China up to now. However, a major country like China, if the world is to reach climate neutrality, needs also embark on a path of reduction in energy demand (similar to a reduction in emissions) rather than just improving energy efficiency. This will also be the case of other major forthcoming emitters such as India and other developing nations.

Final energy demand has apparently to be reduced more in the electricity scenarios than in the scenarios with larger amounts of hydrogen or synthetic fuels (37% compared to 38-30% in the case of the latter). This is due to the fact that imported hydrogen appears as cheaper in those scenarios as it is imported from places where H_2 production is cheaper than in Germany and hence takes a larger role than energy efficiency options in the country. However, this masks the fact that the latter two are imported to quite a large degree which raises questions of renewed import dependence as well as how to balance hydrogen export against sustainability issues and the need to decarbonise their own economy in the exporting countries.

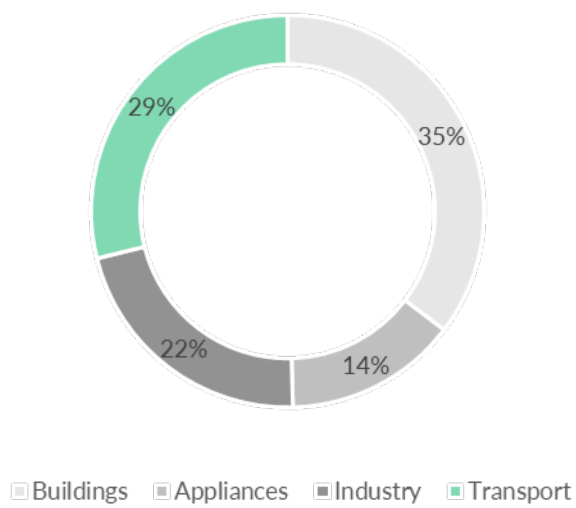
All in all, the Long-term Scenarios illustrate extensively that - independent of the decarbonisation path - energy efficiency needs to be a strong contributor, otherwise environmental impacts of different energy supply types will continue to be large. This is the main reason why the EU has defined the Energy Efficiency First Principle.

Table 1 Required reduction in final energy (FE) demand in recent climate neutrality paths to 2050 for Germany

Reduction compared to present	TN-Electricity	TN-H2	TN-PtG/PtL
Buildings	-41%	-26%	-26%
Industry	-23%	-21%	-18%
Transport	-50%	-44%	-40%
Service Sector Appliances	-30%	-30%	-30%
Household Appliances	-34%	-30%	-34%
All sectors	**-37%**	**-30%**	**-28%**

Source: (Fraunhofer ISI et al. 2021)

Figure 3 Energy consumption per sector in Germany 2020



Source: Own depiction based on (BMWi 2021b)

2. Part 1: Frame for Energy Efficiency (Climate, Supply Security, Competitiveness)

2.1 Climate Neutrality Frame for Energy Efficiency (at European Union and Paris-Agreement level)

The EU ratified the Paris Agreement from 2015 – a legally binding global climate change agreement. Under this agreement, the countries commit to limiting global warming to well below 2°C and undertake measures to limit the temperature rise to 1.5°C. Emission reductions are targeted as soon as possible. For the second half of the century, climate neutrality is aimed for in the sense that remaining emissions are balanced by removals from greenhouse gases from the atmosphere. The EU submitted initially an Intended Nationally Determined Contribution of the EU and its Member States (MS) with the commitment to reduce emissions by 40% by 2030 compared to 1990. This commitment was updated and increased to a reduction of at least 55% by 2030 compared to 1990.

With the proposal of the EU Green Deal and the European Climate Law enforced in July 2021, the EU Member States agreed on a set of targets that are meant to turn the EU into the first climate-neutral continent in the world in 2050. The main targets are the reduction and removal of GHG emissions by 2030 to at least 55% compared to 1990, a share of at least 40% renewables and the reduction of 36% and 39% respectively for the final and primary energy consumption until 2030 (9% compared to 2020). Further targets are the removal of 310 Mt carbon and the creation of 160,000 additional green jobs by 2030. Around 0.6 trillion euro will be financed through the European Green Deal (European Commission 2021a).

All MS agreed on their contribution to these targets. The Governance is regulated in the "Regulation of the Governance of the European Union". Each MS needs to develop a National Energy and Climate Plan (NECP) for 2030 based on a common template that covers decarbonisation, energy security, energy efficiency, internal energy markets and research, innovation, and competitiveness. Updates need to be made until 2024. Additionally, MS are required to develop national long-term strategies. Member states also have to report their emissions and other climate emissions to the EU, who reports on the progress of the EU as a whole each year. Member states will report their own progress for the first time in March 2023 (European Commission 2021h).

With enacting the European Energy Directive in 2007, three targets were set for 2020 on a European level, from which each country was required to derive national targets: 20% cut in GHG emissions compared to 1990, 20% share of renewables in final energy from renewables and 20% improvement in energy efficiency compared to a baseline established in 2007. The directive was amended in 2018 and the target of a 32.5% reduction until 2030 was set with a clause for possible upwards revision by 2023. However, the actual achieved reduction was only at 29.4% regarding final energy use and 29.7% regarding primary energy use (European Commission 2021e).

In July 2021, the proposal for a new directive on energy efficiency has been put forward as part of the package "Delivering on the European Green Deal". The new 36%-/39%-efficiency target translates to an energy consumption of max. 1023 Mtoe of primary and 787 Mtoe of final energy. This means Member States have to almost double their annual energy savings from previous 0.8% to now 1.5%. For the public sectors such as buildings, transport, water and street lighting, this target is set to 1.7% to give a good example (European Commission 2021c).

The proposal also includes an adaption of the governance regulation. The rather soft mechanisms that were in place to regulate the action of Member States to adhere to efficiency targets were found to lead to a lower level of compliance as compared to somewhat harder regulations for renewable energy targets. It further legally anchors the "Energy Efficiency First" principle.

Box 1. The Energy Efficiency First Principle

The key role of energy efficiency is supported in the EED by the Energy Efficiency First Principle. It is recognised as a guiding principle of the Union energy policy and should be taken into account across all sectors, going beyond the energy system, at all levels, including in the financial sector. Energy efficiency solutions should be considered as the first option in planning and investment decisions, when setting new rules for the supply side and other policy areas. Energy efficiency should be recognised as a crucial element and a priority consideration in future investment decisions on the Union's energy infrastructure. The energy efficiency first principle should be applied taking primarily the system efficiency approach and societal perspective into consideration. Consequently, it should help increase the efficiency of individual end-use sectors and of the whole energy system. Application of the principle should also support investments in energy-efficient solutions contributing to environmental objectives. For example, all Member States, National Regulatory Authorities, transmission and distribution system operators should apply the `Energy Efficiency First´ principle and remove all regulatory, technical and non-regulatory measures for energy efficiency improvements in the operation of energy networks.

In order to have an impact, the energy efficiency first principle needs to be consistently applied by decision makers in large-scale investments with a value of more than 50 euro million each or 75 euro million for transport infrastructure projects – affecting energy consumption or supply.

Article 3 quotes the following in the energy efficiency first principle:

1. *In conformity with the energy efficiency first principle, Member States shall ensure that energy efficiency solutions are taken into account in the planning, policy and major investment decisions related to the following sectors:*
   - *(a) energy systems, and*
   - *(b) non-energy sectors, where those sectors have an impact on energy consumption and energy efficiency.*
2. *Member States shall ensure that the application of the energy efficiency first principle is verified by the relevant entities where policy, planning and investment decisions are subject to approval and monitoring requirements.*
3. *In applying the energy efficiency first principle, Member States shall:*
   - *(a) promote and, where cost-benefit assessments are required, ensure the application of cost-benefit methodologies that allow proper assessment of wider benefits of energy efficiency solutions from the societal perspective;*
   - *(b) identify an entity responsible for monitoring the application of the energy efficiency first principle and the impacts of planning, policy and investment decisions on energy consumption and energy efficiency;*
   - *(c) report to the Commission, as part of the integrated national energy and climate progress reports in accordance with Article 17 of Regulation (EU) 2018/1999 on how the principle was taken into account in the national and regional planning, policy and major investment decisions related to the national and regional energy systems.*

Source: (European Commission 2021c)

A new article (Article 3) obliges Member States to ensure this principle also in nonenergy sectors as well as in **policy and investment decisions, and to monitor and report on the application and expected societal benefits. Recommendations and** detailed guidelines provided by the EU to Member States are supposed to help implement this principle practically (European Commission 2021d). A new formula for distributing emissions among Member States is supposed to ensure compliance with the targets by setting objective criteria: a flat rate share, a share based on the GDP per capita, a share based on the energy intensity and a share based on the cost-efficient potential. Additionally, national targets for both final and primary energy have to be set in order to comply with the targets thus calculated. A recent study (Fraunhofer ISI / Scheuer 2021) assessed the Fit-for-55 package published by the Commission, as well as the formula proposed by Member State. It provided high-level recommendations for strengthening the target ambition based on the formula, by increasing the weight put on the realisation of the cost-efficient EE potentials.

The proposal further introduces an enhanced “gap-filling mechanism” in case a country falls behind its tar gets and obliges Member States to support vulnerable groups with efficiency measures to alleviate energy poverty, which is ensured by a mandatory share of energy savings among those vulnerable customers. The efforts will be financed by the revenues from the buildings and transport sector of the EU Emission Trading Scheme, that feed into a newly established Social Climate Fund (European Commission 2021k).

Further amendments for the public sector are a 3% renovation rate for total floor area of buildings, consideration of efficiency standards on all levels in public procurement and a annual reduction of final energy use of the public sector by 1.7% (Pause et al. 2021). It further envisions energy management systems as default obligation for large energy consumers, out-lines stricter planning, reaching out to local and regional levels and requirements to ensure competence of energy service providers, auditors, managers and installers (European Commission 2021k). Supply of heating and cooling has to be planned comprehensively and the standards for the efficiency of heating and cooling networks are being increased. A position for the monitoring of the application of the Efficiency-First Principle needs to be established by the Member States. The policy also addresses national energy regulators directly by obliging them to apply the principle also in the operation of gas and electricity networks. Member states, on the other hand, are obliged to ensure that network operators apply the principle in the planning of the net works (Pause et al. 2021).

Energy efficiency in the building sector is regulated in the Energy Performance of Buildings Directive that is intended to be renewed by the end of 2021. In October 2020, the Commission presented its renovation wave strategy, as part of the European Green Deal. It contains a concrete action plan and measures to achieve at least a doubling of the renovation rate of buildings by 2030. This will also play a role in the upcoming renewal of the Energy Performance of Buildings Directive, for which public feedback has been collected as well as input from stakeholders in various workshops. Currently, the directive comprises measures such as the obligation of Member States to establish long-term strategies to decarbonise the building stock until 2050, an obligation to exclusively build nearly zero-energy buildings from 2021 onwards, the issuing of energy performance certificates to consumers, the establishment of inspection schemes and the promotion of smart building technologies like regulation systems. The Commission has established a set of standards and accompanying technical reports to support the EPBD called the "Energy Performance of Buildings Standards" (European Commission 2021f).

The renovation wave strategy is also meant to address residents' quality of life, the creation of green jobs and energy poverty. A new smart-readiness indicator aims at promoting digital-friendly renovation, integrating renewable energy and enabling measurement of actual energy consumption by raising awareness to the ability in buildings to optimise energy efficiency, adapt their operation to the residents' needs and adapt to signals from the grid .

The long-term renovation strategies must include an overview of the national building stock, policies to promote renovation cost-effectively, especially targeting worst performing buildings as well as initiatives to promote technologies and competence in the sector. Planned measures and measurable indicators must be given. The transition is meant to be supported by the EU Building Stock Observatory tool, which provides data on a wide range of building stock characteristics and performance indicators for all European countries (European Commission 2021f). It can be used to monitor progress and support planning. Besides the more general funding streams of the EU that apply to the building sector, more specific financial instruments will be developed between 2021 and 2027 (European Commission 2021g). Furthermore, the development of sustainable, energy-efficient architecture is promoted in the initiative “New European Bauhaus”

An important means by which the EU supports energy efficiency on the generation of electricity is by obliging the Member States to conduct cost-benefits analyses on the potential of cogeneration (European Commission 2021b). Since the renewal of the Energy Efficiency Directive in 2012, energy companies are also directly required to achieve yearly energy savings of 1.5% of annual sales to final consumers by helping them to improve their energy efficiency (e.g. by insulation, behavioural change or implementation of new heating systems) (European Commission 2021i).

Furthermore, the EU has a strong impact on the efficiency of appliances by means of the European Energy label and Eco design requirements.

Climate Neutrality Frame for Energy Efficiency – Energy Policy SWOT-Analysis

Strength – current framework	Weakness – policy improvement
A strong set of ambitious and interacting policies: ▪ EU Green Deal ▪ European Climate Law ▪ Set of ambitious targets for 2030/2050. Coherence between 2030 (55% GhG reduction) and 2050 targets (climate neutrality) ▪ Governance of the European Union” ▪ National Energy and Climate Plans (NECP) for 2030 ▪ National long-term strategies ▪ Efficiency-First Principle & concrete guidelines for its implementation ▪ Enhanced “gap-filling mechanism” ▪ New formula for distributing emissions among Member States ▪ Support to vulnerable groups in the transition process	▪ Incoherence between European and Member States targets ▪ Lacking translation of the Energy Efficiency First Principle to the national level ▪ Lack in operational implementation of the Energy Efficiency First Principle (only "Slogan") ▪ Targets do not represent full EE potentials
Opportunities – new policies and policy options	**Threats – barriers and market shortcomings**
▪ 11 Regulatory packages developed/ updated in the Fit-for-55 package, notably: ○ Energy Efficiency Directive ○ Energy Performance of Buildings Directive	▪ Lacking acceptance of impacts of the transition process (such as resistance against increasing energy taxes and prices; obligations on existing buildings to renovate etc.)

2.2 Climate Neutrality Frame for Energy Efficiency in Germany

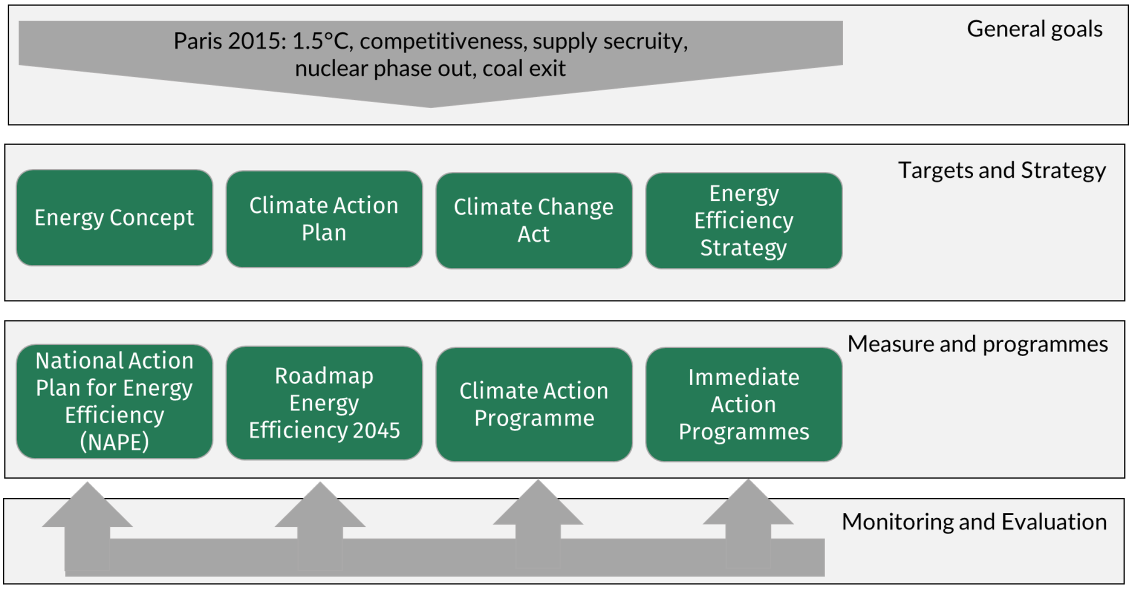
The German climate protection framework (Figure 4) is formed by general goals, targets and strategy, measures and programmes. The headline is given by the Paris Agreement. National targets and a long-term strategy are given by the Energy Concept, Climate Action Plan and the Climate Change Act (Bundes-Klimaschutzgesetz 2019). The Energy Efficiency Strategy (EffSTRA) spells out targets and measures more specifically for energy efficiency (BMWi 2019). In the future, the framework will likely be enhanced by a stronger integration of resource efficiency to energy efficiency policy.[4]

[4] Roadmap energy efficiency recommends to link the two topics more strongly. They suggest specifically to better link and combine information and guidance by the (different) ministries responsible for resource efficiency and energy to ease access for stakeholders (BMWi 2021a:14). Furthermore, they suggest to integrate indicators for material efficiency into support programmes for energy efficiency in industry.

The targets are complemented with several programmes bundling specific measures: the national action plan for energy efficiency (NAPE) and Roadmap Energy Efficiency 2045, the climate action programme as well as immediate action programmes. Targets and programmes are complemented with monitoring and evaluation.

Important boundary conditions for German energy and climate policy are given by the nuclear phase out until 2022 which have been agreed in 2011 as well as the decision to phase out lignite and hard coal in 2038 at the latest agreed in 2020.

Figure 4 Overview on the German climate protection framework (own illustration)



Source: own compilation.

A decision from the jurisdictional court in Germany required climate governance in a way to protect the liberty of future generations. The decision specifies it as a duty of the state to take action to prevent disproportionate limitation of the fundamental right of freedom of younger generations and planning security. This was perceived as a critical decision underlining the importance of climate protection and led to revision of the German climate change act.

Long-term Strategy – The Climate Action Plan

Within the climate action plan, first published in 2016, Germany underlines its commitment to this goal. The plan as a long-term strategy for transforming society and industry aims to give clear guidance to avoid stranded investments. It contains the long-term targets for emission reduction as well as milestones and targets for all sectors. Furthermore, it specifies guiding principles and strategic measures to be taken for each field of action. In accordance with the Paris Agreement, the plan is updated regularly. Annual climate protection reports document the status of implementation and are the basis for timely corrections.

Emission Reduction Targets - The Revised Climate Change Act

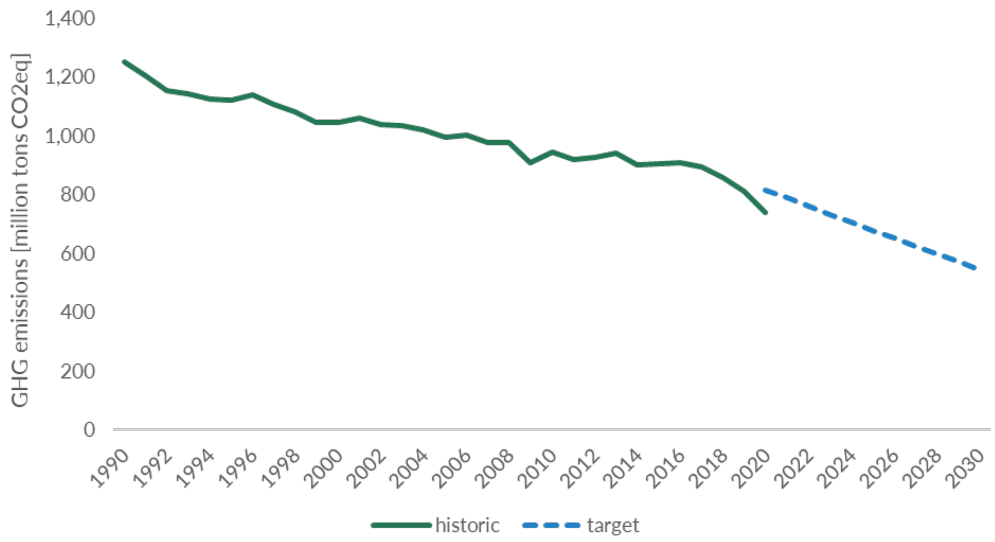
The German Climate Change Act specifies binding emission reduction targets. Climate neutrality is aimed for by 2045. By 2030, CO2 emissions should be reduced by 65% as compared to 1990 and by 2040, the targeted reduction in CO2 emissions is 88% as compared to 1990. From 2050 onwards, Germany aims to achieve negative emissions by absorption in natural sinks.

The overall targets are broken down into six sectoral reduction targets for „energy industry", „industry", „transport", „buildings“, „agriculture“ and „waste industry/ other“. With this explicit and differentiated target setting, the way to climate neutrality is made explicit and foreseeable. Progress towards the goals can be measured and monitored. Annual reports are submitted to an expert council by the German Environmental Protection Agency. In case a sector exceeds the emissions target, the government has to develop an immediate action programme to ensure that the reduction goal will be reached the following year. The expert council reviews the draft programme prior to its proposition and attaches its review statement to the draft. Starting in 2022 the expert council will submit biannually an expert opinion on the targets, measures, and trends with respect to climate policy.[5]

Yearly reduction targets will be fixed until 2030. In 2024 at the latest, the reduction targets for the years from 2031 to 2040 will be determined. In 2034, the reduction targets for 2041 to 2045 need to be set.

Figure 5 shows the level of total German GHG emissions from 1990 onwards as well as the reduction target until 2030 of 543 million tons according to the Climate Change Act

Figure 5 Historic emissions and reduction targets from 2020 to 2030 according to the KSG



Source: Own compilation based on (UBA 2021b)

Energy efficiency targets

The German government aims at making the German Economy the "most energy-efficient economy in the world" since only with a "continuous increase in energy efficiency the energy transformation and climate protection can be reached effectively and cost efficiently" (BMWi 2019:6).

Renewable energy sources and energy efficiency are the two crucial levers for achieving the emission reduction goals. In the short run, energy efficiency contributes directly to emission reduction by decreasing the amount of conventional generation necessary to cover demand. With a renewable-dominated energy system, a second effect becomes more important: energy efficiency helps to spare the use of limited resources such as areas for renewable energy installations or synthetic fuels. It thereby minimises the cost of energy supply (BMWi 2019:33).

Within the **energy efficiency strategy 2050 (EffSTRA)** the German government sets the target for energy efficiency as a reduction in primary energy consumption by 30% in 2030 compared to 2008 and minus 50% by 2050 (Table 2). However, with the increased ambition of the emission reductions and with the revision of the climate protection law, these targets will have to become more ambitious, too. A first estimate is for 2030: the target should be minus 40%. Minus 50% should be achieved by 2045 i.e. five years earlier than currently targeted (BMWi 2021a; Prognos, Öko-Institut, and Wuppertal-Institut 2021). Beyond target setting, the strategy comprises the **National Action Plan for Energy Efficiency 2.0** as a set of measures to reach the reduction target of 30% by 2030 and of the roadmap energy efficiency 2050 – a stakeholder-oriented format to develop

[5] https://www.bundesregierung.de/breg-de/themen/klimaschutz/transparenter-klimaschutz-1792144

pathways and measures to reach the reduction target for 2050. The roadmap is now updated to the **roadmap energy efficiency 2045**.

Table 2 Overview on German energy efficiency and emission reduction targets

	Base year	2018	Target 2020	Target 2030	Target 2050
Primary energy demand (compared to 2008)	14.380 PJ	-8,7 % 13 129 PJ	-20 % 11 504 PJ	-30 %**** 10 666 PJ	-50 %**** 7 190 PJ
Final energy productivity (compared to 2008) GDP (2015) per GJ final demand	309 €/GJ	-1.5 % p.a. 360 €/GJ	-2.1 % p.a. 396 €/GJ	-2.1 p.a. 488 €/GJ	-2.1 % p.a. 740 €/GJ
Gross electricity consumption (compared to 2008)***	615 TWh	-4.4 % 589 TWh	-10 % 554 TWh		-25 % 462 TWh
Greenhouse gas emissions (compared to 1990)	1 251 Mio. t	-31.4 % 858 Mio. t*	-40 % 751 Mio. t	-65 %** 438 Mio. t	-100 %** negative emissions

*Preliminary numbers
** according to revised climate protection law
***without pumped hydro storage
**** according to energy concept resp. efficiency strategy. Likely to be tightened soon.

Source: modified from UBA 2020 Energieeffizienz in Zahlen 2020, table 5.

National Action Plan for Energy Efficiency and Roadmap Energy Efficiency 2045

In 2019, the second national action plan for energy efficiency **NAPE 2.0** has been published as part of the **energy efficiency strategy 2050** (BMWi 2019). While changes in the generation system will contribute nearly half to the reduction target of primary energy consumption, it is clear that demand, too, has to decrease substantially to reach the goal. Hence, NAPE 2.0 is focused on the demand side of the energy system. It addresses all relevant sectors: buildings, industry and commercial sector, transport and agriculture. It focuses on measures to reduce final energy demand in those sectors. The measures of NAPE 2.0 should lead to a reduction of primary energy demand by 300 TWh in 2030. It builds on and extends the measures for energy efficiency already agreed in the climate protection plan 2030.

The **Roadmap Energy Efficiency 2045**[6] implements a stakeholder process that involves the business sector, civil society, scientists, and representatives of the federal states in Germany. The aim is to develop pathways to substantial reduction of primary energy demand by 2045 and to develop concrete measures in a dialogue-oriented and joint setting with all stakeholders. The roadmap process is structured in plenary sessions and working groups that partially have a sectoral focus and partially address cross-cutting issues.

A second dialogue process "climate neutral heat 2045" has been started by the Federal Ministry for Economic Affairs and Energy at the beginning of 2021 and complements the Roadmap Energy Efficiency.

Currently, the energy efficiency strategy is revised to conform with the requirements from EU policy (Fit for 55) as well as the new targets in Germany. A further issue is the discussion of a suitable indicator for energy efficiency against the background of growing shares of renewables and the necessity to reduce final energy demand. The Roadmap Energy Efficiency 2045 will discuss whether targets should be converted from primary energy demand to final energy demand as headline indicator (BMWi 2021a)

Green Economic Stimulus Programmes and Support Programmes

Similar to several other countries, Germany set up economic stimulus programmes to support economic recovery from the Covid-19 related downturn. It integrated aspects to foster climate protection within these stimulus packages to assure that economic recovery goes hand in hand with and not against the necessary transformation towards climate neutrality.

[6] https://www.bmwi.de/Redaktion/DE/Dossier/Energieeffizienz/roadmap-energieeffizienz-2045.html

In 2020 and 2021, Germany provided 80 billion Euro for climate protection within the climate action and economic stimulus programme.[7] With the climate protection immediate action programme 2022, an additional 8 billion Euro support for decarbonisation of industry, green hydrogen, refurbishment of buildings, climate-friendly mobility and sustainable forestry and agriculture is foreseen. The government aims to further support financing of important climate protection measures with more than 93 billion Euro in the years 2022 to 2025.

Germany has several programmes under which financial support for energy efficiency measures is available for private households as well as enterprises and municipalities. These programmes typically provide investment grants or access to loans at reduced interest rates. The programmes can be differentiated in four categories: support for consultation, entry level support, systemic support and specialized funding. The funding programmes are typically targeted towards specific sectors and hence mentioned in the respective subchapters.

The central funding instrument in Germany is the energy and climate fund. The fund is financed from the revenues from auctioning CO2 allowances, from the recently introduced national emissions pricing as well as government money.

Climate Neutrality Frame for Energy Efficiency – Energy Policy SWOT-Analysis

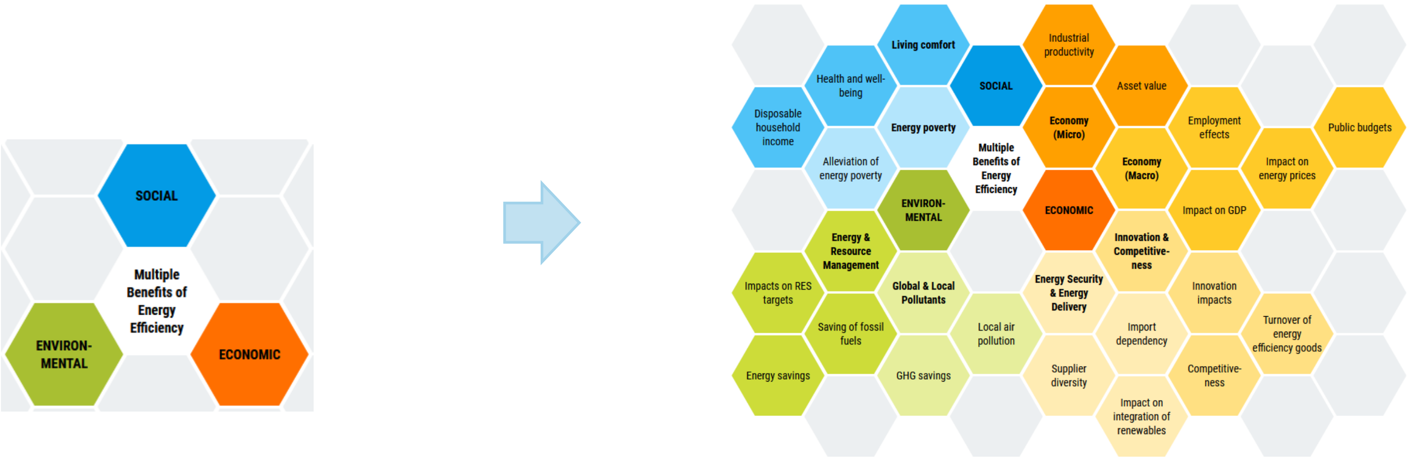
Strength – current framework	**Weakness – policy improvement**
A strong set of interacting policies as a second pillar to the European legislation: ▪ Energy and electricity tax ▪ National CO_2-pricing for transport and heating ▪ NAPE as a detailed set of measures and monitoring ▪ Climate protection programme 2030 quantifying and monitoring measures to reach 2030 targets ▪ Climate protection immediate action programme 2022 for additional measures to reach tightened targets ▪ Green Economic stimulus programmes incentivize firms to become more sustainable while supporting economic recovery ▪ support programs for ambitious solutions prepare energy efficiency solutions in the market. Regulation follows and implements minimum standards.	▪ Detailed policies insufficient compared to the target ambition by climate neutrality ▪ Inefficient price signals/ barriers for electrification from taxes and levies ▪ Large tax exemptions for the industrial sector without strong counterpart in energy efficiency achievements ▪ Discrepancies between ambition at European and national level (gap to be closed in the frame of the Fit-for-55 legislation)
Opportunities – new policies and policy options	**Threats – barriers and market shortcomings**
▪ Climate Contracts for Difference to support decarbonisation of industry ▪ Reform of taxes and levies could improve price incentives for energy efficiency and climate protection ▪ Combination of ambitious standards with financial support could speed up development of efficiency solutions ▪ Refund from CO_2-pricing revenues could reduce burden for vulnerable consumers and business	▪ Distributional effects: high prices disproportionately burden low-income households which lowers acceptance

[7] https://www.bundesregierung.de/breg-de/themen/buerokratieabbau/sofortprogramm-klimaschutz-1934852

2.3 Energy Efficiency, Competitiveness and Supply Security

Energy savings have a large number of so-called **Multiple Benefits** (i.e. benefits in addition to energy savings which are schematised in Figure 6). They can be grouped in environmental, economic and social Multiple Benefits. Two important benefits in this list are supply security / import dependence and competitiveness. Energy efficiency has important impacts on both.

Figure 6: Multiple Benefits of energy efficiency

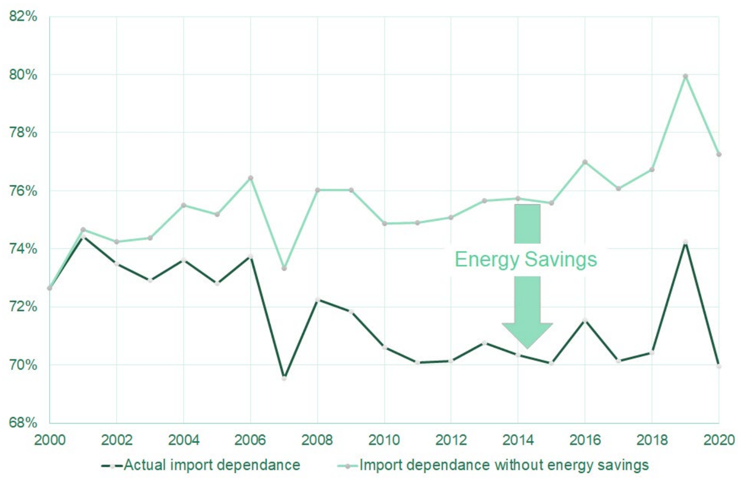


Source: (ODYSSEE-MURE 2021a)

Germany's Import Dependence and the Impact of Energy Savings

The German import dependence is high: though the percentage has been slightly decreasing since 2000, it is above 70%. The German energy system depends to more than two thirds on foreign countries. Oil and gas alone account for 57 percentage points out of the > 70%. The remainder is associated with coal and nuclear. Nevertheless, **energy efficiency has lowered the import dependence over the last 20 years by more than seven percentage points from around 77 to 70%, contributing to the stability of the energy system in Germany** (Figure 7).

Figure 7: Import dependence of Germany (actual and without energy savings)

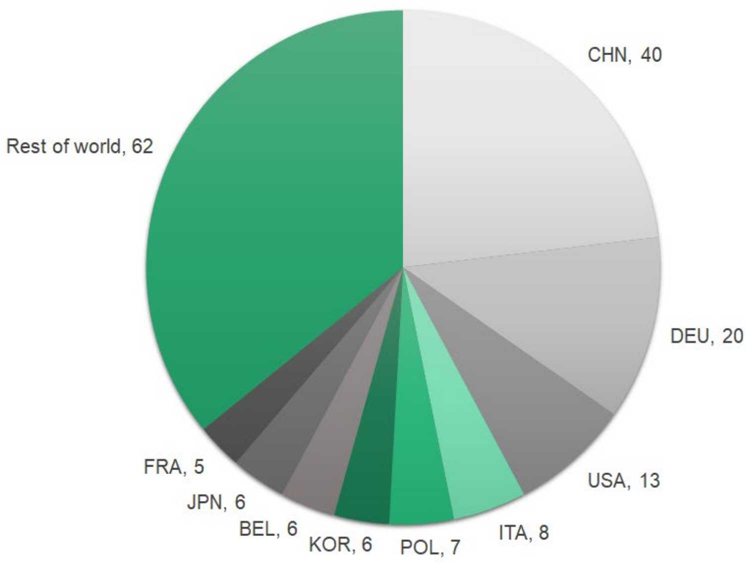


Source: Own calculation based on (AG Energiebilanzen 2021; ODYSSEE-MURE 2021b)

Competitiveness: Advantage through Export of Energy Efficiency Technologies

The competitiveness of an industry is generally strongly impacted by lowering factor costs, in particular when energy and carbon prices are rising. However, energy efficiency does not only improve general competitiveness by lowering factor costs but also by creating technology supply industries, which are able to export their goods worldwide. Germany is a country with a large share in world export. Energy efficiency technologies contribute, next to renewable energy technologies, substantially to this success. **German exports of energy efficiency technologies amount to 12% of the world trade in this field (20 billion USD, approximately 17.7 billion EUR)**, only topped by China with roughly double the export volume and a share of nearly a quarter in world trade (Figure 8). In coming years, these technologies will substantially expand.

Figure 1: Worldwide export volume of goods related to energy efficiency in 2017 by country (Billion USD)



Source: (GWS 2020)

3. Part 2: Fact Sheets and Case Studies on Best Practice Measures and Policies for Energy Efficiency

This chapter analysis energy efficiency policies in five areas in Germany:

- Cross-cutting energy efficiency policies
- Energy efficiency policies for the building sector
- Energy efficiency policies for the industry sector
- Energy efficiency policies addressing appliances
- Energy efficiency policies for the transport sector

The energy efficiency policies in each area are analysed in two steps:

1. Fact sheets for each area which present a concise overview of policies and trends including a SWOT-Analysis of the policies in the area
2. Case Studies of policies in each area which discuss successes and failures and which condense the findings in an individual SWOT-Analysis of the policy

3.1 Cross-cutting Energy Efficiency Policies

3.1.1 Fact Sheet on Energy Demand and Energy Efficiency in Germany

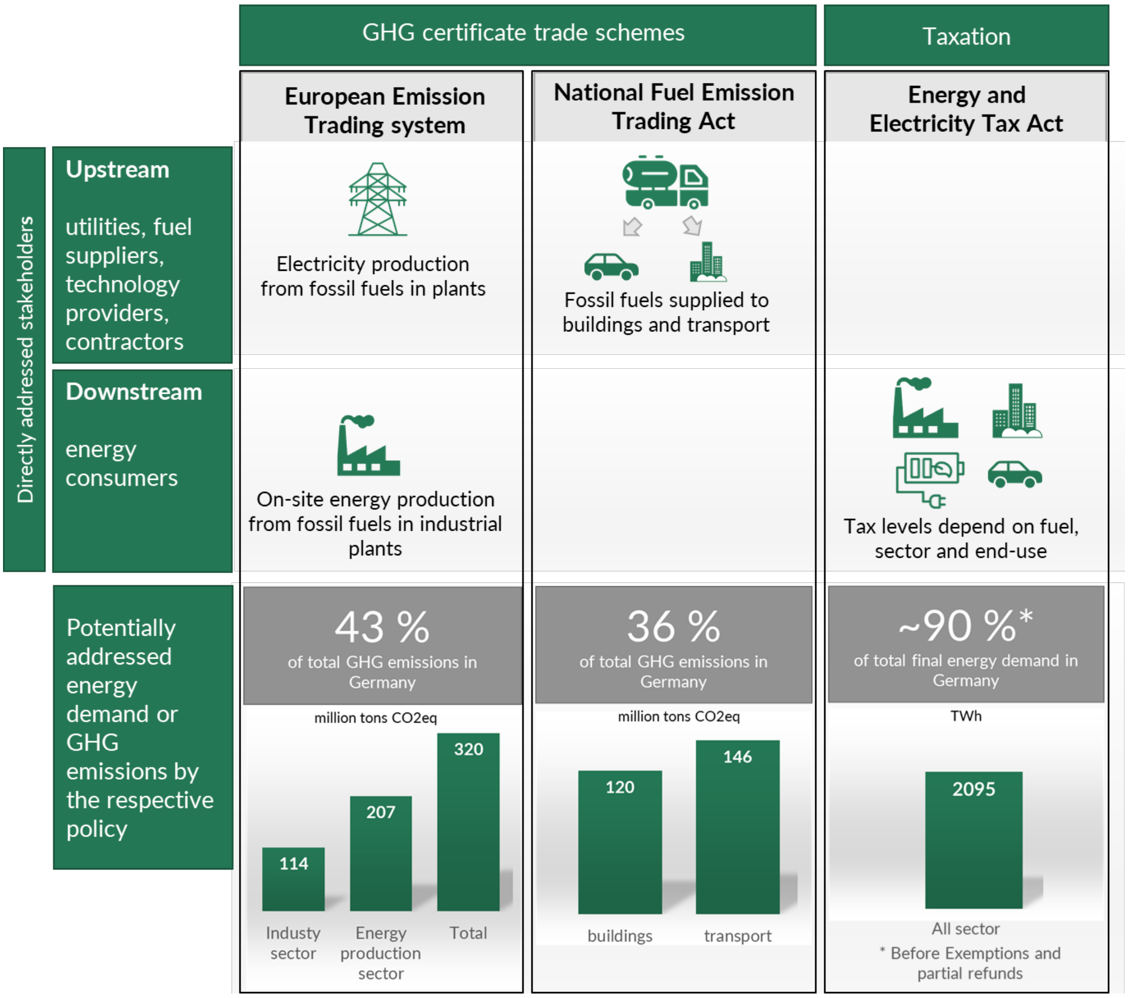
What are cross-cutting policies?

Cross-cutting policies mean policy instruments which are designed to foster energy efficiency or climate protection in different areas or sectors. Those instruments are usually designed to trigger investments in the fields with the highest cost-benefit ratio. Since cross-cutting measures address all or at least several energy demand sectors, the policy design requires a broader approach that can address sector-specific barriers to a limited extent only. For instance, there are major differences in the way investment decisions are made concerning the evaluation and knowledge about available energy efficiency measures. Nevertheless, cross-cutting policies can be effective instruments if they are designed as complementary instrument in a policy bundle with sector-specific instruments. In Germany, experiences with cross-cutting measures are limited. While there is a lot of research on policy design of cross-cutting measures in Germany and in the context of EU wide instruments, there is only few experiences with implemented measures.

Type of implemented cross-cutting policies and relevance for GHG emissions and energy demand in Germany

The main cross-cutting policies in Germany are cap and trade schemes for GHG emissions and taxation on electricity and fossil fuels. A pilot support scheme that was designed similar to a feed-in tariff for energy was closed in 2021 and is therefore not mentioned in the following figures. A widely discussed and comprehensive cross-cutting instrument for energy efficiency are Energy Saving Obligations. Such a scheme has been implemented in several European Member States following the requirement of the Energy Efficiency Directive of the European Union. However, the government in Germany decided to fulfil the requirements with alternative sector-specific measures. Thus, there is no practical experiences with an Energy Saving Obligation Scheme in Germany.

Figure 9: Overview of energy/emission pricing schemes in Germany and coverage in terms of emissions and energy demand



Source: Own depiction IREES based on (BMWi 2021c; UBA 2021b)

Cross-cutting policies – Energy Policy SWOT-Analysis

Strength – current set of policies	**Weakness – policy improvement**
The present set of cross-cutting technologies has a main focus on CO_2 pricing and trading instruments, which are major levers for climate neutrality: ▪ ETS with CO_2 price for industry and energy sector ▪ Since 2021, national fuel emission trading system with CO_2 price also for transport and building sector ▪ Taxation on fuel and electricity consumption	▪ Currently low CO_2 price in the national emission trading system with limited effect on economic feasible of energy efficiency measures ▪ Taxation and other levies on electricity and fuels for district heating are counterproductive since transformation to climate neutral energy systems requires shift to electricity in all sectors as well as maintenance and expansion of district heating networks

Opportunities – new policies and policy options ▪ Expected increase of CO_2 prices ▪ Levies on electricity from the Renewable Energy Act will be gradually reduced in the next years ▪ Implementation of an Energy Saving Obligation scheme or similar market based instruments are in discussion	**Threats – barriers and market shortcomings** ▪ Temporary price jumps of retail fuel prices reduce acceptance of CO_2 pricing and might lead a suspension of the national fuel emission trading system ▪ Increasing investment costs for energy efficiency measures and missing energy efficiency market

3.1.2 Case Study on Cross-Cutting Policies

CO_2-pricing - EU ETS plus national Fuel Emissions Trading Law

Objectives of the programme

Emissions trading is a market-based policy instrument for emission reductions. Capping allowed emissions makes them a scarce resource and effectively puts a price on carbon. This enables companies to internalise the formerly external cost of the environmental impact of their emissions and hence invest in emission reduction if this is cheaper than keeping polluting. By allowing trade of certificates, a market can emerge in which emissions will be reduced where this is possible at least cost and companies with high abatement cost can purchase certificates. This shall lead to cost efficient reduction of emissions to a predefined cap.

Within the EU the EU ETS is the central instrument of climate policy.

Design of the programme

Germany falls under the European Emissions Trading Scheme (EU ETS) which is a central instrument of European climate policy. Installations from the energy industry and energy intensive industry are obliged to hand in emission certificates for the emissions of their installations. A European union-wide cap limits the total amount of certificates available. Member states hand out the certificates to the installations – partly as free allocation and partly via auctioning. The certificates can then be traded and a price per certificate will form in the market.

In addition to the EU ETS, Germany introduced a CO_2-pricing scheme for transport and heating in buildings with implementation of the Fuel Emissions Trading Law (BEHG 2019). The scheme started in 2021 and aims at putting a price on those emissions that are not covered by the EU ETS and thereby contribute to reaching climate policy goals. Enterprises selling heating oil, natural gas, gasoline and diesel are obliged to buy emission certificates for the emissions caused by their products. For the years up to 2025, the certificate price is fixed and will be annually increasing from 25 Euro per tonne in 2021 to 55 Euro per tonne in 2025. In 2026, a price corridor of minimum 55 Euro per tonne and maximum 65 Euro per tonne shall apply. In the years following this introductory phase, certificates shall be auctioned.

Revenues shall be invested into the climate protection programme. Another part shall be used to reduce the burden of increased heating and fuel prices for citizens by reducing the renewable energy levy, increase living support or a mobility premium.

Results of the programme

Little ambitious caps and economic crisis with low production volumes led to low CO2 prices of the EU ETS in the past. However, since 2017, the CO_2 price has increased as a consequence of several reforms to the EU ETS. Mid 2021, the price was at 55 Euro per tonne (UBA 2021a).

Low prices and insecurity about future price development are a barrier for decarbonisation investment e.g. in industry. An expectation of stable and high CO2-prices on the contrary can provide a setting in which companies can invest in decarbonisation.

Since the national CO_2-pricing scheme only started in 2021, no results on the effects are available yet.

CO_2-Pricing – SWOT-Analysis

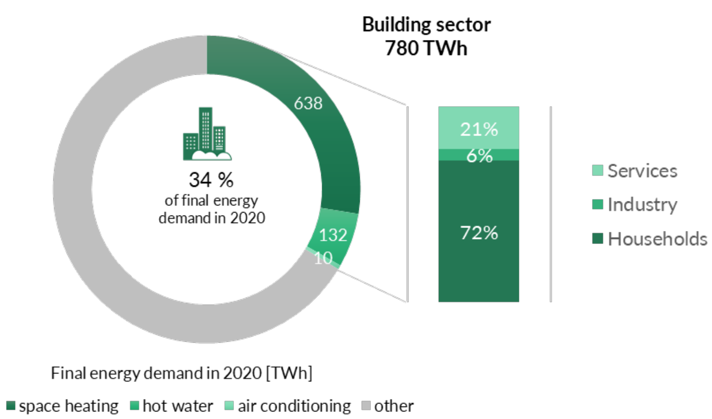
Strength – experience from programme	Weakness – experience from programme
▪ All sectors are addressed by CO_2 pricing due to EU ETS and national scheme. ▪ Increasing CO_2 price signals are sent to the consumers but in a foreseeable price path which makes it easier for the target groups to undertake appropriate measures	▪ Currently low CO_2 price in the national emission trading system with limited effect on economic feasible of energy efficiency measures ▪ Investor-user dilemma in buildings: CO_2 prices are paid by tenants
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ Suggestion for revision of the national Fuel Emissions Trading Law regarding a split of CO_2 costs between buildings owners and tenants ▪ Possible extension of the national trading scheme for building and transport to the European level	▪ Reduction of acceptance with increasing heating and transport cost

3.2 Energy Efficiency in Buildings

3.2.1 Fact Sheet on Measures for Energy Efficiency in Buildings

Building sector by end-uses and relevance for energy demand in Germany

Energy demand in the building sector can be defined[8] as energy needed for thermal conditioning of residential and non-residential buildings (in service sector, industry and transport), including the end-use energy demand for space heating, hot water and air conditioning. Following this definition, the building sector accounts for 34 % of total final energy demand in Germany.

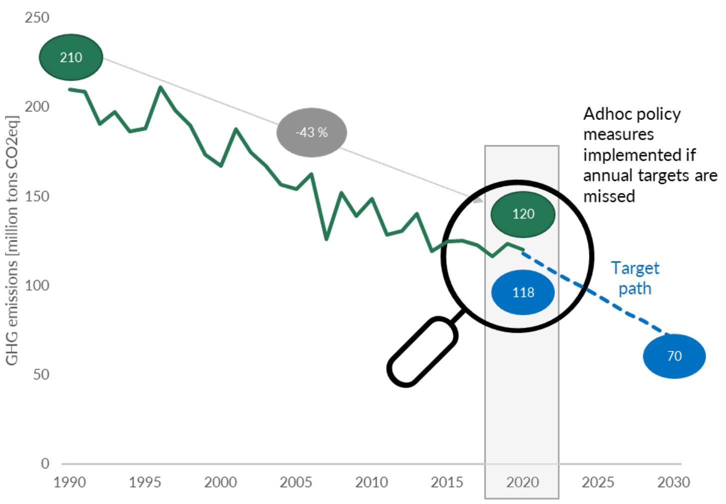


Source: Own compilation based on (BMWi 2021c)

[8] The scope of the German building sector is differently defined in the various political targets and associated studies, making comparability sometimes difficult.

Development of GHG emissions and target path

GHG emissions in the building sector[9] have been reduced by 42 % to 120 Mt CO2-eq. in the period 1990 to 2020. The Climate Change Act defines permissible GHG emissions of 70 million tons by 2030 with annual minimum reduction steps. The target achievement is controlled on annual basis and if targets are failed, the responsible ministry is required to put new policy measures in place, which are evaluated by an independent expert council.



Source: Own compilation based on (UBA 2021b)

Building Sector – Energy Policy SWOT-Analysis

Strength – current set of policies

A comprehensive set of policies, comprising regulation of new and existing buildings, subsidy schemes advice and fossil fuel pricing schemes:

- Building Energy Act (GEG)
  - Mandatory energy efficiency requirements on new buildings and building renovation
  - Requirements on primary energy and quality of the building shell
- Federal Funding for efficient buildings
  - Investment subsidies and soft loans for ambitious efficiency standards and individual measures
  - Additional support for sustainable materials
  - Establishment of market standards for building developers – Efficiency House

Weakness – policy improvement

- Definition of minimum energy standards is strictly limited to economic efficiency, not to requirements due to targets
- Energy performance standards for existing buildings have not been tightened since 2009
- Energy certificates are poorly established since different calculation methods can be used which leads to a lack of comparability among buildings[10]
- Lack of policy instrument that address craftsmen, installers or other relevant professionals
- Still low CO2 prices with limited effects □ expected increase of CO2 prices in the future is not necessarily considered in investment decisions today

[9] Another definition for the building sector is given by the German Climate Change Act. According to the law, the building sector accounts for all GHG emissions from household and service sector.

[10] Energy certificates can either be calculated based on the energy consumption of the last three year or based on the building characteristics (u-Values, geometries) with an energy modelling software

▪ Financial support for comprehensive energy advices and renovation roadmap in buildings o 80 % of cost is funded o Quality standards for energy advisers have been established ▪ Federal Emission Trade Act (BEHG) o CO_2 prices for fossil fuels used for heating and transport (non-ETS sectors)	▪ Missing compliance and few control of regulations
Opportunities – new policies and policy options	**Threat – barriers and market shortcomings**
▪ Ban on new installation of fossil fuel boilers ▪ Addressing of "Worst Performing Buildings" by renovation obligation or additional financial support ▪ Development of regional implementation centres for energy efficiency in buildings ▪ Further development of minimum energy performance standards in combination with financial support for requirements which are economically not feasible ▪ Financial support for training of technicians	▪ Long reinvestment cycles ▪ Majority of implemented measures are not compatible with climate neutrality targets ▪ Shortages of professionals and required skills ▪ Very low transparency about costs and measures ▪ No common market for energy efficiency in buildings mostly regional operating small firms and installers with no holistic approach ▪ Conflicting recommendations on measures by different stakeholders

3.2.2 Case Studies on Policies for Energy Efficiency in Buildings

Federal Funding for efficient buildings

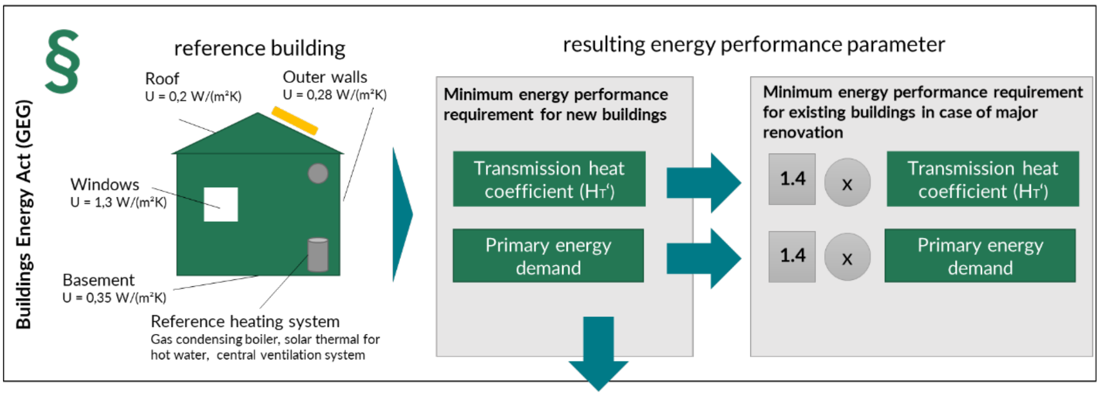
Objectives of the programme

The Federal Funding for Efficient Buildings merged the existing financial support programmes for energy efficiency and renewable energies in buildings in 2020 (BAFA 2021; BAnz AT 18.10.2021 B2 2021; BAnz AT 18.10.2021 B3 2021; BAnz AT 18.10.2021 B4 2021). Furthermore, it provides higher support budget and higher specific subsidies. The existing programmes have been very successful not only in in terms of implemented energy efficiency measures but also in establishing market standards regarding quality and minimum efficiency standards of technologies as well as holistic construction standards for high efficiency buildings. The programme addresses the whole building sector aiming at residential and non-residential buildings as well as new build and renovation of existing buildings. It supports fabric measures such as insulation of building envelope and efficient windows as well as renewable heating systems.

Design of the programme

To address different investment decisions situations, the program supports both individual measures, such as installation of efficient windows, insulation of building parts or new heating systems, and holistic renovations to achieve ambitious energy performance standards. The supported energy performance standards. the so called Efficiency Houses differ with regard to the resulting energy efficiency of the building shelf and the primary energy demand (Figure 10) compared to the minimum requirement defined for new buildings in the Buildings Energy Act (GEG 2020).

Figure 10: Connection between minimum requirements and funding levels for efficiency houses in existing buildings



Federal funding for Energy efficient Buildings

	Subsidies Regular	Subsidies RES class	Requirements compared GEG standards for new buildings: Primary energy demand	Requirements compared GEG standards for new buildings: Transmission heat coefficient (H_T')
Efficiency house 40	45 %	50 %	**40%**	55%
Efficiency house 55	40 %	45%	**55%**	70 %
Efficiency house 70	35 %	40%	**70%**	85 %
Efficiency house 85	30 %	35%	**85%**	100 %
Efficiency house 100	27.5 %	32.5 %	**85%**	100 %

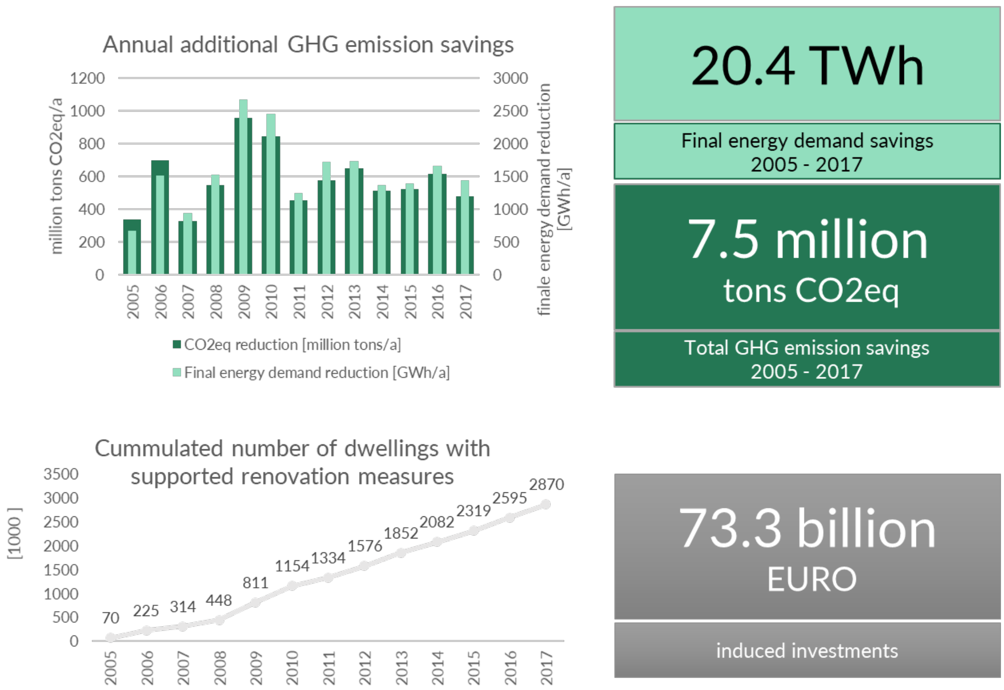
Source: Own illustration IREES

The energy efficiency of the building envelope is measured by the transmission heat loss coefficient resulting an average u-Value of the building envelope. Furthermore, additional financial support is provided if at least 55 % of the heating demand is covered by renewable energy sources. The programme also addresses life cycle efficiency of the buildings by granting additional support for new buildings with low energy consumption and greenhouse gas emissions generated by construction, including the manufacturing phase and upstream supply chains.

Results of the programme

Figure 11 shows the results of the programme segment supporting energy efficiency measures in existing residential buildings. The programme "Energy Efficient Refurbishment" which is now part of the Federal Funding for Efficient Buildings programme has been evaluated for the period 2005 to 2017 (Diefenbach et al. 2018). The supported and implemented measures within this period have led to additional annual saving of final energy demand of 20.4 TWh which represents roughly 3 % of the total final energy demand of the building sector. The corresponding GHG annual emission savings account for 7.5 million tons CO_2eq. The programme has supported energy efficiency measures in existing buildings with a total number of 2.87 million dwellings leading to induced investment in energy efficiency measures of 73.4 billion euros.

Figure 11: Impact of the programme part “Energy Efficient Refurbishment”



Source: Own compilation based on (Diefenbach et al. 2018)

In the program part for efficient new buildings, 1.15 million dwellings have been supported. The figures illustrate the high relevance of the programme for the building sector when it is considered that about 10 % of all dwellings in Germany have been affected either by support for ambitious renovation measures or for efficient new buildings[11].

Since the specific subsidies and overall budget have been further improved in 2020 within the new Federal Funding for Efficient Buildings program, an even higher impact is expected. Compared to the 2019, number of grant applications increased significantly between 60 % and 190 % depending on the program segment (Oeko Institute 2021).

Federal Funding for Efficient Buildings – SWOT-Analysis

Strength – experience from programme	Weakness – experience from programme
▪ Differentiated funding for individual measures and different efficiency house standards ▪ High subsidies for ambitious measures ▪ Efficiency house standards are established standards in the housing market ▪ High impact especially in the segment of new buildings	▪ Funding is still granted for measures which are not compatible with the climate neutrality goals ▪ Efficient fossil fuel boilers have been subsidies until 2019 – now only in combination with renewable systems
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**

[11] In 2017, the total number of dwellings in Germany was 41.97 million.

▪ Shifting support budget from new buildings to holistic renovation measures with ambitious standards ▪ Grants should only be given to measures which support transformation to climate neutrality of the buildings ▪ Further development of sustainable requirements with renovation measures considering life cycle analysis of used materials	▪ Complexity regarding the different standards and in the verification process of ambitious holistic renovation measures leads to focus on individual single measures ▪ Investor-user dilemma in rented buildings ▪ Lack of transparency about investments for renovation measures

Federal funding for energy advice in residential buildings

Objectives of the programme

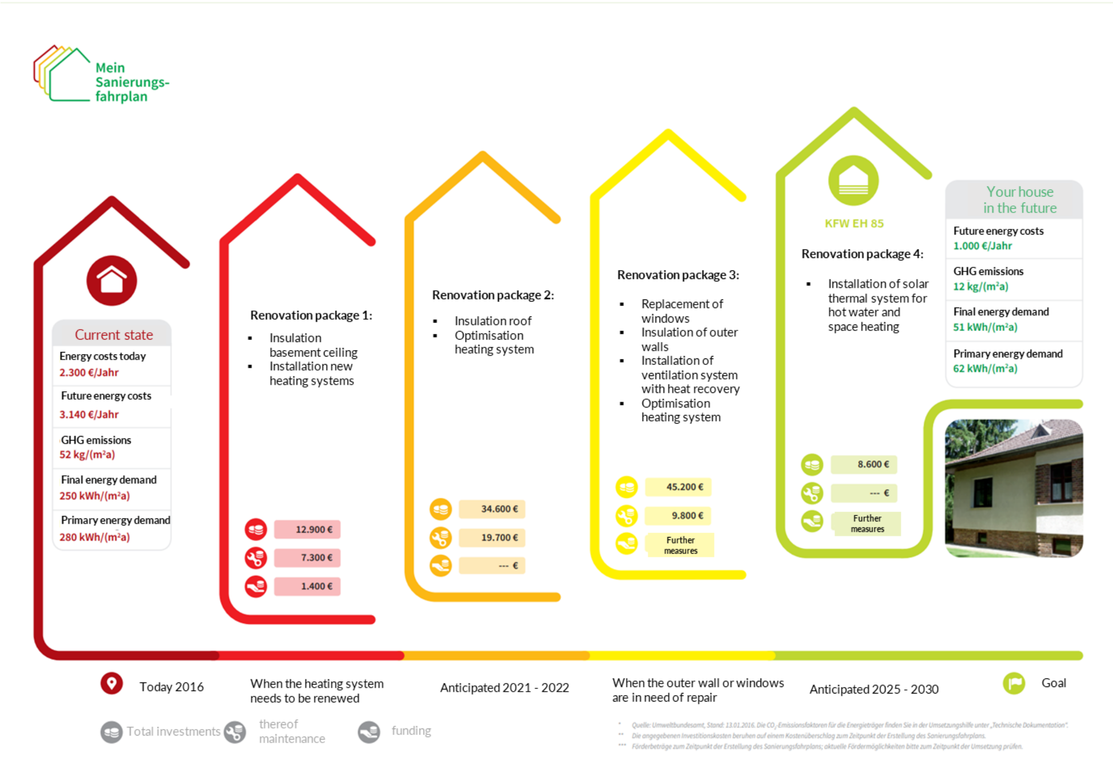
The program “Federal funding for energy advice in residential buildings” supports owners, homeowners' associations, and tenants of residential buildings by the implementation of energy efficiency measures (BAnz AT 04.02.2020 B1 2020). The object of the funding is energy advice for residential buildings, which shows the person being advised the options for energy-efficient building refurbishment. The energy advice provides a comprehensive information and basis for investment decisions making.

Design of the programme

Funding is provided in terms of subsidies for advisory services for residential buildings that are at least 10 years old. The amount of funding is 80 % of the eligible consultancy fee, up to a maximum of 1,300 euros for detached or semi-detached houses and a maximum of 1,700 euros for residential buildings with three or more residential units. Recipients of funding are energy consultants approved by the granting authority. A prerequisite for funding is that the energy advisor must be neutral with regard to manufacturers, suppliers, products and sales and must and may neither accept nor demand a commission or pecuniary advantage from a third party. Grant applications can only be submitted by energy advisors that are approved under the funding programme.

The energy advice must consist at least of on-site data collection, preparation of an advice report and handing it over with subsequent explanation to the person being advised. In addition to the on-site consultation by a certified energy advisor. In addition, building owners can receive an “Individual renovation roadmap”. The individual renovation roadmap presents building owners with the individual options for step-by-step renovation. The composition of the renovation measures is based on the building, the individual needs and personal wishes of the homeowner. The advantage is that holistic energy efficiency renovation can be broken down to step-by-step measures which can be implemented over several years depending on the individual financial and personal situation of the owner. The individual renovation roadmap is valet for 15 years and includes 2 to 5 successive renovation packages with information on the chronological order as well as the amount of the costs of the respective efficiency measures. The identified measures in the individual renovation roadmap are eligible for funding (see case 1).

Figure 12: Example for the illustration of an individual renovation roadmap with 5 packages



Source: (BMWi 2017); own translation

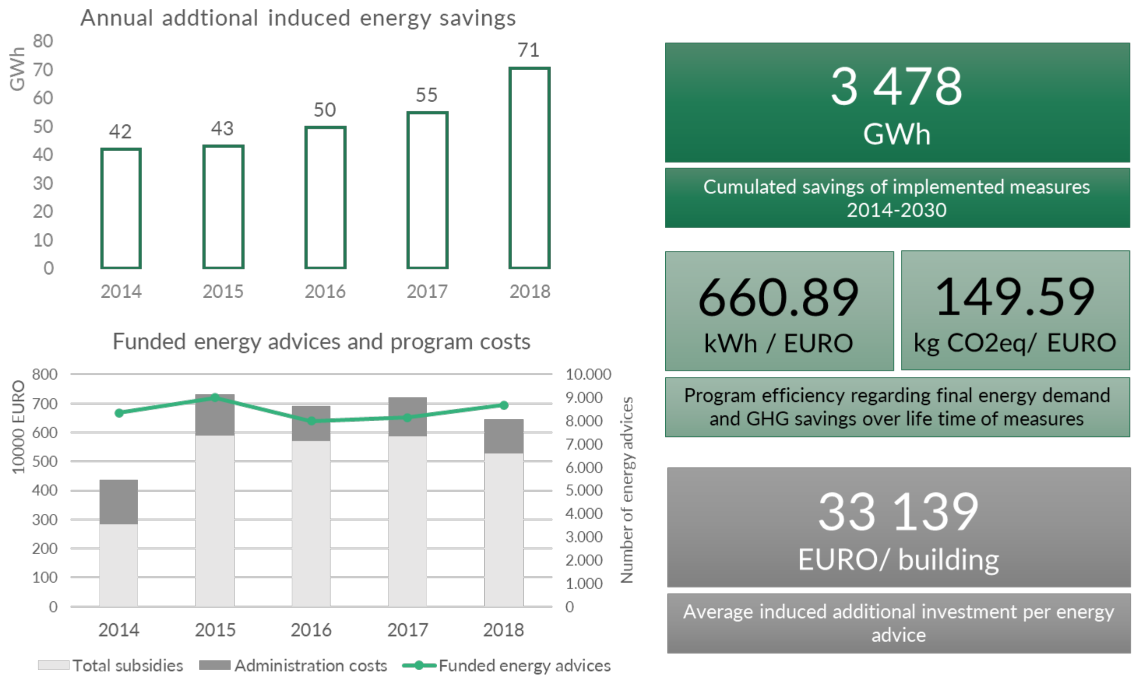
Results of the programme

An evaluation of the impact of the programme is available up to the funding period until 2018 (PWC 2019). Since the specific funding was improved from 60 % to 80 % in 2020, number of funding applications and conducted energy advices are expected to increase significantly[12]. In the period 2014 to 2018, the programme supported about 260 000 comprehensive on-site energy advices in residential buildings with an implementation rate of 64 % and 84 % including planned measures (Figure 13). According to the independent programme evaluation (PWC 2019), the additional induced investments as directly results of the energy advice are on average 33 139 EURO per building. The suggested and implemented energy efficiency measures lead to additional energy savings of 3 478 GWh until 2030[13]. Thus, the programme is highly successful if additional savings compared to subsidies and program cost resulting in additional energy savings of 661 kWh or GHG emission savings of 150 kg CO2eq per EURO provided as funding.

[12] Number on funding applications for the period 2020 – 2021 have not been published yet.

[13] Thereby, it is considered that energy efficiency measures that are implemented today will lead to annual energy savings over the lifetime of the respective building. The number considers energy savings from measures implemented in 2014 to 2018 until 2030.

Figure 2: Impact of the "Funding for energy advice in residential buildings" in the period 2014 to 2018



Source: Own compilation IREES based on (PWC 2019)

Federal Funding for Energy Consulting/ Individual Renovation Roadmap – SWOT-Analysis

Strength – experience from programme	**Weakness – experience from programme**
▪ High funding efficiency ▪ Easy access for building owners application and verification is down by certified energy advisors ▪ Individual renovation roadmap as step-step by strategy for achieving overall goal ▪ Energy advice leads on average to significantly higher investments with more ambitious energy efficiency measures ▪ High funding level with 80 % subsidies ▪ High level of satisfaction with the conducted energy advice	▪ Lack of awareness for the program with building owners ▪ Lack of awareness for available marketing material which is available for energy advisors for free ▪ Level of detail of measures and information for homeowners presented in the individual renovation roadmap is rated too low by the energy advisors
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ Intensification of stakeholder specific public relations work to increase awareness of the programme ▪ Improvement of qualification for energy advisors regarding climate neutrality goals	▪ Gap between energy advice and implementation energy advisors are not allowed to recommend craftsmen and installers for implementation of energy efficiency measures ▪ Lack of qualified energy advisors

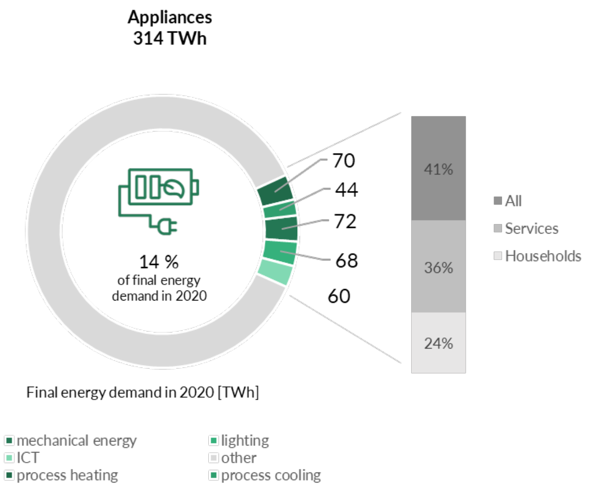
▪ Supporting energy advisors in the preparation of the advisory reports in software programmes by building up regional energy efficiency centres	▪ Recommendations given in energy advise do often not match the policy goals of climate-neural buildings

3.3 Energy Efficiency in Appliances

3.3.1 Fact sheet on measures for Energy Efficiency of Appliances

Appliances (Households and Service Sector) by end-uses and relevance for energy demand in Germany

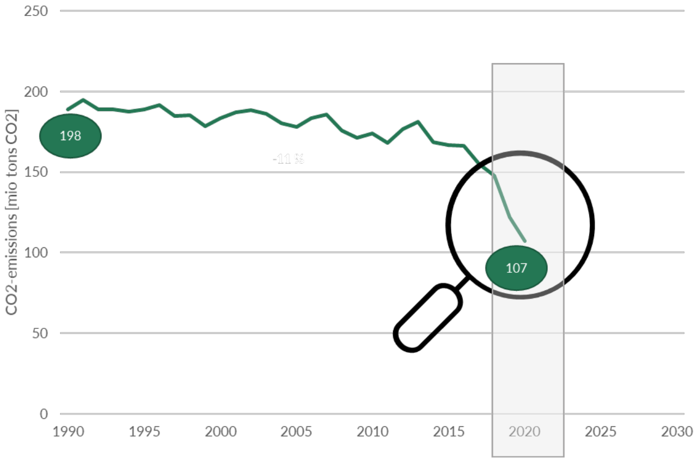
Energy demand of appliances can be defined as energy needed for lighting, ICT, mechanical energy as well as process heat/cold in households and services (for cooking, cooling and refrigeration). Following this definition, appliances account for 14% of total final energy demand in Germany.



Source: Own compilation based on (BMWi 2021c)

Development of GHG emissions and target path

GHG emissions of electricity production and thus of the energy consumption for appliances have been reduced by 46% to 107 Mt CO_2-eq. in the period 1990 to 2020 under the combined effect of electricity savings and decarbonisation of the power sector. The Climate Change Act defines permissible GHG emissions only for the overall energy supply, in which electricity presents a substantial share. Projecting the targets of energy supply to appliances, the 2020 target would be 136 Mt CO_2-eq, and the 2030 target would be 46 Mt CO_2-eq.



Source: Own compilation based on (AG Energiebilanzen 2021; BMWi 2021c; UBA 2021b)

Appliances (Households and Service Sector) – Energy Policy SWOT-Analysis

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Strength – current set of policies

A comprehensive set of six main measures, the first two harmonised with European frame (both for households and the service sector):

- Eco-design
  - High impact
  - Effectively speeds up market developments
- Energy Labelling
  - Large Market, high recognition
  - Simple and universal tool for a lot of appliances
- Subsidy programmes under the National Climate Initiative NKI (cold/air conditioning; municipal investment directive), the Federal Support Programme for Energy Efficiency in companies and the KfW Efficiency Programme
- Energy audit obligations for companies which are not small/medium size (SME)
- Energy Efficiency and Climate Protection Networks

Smaller accompanying measures:

- Energy and electricity tax
- Ecologic tax reform
- Reform of the charges from renewable energy support on electricity
- Pilot programme "Saving Meter"
- Energy advice to poor households ("Electricity saving check")

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Weakness – policy improvement

- Eco-design/labelling policies gradually have exhausted their long-term potentials for electric appliances
- Distributional impacts are considered in a systematic manner by supporting energy efficiency in energy poor households
- Audit recommendations are not systematically translated in practice when economic

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Opportunities – new policies and policy options

- Inclusion of new product groups and tightening of standards under Eco-design/labelling
- Increasing electricity/energy prices (triggered by the EU Emission Trading Scheme ETS, fuel prices and strategic issues around gas delivery in Europe) make saving measures more attractive
- Intelligent appliances/smart meters may both contribute to a flexible energy system and to energy savings

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Threats – barriers and market shortcomings

- Rebound effects both in the household and service sector can be important: size of appliances, the duration of use, increasing number of appliances (e.g. screens in public areas, LEDs)
- Distributional effects due to high charges on electricity and fossil fuels impact low-income households. Support measures are required for those consumer groups

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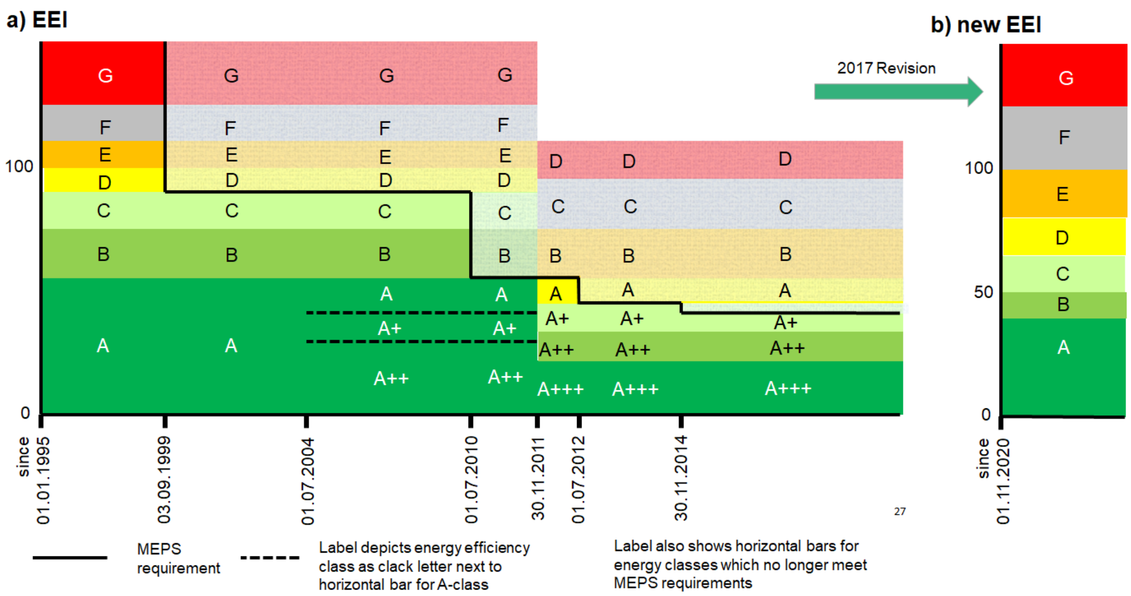
3.3.2 Case Studies on Policies for Energy Efficiency of Appliances

Eco-design and labelling of appliances

Objectives of the programme

Going back to 1992, the EU Labelling Directive made it mandatory to provide comparative energy labels for the sale of certain household appliances (Schleich et al., 2021). The underlying idea is to inform consumers about the usage costs to expect, in order to deter them from buying products with low purchasing costs but high total expenses. As shown in Figure 14, the initial scheme differentiated between seven efficiency classes, going from A (best) to G (worst). The EU Eco-Design Directive followed, taking effect in 1999 and introducing Mandatory Energy Performance Standards (MEPS) for a range of appliances. Following an objective which is similar to the labelling scheme, this directive addresses people's propensity to buy products for the sole sake of a low purchasing price by requiring all new appliances to comply with the defined mandatory standards. Both programmes are market pull measures designed to foster the sale of energy-efficient products, while reducing the market share of energy-inefficient products (Schleich et al. 2021).

Figure 3: Labelling and eco-design standards regarding cold appliances



Note: "In the new EU regulation, the calculation of the Energy Efficiency Index EEI has been changed. Furthermore, the assessment of the energy consumption is mostly based on IEC 62552-3:2015/AMD1:2020, which is a major update compared to the 2007 version of the standard. Therefore, it is not possible to compare directly the MEPS level and energy classes of the new EU regulations from 2019 with the older one."

Source: own design based on and extended from (Schleich, Faure, and Meissner 2021)

Design of the programme

The labelling system of the EU Energy Labelling scheme is based on an energy efficiency index (EEI) calculated in relation to standard values for every product (European Commission 2009):

$$EEI = 100 \cdot \frac{Tested\ appliance's\ annual\ energy\ consumption}{Reference\ appliance's\ annual\ energy\ consumption}$$

The reference consumption is calculated through a formula considering specific characteristics of the tested appliance, thus comparing it to the reference value of a similar appliance model.

Due to technological advancement and an increasing share of class A labels for certain product categories, for some appliances the top class has been subdivided (A, A+, A++, sometimes A+++) in order to account for the strongly differing energy efficiency values previously labelled A. At the same time, the available range of labelling classes is limited by the mandatory standards defined in the Eco-Design Directive, essentially banning certain poor efficiency classes, as depicted in Figure 14 (Schleich et al. 2021).

Addressing this shift in energy efficiency classes, the labelling scheme's 2017 revision returned to the initial A to G labelling range without any plus signs (starting from 2020). Furthermore, it was upgraded to a regulation, meaning that contrary to a directive, it immediately takes effect and does not need to be implemented nationally. In Germany, the regulation is enhanced by two additional pieces of legislation (Bundesregierung 2021).

The EU Eco-Design Directive defines the minimum energy performance standards for appliances to receive the CE marking and thus, be allowed on the European market. These are determined individually for every product category on the basis of a technical, economical, and ecological analysis. A key tenet is the aspect of cost-effectiveness, requiring that no mandatory standard entails higher costs for consumers over the appliance's lifetime. Therefore, a preliminary study is commissioned by the European Commission, inter alia including a technical and a market assessment. Thereupon, the European Commission can proceed by creating a draft regulation, which has to undergo a consultation forum and an impact assessment. Alternatively, the Commission is entitled to accept voluntary agreements proposed by the relevant industry. As of 2021, 29 Eco-Design regulations and 2 voluntary agreements are in effect (Bundesregierung 2021).

Results of the programme

Overall, the EU Energy Labelling Regulation as well as the EU Eco-Design Directive have proven to be very expedient in their scope to reduce energy consumption (Bundesregierung 2021). In Germany, the labelling scheme has entailed savings of 2.9 TWh in 2020 (2.9% of private households' energy consumption), while minimum energy performance requirements have led to a reduction in consumption of additional 14.4 TWh in 2020 (14.5%). Thus, the two schemes have instigated significant energy savings in the residential sector through the fostering of appliances' energy efficiency (Bundesregierung 2021).

Eco-design and Labelling of Appliances – SWOT-Analysis

Strength – experience from programme	**Weakness – experience from programme**

Two powerfull and comprehensive, European-wide harmonised schemes on standards and labels:
▪ Eco-design
  o High impact
  o Effectively speeds up market developments
▪ Energy Labelling
  o Large Market, high recognition
  o Simple and universal tool for a lot of appliances
	▪ Eco-design
	  o Only energy use in the use phase is covered for most projects
	  o Market surveillance sometimes weak
	  o Cannot cope with disruptive developments and react to new applications
	  o Slow process
	  o Most important product groups are covered, the remaining new products are too complex or don't offer sufficient improvement potential
	▪ Energy Labelling
	  o Readjustment of the label classes creates uncertainty for users

Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ Focus on the LCA approach ▪ Inclusion of social aspects in the assessment (e.g. working conditions)	▪ Rebound effects are not properly addressed (efficiency vs. energy demand reduction) ▪ The substitution of old appliances is not directly encouraged ▪ For some project categories, only small improvements can be made if no behavioural change is addressed

Pilot programme "Electricity savings through competitive tendering: Exploiting electricity efficiency potentials" (STEP up!)

Objectives of the programme

STEP up! was launched in May 2016 as a pilot programme under the National Action Plan on Energy Efficiency (Heinrich et al. 2019). It was intended to test a competitive tendering model as a new way to promote energy efficiency across sectors, technologies and stakeholders. The design of the German support programme for competitive tendering was based very closely on experience gained in Switzerland with the implementation of the "ProKilowatt" programme (BFE 2021; Kotin-Förster, Bons, and Dinges 2019). STEP up! was intended to test the efficient use of public funds to achieve significant electricity savings. In practice, the applicant should be given leeway through the competition concept: within the framework of the specifications, they can individually decide which funding volume they apply for their planned efficiency measure (max. 30 % of the additional investment costs). New, creative sales or technical solutions should thus be realised through the financial competitive pressure. If necessary, new players should be encouraged to enter the market, to generate competition. STEP up! is part of a general energy policy trend towards tenders as an element of controlling energy policy, which is currently also being discussed intensively in connection with the further development of the Renewable Energy Sources Act in Germany.

Design of the programme

The STEP up! funding was open to all actors and is aimed at companies and municipal enterprises with a permanent establishment or branch in Germany as well as contractors who implement eligible measures within the framework of a contracting agreement at eligible companies. Funding was available for investment measures to reduce electricity consumption (renewal investments, early replacement investments and additional investments). Individual and collective projects could be applied for. Individual projects were implemented at the applicant's premises or by a contractor at eligible companies. Collective projects consist of one or more measures of the same kind that are carried out by third parties (companies, private individuals) and coordinated by a project coordinator.

The programme had the following design elements:

- The payback period of each (partial) measure should be more than three years in relation to the electricity costs saved without funding. The reason for setting the limit at 3 years is that all measures below are generally implemented according to the economic criteria of companies (unless non-economic barriers come in addition.
- The subsidy rate applied for in the competition should not exceed 30 % of the additional investment costs of the measures, given the competitive environment.
- The cost-benefit threshold should not exceed 10 ctEuro/kWh. The cost-benefit value (funding efficiency in centEuro/kWh) reflects the amount of funding required for the amount of electricity saved.

The tender rounds were each divided into an open and a closed round. The open tenders were generally open to all sectors and technologies. The closed tenders focused on specific sectors, target groups, technologies or topics with known high potentials and barriers, which were to be addressed specifically. Topics of the closed calls included:

- Energetic refurbishment of lift systems
- Implementation of efficiency measures within the framework of contracting
- Implementation of electricity efficiency measures in data centres
- Implementation of efficiency measures in drying and cleaning processes, "combined electricity-heat projects"
- Implementation of energy efficiency measures in water and wastewater technology, "combined electricity-heat projects"
- "Combined electricity-heat projects", open to all technologies and sectors

Results of the programme

In total, 89 tenders were funded, nearly all of the admitted tenders, i.e. no substantial cut occurred with the project pipeline (Table 3).

Table 1 Step-up! - Development of funding figures by funding year

Year	Tender round	Number of tenders	Admitted tenders	Funded tenders	Share funded tenders
2016	round 1	18	3	2	11%
2017	round 2	8	4	3	38%
	round 3	6	3	3	50%
2018	round 4	26	20	19	73%
	round 5	41	28	28	68%
2019	round 6	52	34	34	65%
Total		**151**	**92**	**89**	**59%**

Source: Own depiction based on (Heinrich et al. 2019)

In total, the pilot programme subsided projects in a value of 28.8 million Euro (Table 4). The cost-benefit ratio of the subsidised projects ranged from 0.5 to 10 ctEuro/kWh and was on average 4.8 ctEuro/kWh, well below the maximum permissible value of 10 ctEuro/kWh. If the above-mentioned "cut" were to become relevant due to competition, the maximum permissible value could be adjusted downwards, if necessary, and thus increase the intensity of competition. The admissibility criterion of a minimum payback period of three years without subsidy had proven itself. It also seemed to be a valid criterion for applicants. Many of the companies interviewed cited the reduction of the payback period as the main motivation for taking advantage of the funding. Especially in large companies, three years was mentioned as the limit that projects have to meet in order to be implemented. The payback period of most of the funded projects was over five years, only 10 projects indicated periods of 3.5 to 5 years. The median payback period was 11.7 years without funding and 8.4 years for the payback of total costs minus funding. Given a useful life of 10 years for almost all projects, the subsidy was relevant for the economic viability of the projects. The abatement costs for STEP up! over its economic lifetime amount to around 54 Euro/tonne CO_2. Achieved savings were 113 GWh per year, considerably below the expected result, due to comparatively small project proposals (Table 4).

Table 2 Step-up! - total cost, additional investment, subsidies and electricity savings

	Total cost	Additional investment	Subsidies	Electricity savings per year	Electricity savings lifetime
	[million EURO]			[MWh]	
Open tender	**133.2**	**61.5**	**21.5**	**83,064**	**840,432**
Single project	108.1	53.5	16.3	63,934	645,882
Collective project	25.1	8.0	5.1	19,130	194,559
Closed tender Single project	**35.1**	**20.4**	**7.3**	**30,167**	**301,665**
Total	**168.3**	**81.9**	**28.8**	**113,231**	**1,142,097**

Note: The Additional Investment is the part of the Total Cost which exceeds the cost of the standard technology. The subsidy should reduce those additional costs but not exceed 30% of them.

Source: (Heinrich et al. 2019)

Pilot programme "Electricity savings through competitive tendering: Exploiting electricity efficiency potentials" (STEP up!) – SWOT-Analysis

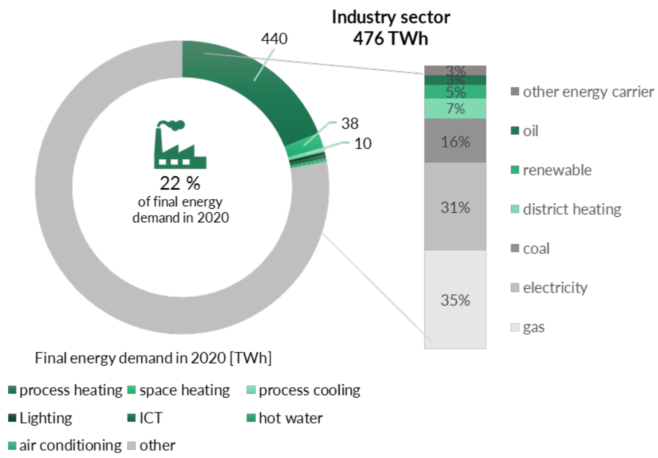
Strength – experience from programme	Weakness – experience from programme
▪ Technology/actor/sector openness was fulfilled. ▪ Cost-benefit value proven as a guiding parameter for competition (approx. 3-5 ct/kWh, i.e. far below limit of 10ct/kWh. ▪ Avoidance of windfall profits due to specified minimum payback period. ▪ Pilot programme stimulated creativity among the grant recipients.	▪ Low number of applications submitted: (fixed funds were not exceeded). ▪ Selection of projects for funding according to cost-benefit value could not be tested. ▪ Substantial effort required in submitting applications in connection with the uncertainty of funding approval. ▪ Significant deviation from targets for electricity and CO_2 savings.
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ Competitive tenders for energy efficiency fit well to the trend of auctioning renewable energy capacities. ▪ Tapping further potential by expanding to heat. ▪ Collective projects are suitable for activating a large number of consumers in a short time (large volumes).	▪ Limitation to 30% funding does not represent added value compared to other funding programmes

3.4 Energy Efficiency in Industry

3.4.1 Fact Sheet on Measures for Energy Efficiency in Industry

Industrial sector by end-uses and relevance for energy demand in Germany

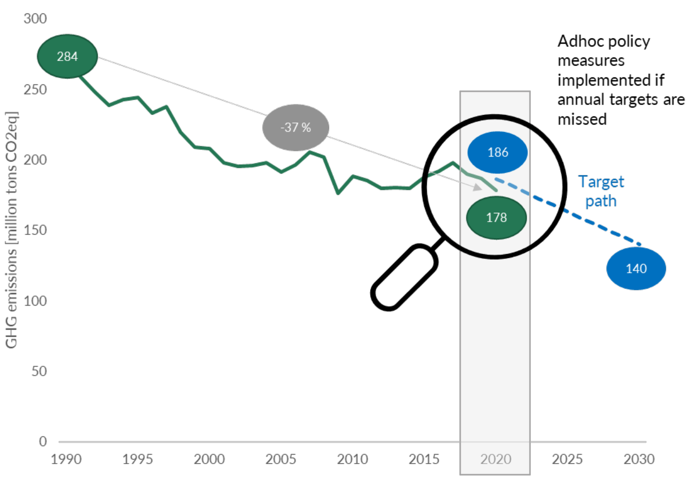
Final energy demand in the industry sector is mainly defined by energy needed for process heating and cooling[14]. The industrial sector accounts for 22 % of total final energy demand in Germany. The main energy sources used in the industry sector are natural gas, electricity, and coal. Renewable energy sources used in industry is almost only biomass which accounts for 7 % of final energy demand.



Source: Own compilation based on (BMWi 2021c)

Development of GHG emissions and target path

GHG emissions in the industry sector[15] have been reduced by 37 % to 178 million tons CO_2-eq. in the period 1990 to 2020. The Climate Change Act defines permissible GHG emissions of 140 million tons by 2030 with annual minimum reduction steps. In 2020, the target in the industry sector has been exceeded, which is also due to the economic slowdown as an effect of the Covid-19 crisis.



Source: Own compilation based on (UBA 2021b)

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[14] Note that space heating energy demand of industrial buildings is included in the building sector.

[15] Another definition for the building sector is given by the German Climate Change Act. According to the law, the industry sector accounts for all direct GHG emissions from industry sector including those for space heating. GHG emissions from electricity use and district heating are not accounted in the industry sector, though.

Industry Sector – Energy Policy SWOT-Analysis

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<u>Strength – current set of policies</u>

A comprehensive set of policies comprising pricing carbon pricing and trading, subsidy schemes, climate networks, audit and management schemes, as well as innovation instruments:

Federal funding programme for energy and resource efficiency in the economy (Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft); new programme: Nov.2021
Energy Efficiency and Climate Protection Networks enable exchange of ideas and experiences and lead to energy savings
Audits and Energy Management Systems EMS increase transparency and increase implementation of energy efficiency measures
Energy taxation and exemptions incentivize energy efficiency
EU Emission Trading Scheme
Grant programme ‘Decarbonising in Industry’ advances investments in low-carbon technologies by investment grants
Pilot programme for climate protection contracts (carbon contracts for difference) secures investments in breakthrough low-carbon technologies with higher operating cost by guaranteeing the contract price on avoided CO_2

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<u>Weakness – policy improvement</u>

Low carbon prices up to recent time
Strong focus on decarbonisation may lead to neglect energy efficiency (hydrogen economy with low efficiencies)
Lack in dedicated implementation of recommended measures under energy audits
Untapped potentials of using industrial waste heat in district heating

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<u>Opportunities – new policies and policy options</u>

Support from the EU Innovation Fund based on the EU Emission Trading scheme
Ongoing revision of Energy and Environmental State Aid Guidelines at EU level which help Member States enable Member States to support projects for environmental protection
Carbon Border Tax Adjustment CBAM

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<u>Threats – barriers and market shortcomings</u>

Capital intensive assets with long lifetimes
Radical changes required - incremental improvements remain important but are not sufficient
Risk of stranded assets, carbon lock-in or investment withholding

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3.4.2 Case Studies on Policies for Energy Efficiency in Industry

Energy Audits and Energy Management Systems

Objectives of the programme

Energy audits are an important and effective instrument for raising awareness in the respective enterprise for efficiency measures. Audits in Germany increased the importance that companies attribute to energy efficiency (Mai et al. 2017). Also, the introduction of energy management systems (EMS) is seen as an important step towards more energy efficiency by identifying energy efficiency measures and overcoming implementation barriers (Hirzel, Sontag, and Rohde 2011). However, the introduction alone does not say anything about the realised impact on energy consumption.

Companies with an EMS state as important consequences the definition of energy reduction targets and of responsibilities for the implementation as well as the achievement of continuous improvements with respect to energy (Mai et al. 2017).

According to DIN EN 16247, an energy audit is "a systematic inspection and analysis of the energy input and energy consumption of an installation, a building, a system or an organisation with the aim to identify energy flows and potential energy efficiency improvements and report on them" (BAFA 2020). The energy auditor evaluates energy efficiency measures and thereby enables companies to identify where they can potentially and profitably save energy. However, the audit does not require the companies to subsequently act upon the identified measures.

An energy management system establishes a systematic structure and responsibilities to improve energy efficiency within an enterprise. It further establishes targets for energy consumption and/ or efficiency. Progress towards the targets is measured with specific indicators. The foundation of an EMS is regular measurement and analysis of energy carriers and energy flows. Based on the data, the auditor identifies potentials for energy efficiency improvements. These can be either measures or changes to processes or behaviour. The potentials are evaluated economically.

The International Standard for energy management systems is DIN ISO 50001. The Eco-Management and Audit Scheme (EMAS) (European Commission 2009) is primary an environmental management system. However, it covers energy use as one critical aspect for environmental management. Companies that already apply EMAS have to realize only small adaptations to also comply with ISO 50001 (UBA 2021c). Also vice versa, an energy management system according to ISO 50001 can be the first step and lead eventually to the implementation of a broader environmental management system.

Design of the programme

The Energy Efficiency Directive (Article 8) makes energy audits mandatory for large companies. Germany transposed this requirement into national law with the law on energy services and other energy measures (EDL-G 2021). The audit obligation applies to companies that are not SMEs[16] unless they already have an energy or environmental management system. The audit has to be repeated every four years, the initial audit was due by December 5, 2015. Companies that fail to carry out and submit energy audit correctly and completely may be fined with up to 50,000 Euro. Companies that have an EMS do not have to carry out an audit.

Germany introduced a **threshold for minimum energy consumption** for the audit obligation to be effective to maintain a sensible cost-benefit ratio. Companies with an annual consumption of less than 500 000kWh/a are exempt. They only have to submit annual energy consumption and energy cost both differentiated by energy carrier.

There are furthermore two financial incentives for enterprises to introduce EMS or energy audit:

1. The tax peak compensation scheme[17] enables a substantial refund on energy and electricity taxes for companies from the manufacturing sector. A requirement for the application is the implementation of an energy or environmental management system. Small and medium enterprises can qualify with an energy audit or an alternative energy management system according to the regulation on tax peak compensation (SpaEfV 2013)[18].

[16] SMEs are companies with up to 250 employees, an annual turnover of up to 50 Mio Euro and total assets according to the balance sheet of no more than 43 Mio Euro according to the definition of the European Commission ABl. Nr.L 124 p. 36 (European Commission 2003).

[17] German: "Spitzenausgleich"

[18] The alternative system is further specified in the regulation in connection with the refund of energy and electricity tax in special cases (Spitzenausgleichseffizienzsystemverordnung -SpaEfV). f

2. The special compensation mechanism within the renewable energy law (German: "Besondere Ausgleichsregelung (BesAR)") which entitles qualified energy intensive enterprises to pay only a reduced renewable energy levy. The mechanism also requires privileged enterprises to implement an energy or environmental management system. Companies with up to 5 GWh/a electricity consumption can instead carry out an energy audit or an alternative energy management system.

Both schemes reduce energy cost for the enterprise, and the requirement for an audit or EMS aims to maintain or even strengthen incentives to increase energy efficiency despite reduced effective energy prices.

Financial support for the realisation of an audit is available for small and medium companies that are not required to carry out an audit. They can receive up to 80% of the audit cost. Enterprises that receive a reduced renewable energy levy under the BesAR are not eligible. Similarly, enterprises that benefit from the tax refund on energy or electricity tax under the peak compensation scheme can only in exceptional cases apply for funding.

Figure 4: Overview of legal obligations for EMS and energy audits in Germany

	Renewable Energy Law EMS/Audit required for special compensation schem (annually)	**SpaEfV** EMS/Audit required for refund under tax peak compensation scheme (annually)	**EDL-G** EMS/ Audit initially Dec 2015, then min. every 4 years
SME (manufacturing sector)	• 1-5 GWh/a electricity consumption alternative audit according to SpaEfV • <5 GWh/a electricity consumption ISO 50001/EMAS	• Audit according to DIN EN 16247-1 or alternative audit according to SpaEfV • Alternatively ISO 50001/EMAS	
Non-SME (manufacturing sector)	• 1-5 GWh/a electricity consumption min alternative audit according to SpaEfV • <5 GWh/a electricity consumption ISO 50001/EMAS	• ISO 50001/EMAS	• Audit according to DIN EN 16247-1 • ISO 50001/EMAS
Non-SME (other sectors)			• Audit according to DIN EN 16247-1 • ISO 50001/EMAS

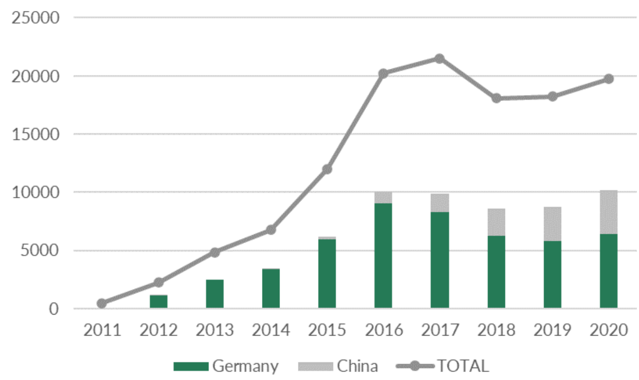
Source: Own illustration based on Mai et al. 2017

Results of the programme

The internationally dominant energy management system is the certification according to ISO 50001. Worldwide, 19 731 valid certificates for 45 092 sites exist according to the ISO Survey 2020. With one third, the major share of certificates is held by German companies. The data shows a peak in certificates for Germany in the years 2016 and 2017 with a subsequent decline. The strong increase in the years 2014 and 2015 is likely influenced by the requirement of an EMS for reductions in taxes and levies, as described above, that had a cut-off date at the end of 2015. The continued increase in 2016 might then be driven by the EED obligation. The German EDL-G had an introductory phase until 2016.

China, in 2020, had a share of nearly one fifth of worldwide certificates with strong annual increases since 2015.

Figure 5 Worldwide evolution of EMS (according ISO 50001)



Source: own illustration based on data from: ISO Survey 2020

In an evaluation, the **savings in final energy resulting from implemented and planned measures** in consequence of an energy audit or energy management system were estimated at 3.4% of their total energy consumption. This was not much less than the reported potentials of 3.9% (Mai et al. 2017). An estimation of savings for different sectors finds a potential average reduction of 2.9%, if all implemented and planned measures were considered. The potential savings diverge between sectors from roughly 0.5% to 6.5%. These potentials could be tapped with investments within three to five years. This implies that planned measures have a potential of about 1% savings per year (Mai et al. 2017)

After the introduction of the audit obligation in 2015, quite a number of companies rushed to get an audit and paid more attention to low cost than to quality. There were also problems with the capacity of qualified auditors to do the audits in time and there were also problems with the quality of audits (Mai et al. 2017). In consequence, Germany adjusted the rules for compliance with the review of the EDL-G in 2019: Companies are now required to fill in an online audit statement. In this statement, several data from the energy audit have to be submitted such as energy consumption, energy cost, identified energy efficiency measures and cost for the auditor. This enables the responsible government entity to perform certain **checks on the audits automatically**. Additionally, BAFA continues to conduct random checks of the submitted audit reports. This "threat of scrutiny" sets an incentive for companies to submit high quality reports.

Quality of auditors is an important factor for high quality reports as well as solid information on potential energy efficiency investments. Only then, the audit is of real benefit to the company, its usefulness becomes accepted by the management and implementation of identified energy efficiency measures is more likely. In Germany, a certain standard is achieved by the requirement for auditors to register with the BAFA and provide evidence for their qualifications. Furthermore, they are required to participate regularly in trainings. Additionally, in the future it might be helpful to introduce a mechanism for removing auditors from the list in case they repeatedly submit low quality reports. In addition to the prequalification of auditors, the BAFA provides a guidance document to assist auditors in producing good quality energy audit reports.[19]

Effort for the audit was rated high in particular by smaller companies. This led to an unfavourable cost-benefit ratio until the minimum threshold was introduced.

[19] Available in German only: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/ea_leitfaden.html;jsessionid=0C61F2201B7E119A5F4557C0DA179D58.2_cid378?nn=8064128

Energy Audits and Energy Management Systems – SWOT-Analysis

Strength – experience from programme	Weakness – experience from programme
▪ EMS and audits contribute to: o identification of energy efficiency potentials o reduction of implementation barriers o increased realisation of energy efficiency potentials ▪ EMS and audits increase awareness for energy efficiency ▪ threshold value and simplified rules for small companies help maintain acceptable balance of cost and effort	▪ Lack in dedicated implementation of recommended measures under energy audits
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ Requirement to realize a certain share of identified potentials	▪ Auditor quality is important

Implementation Case Study – Reduction in CO2 emissions and fossil energy consumption at the CEMEX cement plant in Rüdersdorf.

CEMEX is one of the biggest cement producer in the world. In Germany, it operates notably a plant in Ruedersdorf close to Berlin. The clinker production operates at 5,500 t clinker per day.

The fuel mix used contains coal dust, animal meal, sewage sludge, fluff, gas from a Circulating Fluidized Bed Combustion.

The plant is certified for an environmental management system (EMAS and ISO 14001). Since 2011, the plant has introduced an energy management system according to DIN EN ISO 50001.

In the last two decades the company has put a lot of efforts into the use of secondary input fuels such as sewage sludge, animal meal and other fuels. The share has reached 70% on average (Figure 17) while the company intends to increase this share further in future to 80% and more. The use of secondary fuels reduces CO_2 emissions, as partly they are composed of renewable fuels. Overall, CO_2 emissions have been reduced by 17% over the time period 2000-2019 (and much more compared to 1990) (Figure 18).

Nevertheless, challenged the progress achieved in energy efficiency, given that less homogeneous fuels were used with partly high moister content. The use of an energy management helped to compensate for the additional energy required.

Most recent objectives/measures linked to energy efficiency include:

- Implementation of the Expert Optimizer (EO). The EO is a computer-based system for controlling, stabilizing and optimizing industrial processes. Due to its optimization technologies the software helps to make the best operational decisions accurately and consistently at all times. EO provides advanced process techniques, including linear and non-linear model predictive control, fuzzy logic and neural networks.
- An average annual improvement of 0.5 kWh/t cement while keeping structural properties of the cement
- Furnace efficiency (operational efficiency) > 90% on annual basis: achieved with a permanent monitoring and evaluation of the furnace efficiency with the energy management system

Sources: Environmental Reports CEMEX up to 2019; Expert Optimizer for cement, see https://new.abb.com/cement/cement/systems-and-solutions/advanced-process-control/abb-ability-expert-optimizer-cement

Implementation Case Study – Reduction in CO2 emissions and fossil energy consumption at the CEMEX cement plant in Rüdersdorf (continued)

Figure 6: Mass share of Secondary Fuels in the CEMEX cement plant in Ruedersdorf/Berlin.

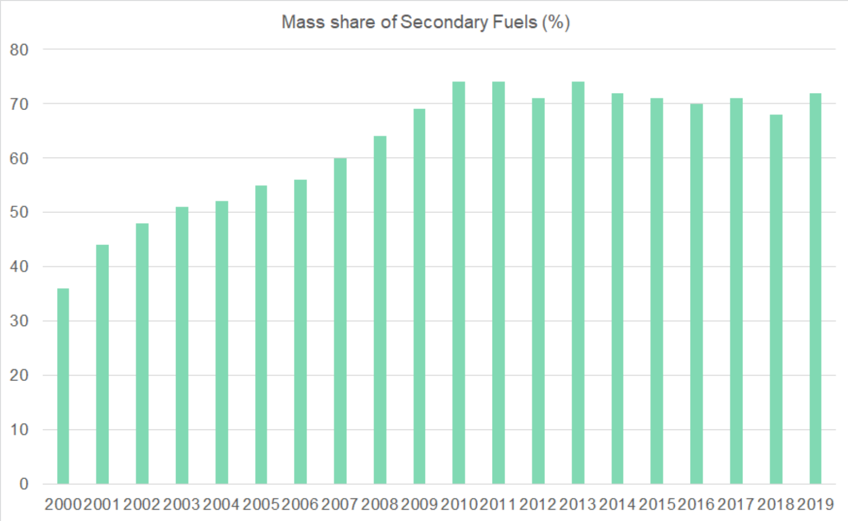
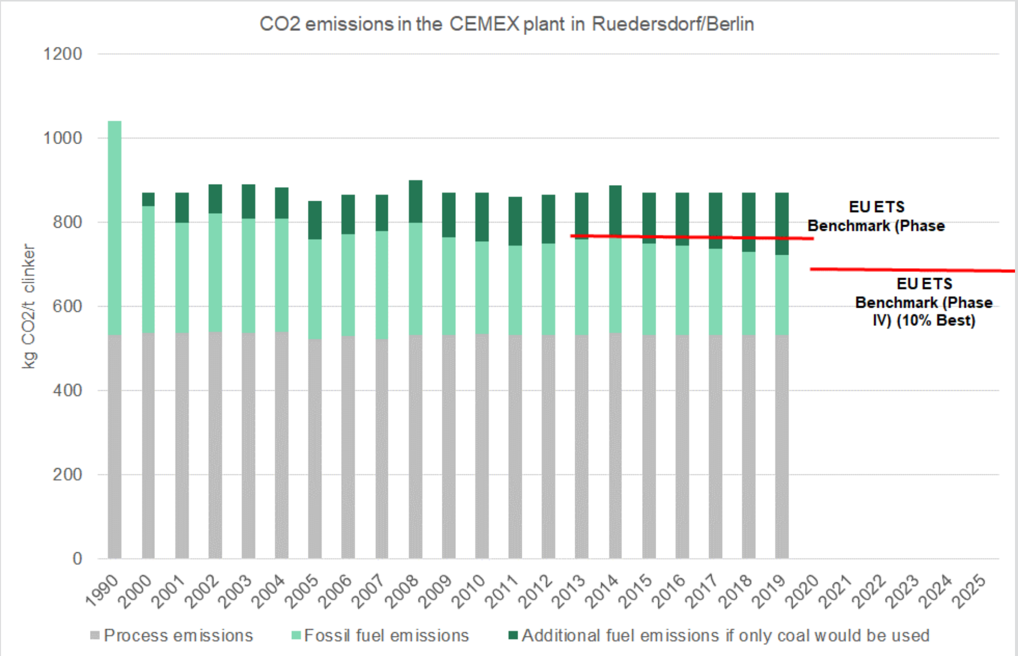


Figure 7 CO_2 emissions in the CEMEX cement plant in Ruedersdorf/Berlin.



Sources: Environmental Reports CEMEX up to 2019 (https://www.cemex.de/ueber_cemex/nachhaltigkeit/umweltschutz)

Implementation Case Study – Utilising industrial excess heat from paper mill for district heating at the Stora Enso Maxau (SEM) paper mill

Part of the industrial process waste heat from the Stora Enso Maxau (SEM) paper mill on the Rhine will in future be used for the district heating supply in the city of Karlsruhe (Stadtwerke Karlsruhe 2020) (1). The Maxau Mill of Stora Enso in southwest Germany produces supercalendered paper and deinked pulp primarily from recovered paper with an annual capacity is 530 000 tonnes (paper) and 270 000 tones (Stora Enso 2021) (2). Karlsruhe's district heating network is one of the largest in Germany with over 600 MWth heat supply capacity and a network length of over 180 kilometres (VfW 2021) (3). More than 90% of Karlsruhe's district heating is already supplied by industrial excess heat and from combined heat and power (CHP) plants. The main suppliers are the mineral oil refinery Oberrhein (MiRO) and the Rhine harbour steam power plant of Energie Baden-Württemberg AG. The refinery and excess waste from industrial process that would otherwise be lost for the district heating supply.

Photo source:

Stora Enso Maxau (SEM)

The project to integrate excess heat from the paper as another feed-in source started in beginning of 2020. To supply the paper mill with process steam and electrical energy, the SEM has a fluidised bed boiler, which runs on more than 80 per cent biomass, with associated steam turbines in operation. The turbines are used in combined heat and power (CHP) and condensing operation. The current construction of a new, highly efficient turbine will result in further CHP potential in the future. The two partners SEM and the local utility want to make this available for the heat supply in the future. This will lead to an avoidance of 10,000 tonnes of CO_2 emissions per year (Stadtwerke Karlsruhe 2020). SEM's new steam turbine and new heating condenser, around 40 tonnes of steam per hour can be used in CHP operation to supply heat. This is to be conducted via a new, approximately two-kilometre-long connecting pipeline from the paper mill to the existing district heating pipeline.

Sources:
(1) Stadtwerke Karlsruhe (2020). Prozessabwärme der Papierfabrik wird zu Fernwärme. https://www.stadtwerke-karlsruhe.de/de/presse/meldungen/2020/20200123.php

(2) Stora Enso (2021). Maxau Mill. https://www.storaenso.com/en/about-stora-enso/stora-enso-locations/maxau-mill

(3) VfEW (2021). Karlsruhe heizt mit Fernwärme aus Abwärme und KWK. https://www.vfew-bw.de/magazin/waerme/karlsruhe-heizt-mit-fernwaerme-aus-abwaerme-und-kwk/

Implementation Case Study – Intelligent Energy Management at the Ceramics producer Adolf Gottfried Tonwerke GmbH

The family-owned SME company Adolf Gottfried Tonwerke GmbH extracts and refines clay and other raw materials for the ceramic and clay processing industries in Großheirath, Bavaria. the company is running an Energy Management System EMS according to ISO 50001 since 2014. It was actively involved in the Energy Efficiency Network Franconia*. For the achievement, the company received the dena energy efficiency award 2019, together with Orcan.

Following the successful implementation of initial energy efficiency measures, the company pursued the goal of extending the use of waste heat, which had already been implemented in production, to the firing processes as well. The focus was on two rotary kilns for firing the clay. With as few changes as possible to the existing process, the high waste gas temperatures generated there were to be made usable.

A suitable solution was offered by the cooperation with Orcan Energy AG. The company, which specializes in ORC (Organic Rankine Cycle) plants, took over the planning and implementation of the ORC module. Due to its flexible behavior, the module can react to fluctuating heat quantities within seconds and achieves high efficiency in the conversion of heat to electricity even at partial load. In addition, the ORC module is characterized by a second high-temperature circuit and can thus also generate higher temperatures in the waste heat stream. A technical challenge in the project was the integration of the ORC plant into the existing rotary kiln system. Thus, an additional exhaust gas heat exchanger had to be installed on the exhaust gas stream of furnaces 1 and 2. A high dust content in the exhaust gas complicated the situation. The solution was finally provided by an exhaust gas heat exchanger specially designed for this application. Its operation enabled the ORC solution and ensured a reduction in the load factor of the intake air fan, saving an additional 15 kW of energy. The savings achieved are demonstrated by an integrated control system that continuously measures the electrical power generated.

Energy efficiency measures:

- ORC (Organic Rankine Cycle) plant for conversion of waste heat to electricity.
- Installation of a special heat exchanger for waste gas with high dust content
- Dust/ash separation and piping construction.

Savings achievements:

- Reduction in electricity consumption: 304,000 kWh/yr.
- CO_2 reduction: 181 t/year
- Reduction of over 50,000 euros in electricity costs for the company

*Concerning the Energy Efficiency Network Franconia:

Together with a total of 14 industrial customers, the energy supply company E.ON joined forces with another electricity provider Bayernwerk to launch the learning energy efficiency network "Franken vernetzt sich" (Franconia interlinks) in mid-2016. With reference to the base year 2015, the companies wanted to jointly improve their energy efficiency by 5% and reduce their CO_2 emissions by 6%. After three years, the quite ambitious goals were even exceeded. In total, 113 energy efficiency measures were implemented by the companies, saving around 13,700 MWh of energy and 5,400 t of CO2 annually. In the three years of network operation, the companies improved their energy efficiency by a total of 5.5%. CO_2 emissions were reduced by 7.1%. The Network continued in 2020 ("Franken vernetzt sich II"), by fixing another of 7000 MWh for the time period 2019-2022.

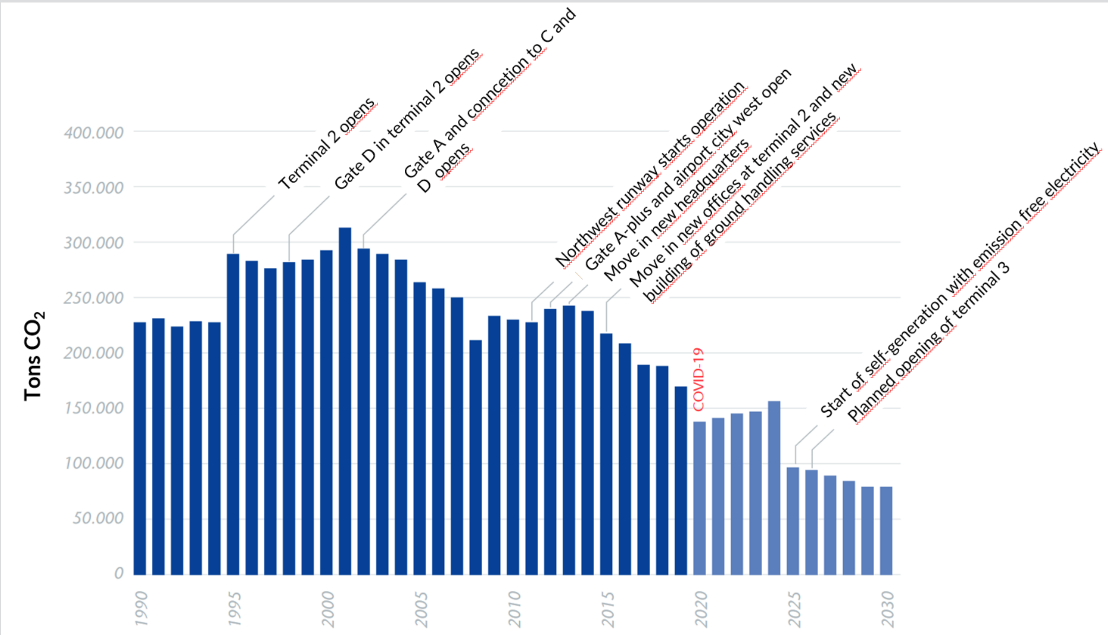
Sources: dena 2019 and Initiative Energy Efficiency and Climate Networks 2021.

Implementation Case Study – Intelligent Energy Management Frankfurt Airport

Fraport decided in the 1990ies to introduce an externally validated environmental management system. Frankfurt airport was first certified according to EMAS in 1999. It continuously followed up and improved its environmental and energy management. Furthermore, Frankfurt airport is certified according to the Airport Carbon Accreditation that aims to lead European Airports to carbon-free operation. For Frankfurt,

Fraport aims to reduce emissions to 80 000 t/CO2/a in 2030. This is a reduction of 65% compared to 1990. By 2050, Frankfurt airport shall operate carbon free (i.e. without compensation required).

Figure 8: Historical and planned emissions Frankfurt Airport. Source: Fraport 2021. Author's translation



A critical tool to achieve these ambitious goals is transparency. Fraport carried out a detailed review of the energy conservation potentials at Frankfurt Airport in 2011/2012 supported by Oeko Institute Darmstadt. Subsequently, they introduced a detailed controlling of energy consumption and CO_2-emissions in 2013 and energy management in 2014. Data is reported monthly at the level of individual processes, installations or buildings. This allows Fraport to identify potentials to increase energy efficiency and to evaluate the effectiveness of measures implemented. At the same time, progress towards the goals can be continuously tracked. Since its introduction in 2013, the controlling system enabled savings of 112 000 Mwh (or roughly 16% (2019)) mainly electricity, district heating and cooling through the implementation of diverse technical and operational measures.

For further savings, Fraport identified four key levers:

LED lighting	Energy efficient buildings	Renewable generation	Vehicle fleet
▪Change of conventional lighting to LED	▪energy efficient refurbishment and construction ▪optimized AC and ventilation based on simulation model.	▪2020 first PV plant started operation ▪planned generation 1.5mio kWh/a ▪Analysis of wind potential ▪renewable power purchase agreements	▪Electrification of car fleet and special purpose vehicles ▪Investigation of alternative fuels

Sources: Fraport 2020a, Fraport 2020b.

Energy Taxes

Objectives of the programme

In Germany, an **ecologically motivated tax reform,** which was implemented in 1999, increased the energy tax rates and newly introduced electricity taxation. Taxes are a tool to internalise so called externalities – in the case of energy consumption, this refers to negative environmental consequences of burning fossil fuels i.a. CO2-emissions. The taxation of energy use increases the price of energy and thereby sets economic incentives for energy conservation and rational use of energy. Thereby overall energy consumption and the associated emissions should be reduced.

The tax revenue can be used to fund other topics. In Germany, revenues from the ecological tax reform were used to subsidise the pension system for reducing the employer share of levies on wages. This was intended to foster economic development and stimulate the labour market.

Several **exemptions** that reduce the effective tax rate exist with the aim of a) avoiding undue burdens on industry and consumers or b) fostering the use of relatively environmentally favourable energy carriers or transport modes.[20]

Design of the programme

The laws for energy taxation and electricity taxation prescribe differentiated tax rates by energy carrier and by utilisation (Table 5). Inter alia renewable energy and certain energy intensive processes (Table 6) are exempt from the tax. Reduced rates apply for forestry and agriculture, public railways, liquid natural gas, natural gas for transport utilisation.

Table 3: Tax rates before and after ecological tax reform

Energy carrier		before 01.04.1999	EnergieStG since 01.08.2006
gasoline	EURO/1 000l	501.07	654.50
diesel	EURO/1 000l	317.00	470.40
Light heating oil	EURO/1 000l	40.90	61.35
Heavy heating oil	EURO/1 000kg	15.34/28.12	25.00
Natural gas (for heating)	EURO/MWh	1.84	5.50
Coal (for heating)	EURO/GJ coal		0.33
electricity	EURO/MWh		20.50
Source: modified from UBA 2021b			

[20] Further information: https://www.zoll.de/DE/Fachthemen/Steuern/Verbrauchsteuern/Energie/energie_node.html

Table 4 Production processes that are completely exempt from energy and/or electricity tax

Processes*	Electricity tax	Energy tax
Thermal waste treatment		X
Eletrolysis	X	
Production of* -glass -ceramics -tiles -cement -lime	X	X
Metal production and processing	X	X
Chemical reduction processes	X	X
*selection. Incomplete list.		
Source: own illustration based on § 51 EnStG and § 9a StromStG		

Enterprises from the manufacturing sector can furthermore benefit from the **tax peak compensation scheme**[21]**.** It aims at protecting the international competitiveness of German energy intensive production. It reduces the tax rate except for a reasonable base contribution. The refund is calculated based on a comparison of the increased amount of energy and electricity taxes paid due to the ecologic tax reform with the reduction in the employer's payments to the pension system. 90% of the exceeding amount are eligible for refund.

The tax refund is subject to three conditions that need to be fulfilled:

1. The electricity tax paid exceeds the basic amount of 1,000 Euro respectively 750 Euro for energy tax.
2. Applicants are required to introduce and follow up on an energy management system according to DIN EN ISO 50001 or an environmental management system according to EMAS. SMEs can alternatively carry out an energy audit according to DIN EN 16247-1 or implement an alternative energy management system. The aim is to limit the administrative burden for smaller companies.
3. The manufacturing sector as a whole has to reduce its energy intensity by a specified percentage. For refund applications in the years 2018 to 2022, the target value is 1.35% annually from 2016 onwards (base years 2016-2020). Previously, the target value was 1.3% starting in 2013.

Conditions 2. and 3. address the issue that reduced taxes - which lead to lower effective energy cost (all else equal) - carry the risk of weakened incentives to increase energy efficiency. The requirements to introduce an EMS and for the sector as a whole to reduce its energy intensity, serve to foster energy efficiency in the manufacturing sector despite reduced energy prices.

Results of the programme

[21] German: "Spitzenausgleich"

The ecological tax reform fulfilled its goal of reducing the cost on labour by supporting the pension scheme (DIW 2019). With a revenue of roughly 38 billion Euro[22] annually, the energy tax is an important contributor to public finances. The environmental impact, however, is rather meagre. Energy tax only contributed to a small degree to price increases between 1999 and 2008 (DIW 2019). Only little emission reductions can be attributed to the ecological tax reform. The projection report 2021 for Germany attributes savings of 0.4 TWh electricity and 1.5 PJ fuel in the industrial sector to energy and electricity tax (year: 2020). For the services sectors, savings are estimated at 2.9 TWh in 2020 (Prognos et al. 2021).

The taxes are criticised for being inconsistent across uses, sectors and with respect to the effective tax rate per t CO2 eq. (DIW 2019; FOES 2016, 2017). Furthermore, exemptions and reductions, in particular for industry, are set up for review. They should be more specifically targeted at those companies that are threatened in international competition and be better aligned with climate policy goals (Expertenkommission Energie der Zukunft 2021). The coupling of the tax peak compensation scheme with measures to foster energy efficiency is seen positively. Nonetheless, incentives for improving energy efficiency should still be strengthened (FiFo, Fraunhofer FIT, and ZEW 2019).

Despite criticism, taxation remains an important tool. Experts suggest a better coordination of different instruments such as CO_2 pricing and energy taxation both nationally and in the EU. They demand a reform to create a consistent price signal on CO_2 (Expertenkommission Energie der Zukunft 2021)

Energy Taxes and Exemptions in Industry – SWOT-Analysis

Strength – experience from programme	**Weakness – experience from programme**
▪ Established instrument that has led and still leads to energy conservation ▪ Revenue can be used to further foster climate protection or to support other goals	▪ Taxes are not designed consistently which causes distortions within and among heating, electricity and transport ▪ Tax rate per CO_2-content varies largely ▪ Many exemptions. More specific design required to align with climate targets and provide reductions only where necessary ▪ Effective tax rate in real terms decreased over time deflating the incentive to conserve energy
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ Reduction of energy tax and replacement with a CO_2-based instrument ▪ Price corridor for CO_2 improves incentive since stable and increasing price level is beneficial for investment decisions	▪ Price based instruments are not sufficient to overcome all barriers for energy efficiency such as e.g. informational barriers ▪ Separate support for infrastructure, future technologies or education of skilled personnel are required

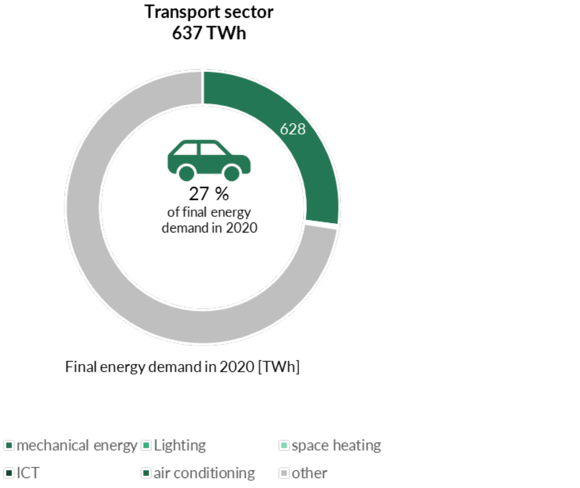
[22] https://www.zoll.de/DE/Fachthemen/Steuern/Verbrauchsteuern/Energie/energie_node.html

3.5 Energy Efficiency in Transport

3.5.1 Fact Sheet on Measures for Energy Efficiency in Transport

Transport by end-uses and relevance for energy demand in Germany

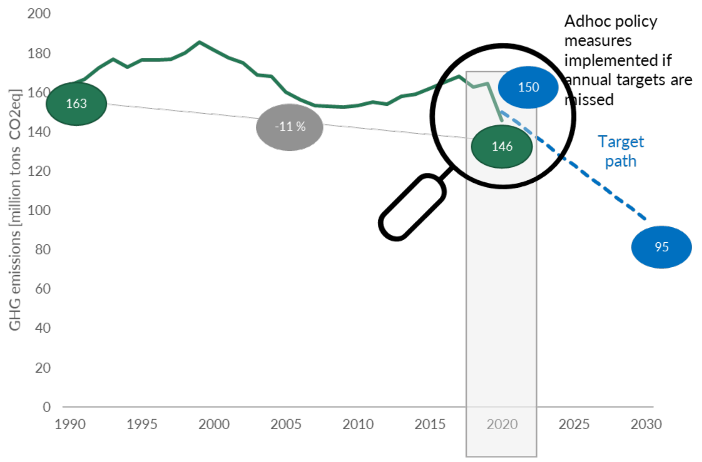
Energy demand of transport can be defined as energy needed for mainly mechanical energy in transport. Other energy uses specified in the graph only account for minor contributions. Following this definition, the transport sector accounts for 27 % of total final energy demand in Germany.



Source: Own compilation based on (BMWi 2021c)

Development of GHG emissions and target path

GHG emissions of the transport sector have been reduced by 11 % to 146 Mt CO2eq in the period 1990 to 2020 but with an increasing trend from 2015-2019. The 2020 sector target for 2020 was achieved, but only due to Covid impacts. The Climate Change Act defines permissible GHG emissions of 95 million tons by 2030 with annual minimum reduction steps. Therewith, the transport sector has achieved the lowest reduction of GHG emissions of all demand sectors since 1990.



Source: Own compilation based on (UBA 2021b)

Transport – Energy Policy SWOT-Analysis

Strength – current set of policies

A comprehensive set of transport policies comprising standards for light and heavy vehicles (European-wide harmonised), taxation and pricing schemes, quota for renewables shares in transport as well as modal shift policies:

- EU CO_2 standards for passenger cars and light commercial vehicles LNF
- Vehicle tax differentiated more strongly according to the CO_2-emissions of cars
- CO_2 pricing in the heat and transport sectors
- EU CO_2 standards for heavy-duty vehicles
- Development of renewable fuels and national implementation RED II: Adjustment of greenhouse gas quota
- Modal shift policies (mostly at urban and regional level)

Weakness – policy improvement

- CO_2 limits based on average fleet emissions
- Concessions for heavy vehicles via a weight bonus
- No CO_2 limit values in real-world operation on the road
- No effective efficiency standards and consumption cap for electric cars
- Missing strong policy for modal shift in cities and the regions in order to increase the offer

Opportunities – new policies and policy options

- From 2021, most of the EU climate legislation will be revised, including the CO_2 standards for passenger cars
- Zero emission limit for cars by 2035 in order to achieve climate neutrality by 2050

Threads – barriers and market shortcomings

- Increase in the share of large size cars (SUVs)
- Unclear technology perspectives for heavy goods transport (battery electric, overhead lines, hydrogen)
- Increasing decoupling of CO_2- and energy savings

3.5.2 Case Studies on Policies for Energy Efficiency in Transport

CO_2 Standards for Cars and Light Duty Vehicles

Objectives of the programme

The regulation on CO_2 standards for passenger cars and vans (Regulation EU2019/631) is a central instrument of the EU for the transformation of the transport sector, and as such also a central instrument for the Germany energy transformation. It is intended to ensure that car manufacturers produce ever lower-emission and increasingly electric cars. The CO_2 standards are **fleet limits**, i.e. they apply to the average emissions of a manufacturer's new cars sold within a year, not to the individual car. In this context, purely electric cars are included in the balance with 0 g CO_2/km, which creates an incentive for their production. In 2015, the first mandatory CO_2 fleet limit of 130 g CO_2/km came into force, which manufacturers achieved, but partly by manipulating laboratory test procedure. Between 2016 and 2019, average emissions from new cars rose again as manufacturers pushed sales of ever larger and heavier vehicles with high profit margins. Since 2020, a fleet limit of 95 g CO_2/km applies. If exceeded, penalties of 95 Euro per car sold will be due for each gram above the limit. In 2019, the latest revision of the CO_2 standards stipulated that manufacturers must reduce their fleet emissions by a further 15% by 2025 and 37.5% by 2030, compared to the base year 2021. As part of the Fit for 55 legislative package, the European Commission proposed in July 2021 to revise Regulation (EU) 2019/631, by setting more ambitious CO_2 emission targets for new cars and vans from 2030 onward.

Design of the programme

For the **period 2020-2024**, Regulation EU2019/631 confirmed the EU fleet-wide CO_2 emission targets set under the previous Regulations EC443/2009 and EU510/2011 (95 g CO_2/km for cars and 147 g CO_2/km for vans respectively)[23]. Starting in the **years 2025 and 2030**, Regulation EU2019/631 sets stricter EU fleet-wide CO_2 emission targets, which are defined as a percentage reduction from the 2021 starting points: -15% for both cars/vans from 2025 onwards; -37.5%/-31% reduction as from 2030 onwards for cars and vans respectively. In the Fit-for-55-Package from July 2021, the European Commission proposed to update the targets for 2030 compared to 2021 to -55%/-50% for cars/vans respectively. From 2035 onwards, cars and vans should reach zero emissions. Otherwise, climate neutrality will not be achievable by 2050. All targets are based on EU fleet-wide targets and take into account the average mass of new vehicles registered in a given year for each manufacturer, using a limit value curve. This means that manufacturers of heavier cars are allowed higher average emissions than manufacturers of lighter cars. The curve is set in such a way that the targets for the EU fleet-wide average emissions are achieved. Regulation EU2019/631 also introduced a complex **incentive mechanism for zero- and low-emission vehicles (ZLEV)**[24]. The Commission proposed in 2021 to remove this incentive from 2030 onwards, as those cars then will become the standards. The 2021 proposal of car standards is flanked by a proposed Alternative Fuels Infrastructure Regulation (European Commission 2021j) which shall ensure the availability of the recharging and refuelling infrastructure for the zero-emission vehicles that the strengthened CO_2 standards will bring to the market.

In Germany, the car standards are flanked by two other instruments:

- As of 1 January 2021, a **higher vehicle tax** applies to cars with high fuel consumption that are registered for the first time (BMF 2020). This particularly affects the so-called Sports Utility Vehicles and sports cars with emissions of over 116 g CO_2/km. This is intended to create an incentive to buy more economical cars.

- Also in 2021, the **CO_2 pricing in transport came into force**. Initially, the price for one tonne of carbon dioxide is set at 25 euros, which increased the price of a litre of Super E10 by an average of 7.7 Eurocents and a litre of diesel by 7.6 Eurocents over. The CO_2 price will be raised annually and is expected to reach 55 euros in 2025. Then, the litre of petrol will cost 15 Eurocents and the litre of diesel 17 Eurocents more than at the end of 2020.

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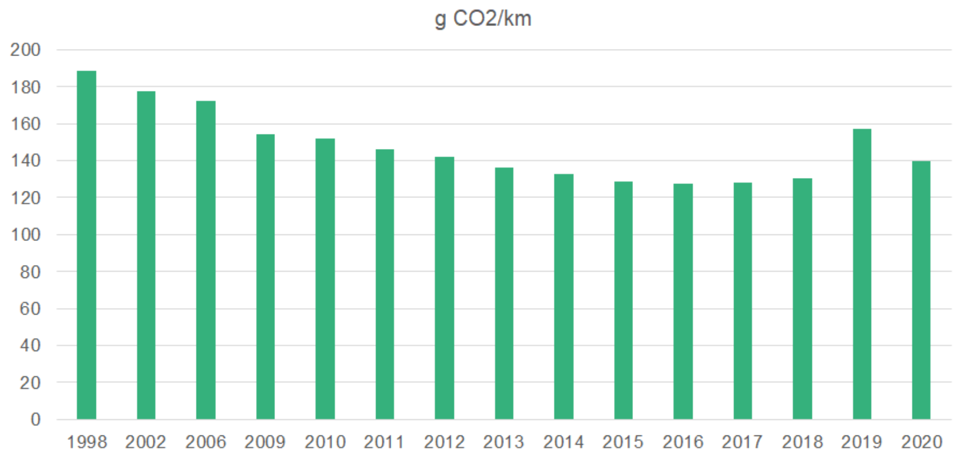
[23] These target levels refer to the NEDC (New European Driving Cycle) emission test procedure (dating from 1997). From 2021 onwards, the emission targets for manufacturers are based on the new WLTP (Worldwide harmonised Light Vehicles Test Procedure) emission test procedure (dating from 2017).

[24] https://ec.europa.eu/clima/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_de

Results of the programme

As a result of the CO_2 standards, CO_2-emissions have been decreasing in 2020 to 136 g CO_2/km in Germany[25] (EEA 2021). The jump in 2019 is due to the introduction of the WLTP measuring cycle (Figure 20). This compares to a European level in average CO_2 emission from new cars in 2020 of 130.8 g CO_2/km (average WLTP emissions) or 107.8 g CO_2/km (average NEDC emissions). Germany's emissions exceed the European average due to the larger size of cars (1.53 t average car weight in 2020 compared to 1.46 t European average).

Figure 9 Average CO_2 emissions of newly registered passenger cars in Germany



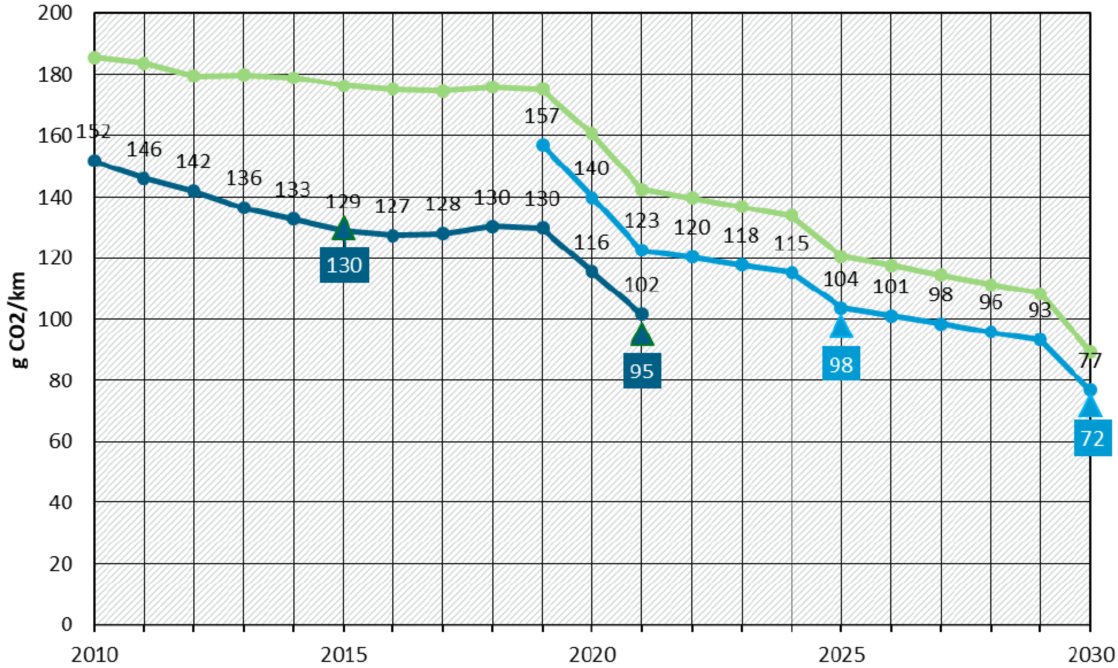
Source: (KBA 2021)[26]

The expected impacts of the CO_2 standards and flanking measures, including Regulation EU2019/631 is presented in Figure 21. The figure shows also the impact of the two measurement cycles NEDC and WLTP, as well as the comparison with real CO_2 emissions. The figure does not yet include the proposed tightening of the CO_2 standards at EU level in the frame of the Fit-for-55 Package up to 2030, and in particular the intended reduction of emissions to zero by 2035.

[25] Average WLTP emissions representing 113.6 CO_{2eq}/km as average NEDC emissions

[26] In the 2018 reporting year, as in the past, the CO_2 values published in the official statistics on new registrations are based on the values determined in the course of CO_2 and fuel consumption measurements in accordance with the New European Driving Cycle (NEDC). However, with the replacement of the NEDC by the Worldwide harmonised Light-duty vehicles Test Procedure (WLTP), which has been applicable for newly approved vehicle types since 1 September 2017 and for all newly registered vehicles since September 2018, comparable NEDC CO_2 values will be calculated for these WLTP CO2 values until the end of 2020 using a correlation method defined by the EU Commission. The underlying data basis for the reporting year 2018 thus includes both measured and correlated CO2 values. From 01/01/2019 onwards, however, only CO_2 values based on WLTP are reported in the official statistics.

Figure 10: Expected CO_2 emissions of newly registered passenger cars in Germany



Source: (Bundesregierung 2021)

Overall, the impact of the measure appears as quite large in transport (Table 7).

Table 5: Expected reduction in emissions from CO_2 Standards for Cars and Light Duty Vehicles

Effect of the mitigation measure (million t CO2eq)	2025	2030	2035	2040
Updating EU CO2 standards for passenger cars and light commercial vehicles (excluding yet additional impacts from the Fit-for-55 Package)	0.98	4.93	9.62	10.37

Source: (Bundesregierung 2021)

CO_2 Standards for Cars and Light Duty Vehicles – SWOT-Analysis

Strength – experience from programme	**Weakness – experience from programme**
▪ Regular decrease in CO_2-emission standards up to 2030 ▪ Measurement cycles which bring the values closer to real-world values (WLTP instead of NEDC measurement cycle)	▪ CO_2 limits based on average fleet emissions (allowing larger cars being compensated by smaller cars) ▪ ZLEV mechanism that mitigates CO_2 limits ▪ Concessions to heavy vehicles via a weight bonus ▪ Crediting of alternative fuels to CO_2 limits ▪ No CO_2 limit values in real-world operation on the road ▪ No effective efficiency standards and consumption cap for electric cars (i.e. car

	weight can be compensated by CO_2-neutral fuel)
Opportunities – perspectives of programme ▪ The proposed revision under the European Fit-for-55 package provides pressure to achieve zero emissions from cars by 2035. ▪ The flanking of CO_2 standards with rising car taxes (annual car tax) and fuel taxes, taking into account CO_2 emissions will further exert pressure to remove fossil fuels from the car markets.	**Threats – barriers and market shortcomings** ▪ Increase in the share of large size cars (SUVs) may not allow energy efficiency targets in transport to be reached.

Vehicle tax: stronger weighting of the CO_2 component for passenger cars

Objectives of the programme

The Seventh Act Amending the Motor Vehicle Tax Act of 16 October 2020 / Siebtes Gesetz zur Änderung des Kraftfahrzeugsteuergesetzes vom 16. Oktober 2020 (Federal Law Gazette I p. 2184 / BGBl. I S. 2184) provides for the CO_2 component for passenger cars registered for the first time in Germany to be weighted more clearly from 2021 by means of progressively graduated tax rates in order to provide a stronger incentive for lower-emission vehicles.

Design of the programme

The CO_2 tax rates cars are of 2 to 4 Euro / g CO_2 per kilometre, which will apply in the range of more than 95 to 195 g CO_2/km, in each case within five equal stages and one stage that is open to the top. The individual stages (per g/km in relation to the CO_2 test values) are structured as follows:

- over 95 up to 115 g/km: € 2.00,
- over 115 up to 135 g/km: 2,20 €,
- over 135 up to 155 g/km: 2,50 €,
- over 155 up to 175 g/km: 2,90 €,
- over 175 up to 195 g/km: 3,40 €,
- over 195 g/km: € 4.00.

The CO_2 values of the WLTP emission test procedure are used, which more realistically depicts the exhaust and consumption values.

Results of the programme

Up to now, the CO_2 tax rate of the motor vehicle tax for passenger cars with combustion engines was 2 Euro/g CO_2 and km above 95 g/km. A higher motor vehicle tax than before results from 1 January 2021 for passenger cars registered for the first time with CO_2 test values from 116 g CO_2/km upwards. After the effects of the tax assessment based on the CO_2 values of the WLTP already introduced in 2018, the new progressive CO_2 tariff will further increase the average annual tax for first-registered passenger cars with combustion engines from 2021 onwards; under the theoretical assumption of a constant composition of first registrations, up to €230 (+60% overall). The vehicle tax affects the costs of car ownership and thus indirectly the choice of propulsion.

Overall, the impact of the measures appears as comparatively small and is decreasing over time, because of the interaction with other measures (Table 8).

Table 6: Expected reduction in emissions from a stronger weighting of the CO_2 component of the motor vehicle tax as of 2021

Effect of the mitigation measure (million t CO_2eq)	2025	2030	2035	2040
Stronger weighting of the CO_2 component of the motor vehicle tax as of 2021	0.29	0.20	0.08	0.09

Source: (Bundesregierung 2021)

Nevertheless, the CO_2 component in the car tax appears as a flanking instrument to car standards (see previous case study) which offers potential in the coming years to accelerate the phase-out of fossil fuels for cars and light duty vehicles.

Vehicle tax: stronger weighting of the CO_2 component for passenger cars – SWOT-Analysis

Strength – experience from programme	**Weakness – experience from programme**
▪ First time introduction of a strongly differentiated vehicle tax for cars ▪ Flanking instrument for other measures in transport such as CO2-standards ▪ Increase for the car owner quite important in relative terms (+60%)	▪ Comparatively small addition to the cost of a car ▪ Cutting of tax increase beyond 195 g CO2/km ▪ Linear increase with specific CO2 emissions ▪ No energy efficiency incentive for electric cars
Opportunities – perspectives of programme	**Threats – barriers and market shortcomings**
▪ The CO2 tax can be further differentiated in coming years to accelerate the transition process ▪ The vehicle tax may be further differentiated to include an energy component	▪ The increasing penetration of large-size electric and other low-carbon technologies in transport could increase energy consumption, if the tax is not designed accordingly

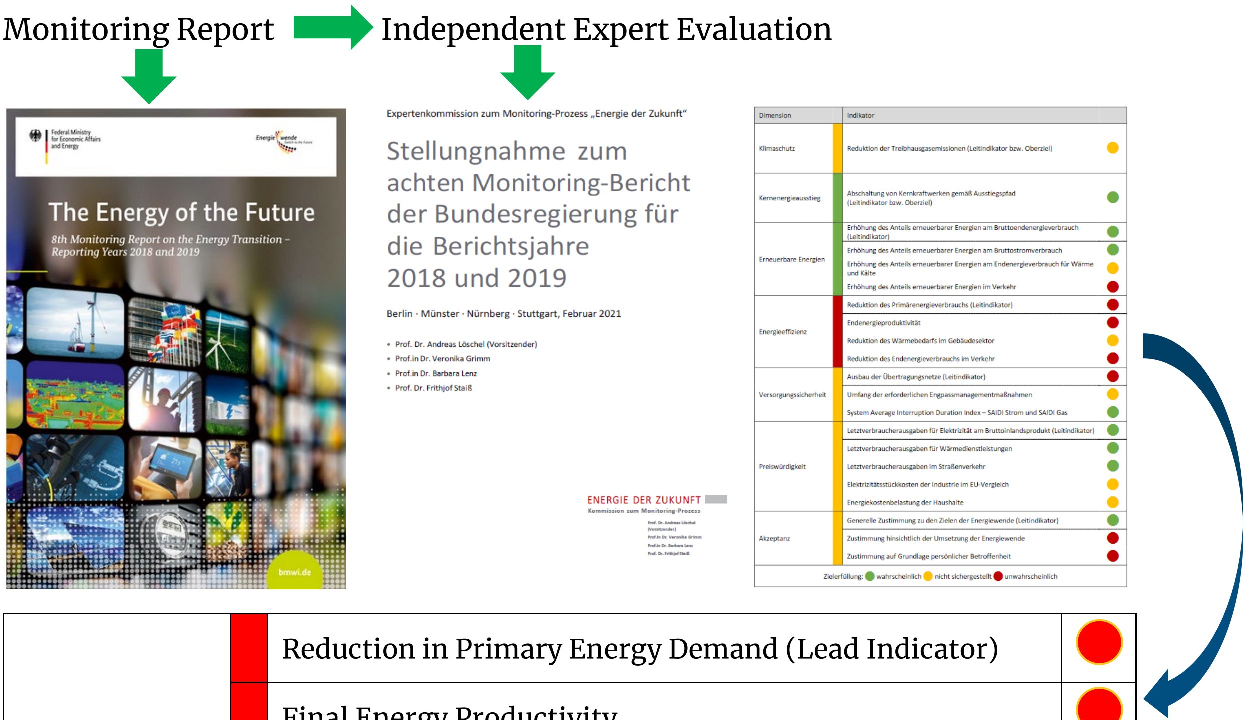
3.6 Best Practice Monitoring and Implementation

Monitoring Report of the German Transition of the Energy System

The Germany Transition of the Energy System is monitored on an annual basis. The Federal Ministry for Economic Affairs and Energy has been appointed lead ministry for the monitoring process for the energy transition. The **Monitoring Report** for each year is approved by the Federal Cabinet and transmitted to the first and second chamber of the Parliament (Bundestag and Bundesrat). Also involved in the process is an independent commission of four renowned energy experts, who provide advice for the drafting process and a **scientific opinion on the Monitoring Report**. Their scientific opinion is published alongside the Federal Government's report. The detailed analyses are translated into simple "traffic light" assessments (Figure 22). Every three years, the Federal Government publishes a Progress Report on the energy transition. The **Progress Report** provides for a wide overview of the energy transition, thus allowing for deeper analysis over a longer period, which makes it possible for trends to be discerned. The report also looks at whether the country is on track to attain the goals and targets set out in the

Energy Concept, and at what additional measures might need to be taken. The annual monitoring report is incorporated into the Progress Report. The latest publications are the 8th Monitoring Report and its expert opinion, and the second Progress Report "Energy of the Future" (BMWi 2021a). The expert opinion is particularly sceptic about the energy efficiency component of the transformation of the energy system, while it is more confident on renewables.

Figure 11 Main Monitoring Report for the Energy Transition in Germany



Energy Efficiency	Reduction in Primary Energy Demand (Lead Indicator)	● (red)
	Final Energy Productivity	● (red)
	Reduction of Heat Demand in Buildings	● (yellow)
	Reduction of Final Energy Demand in Transport	● (red)

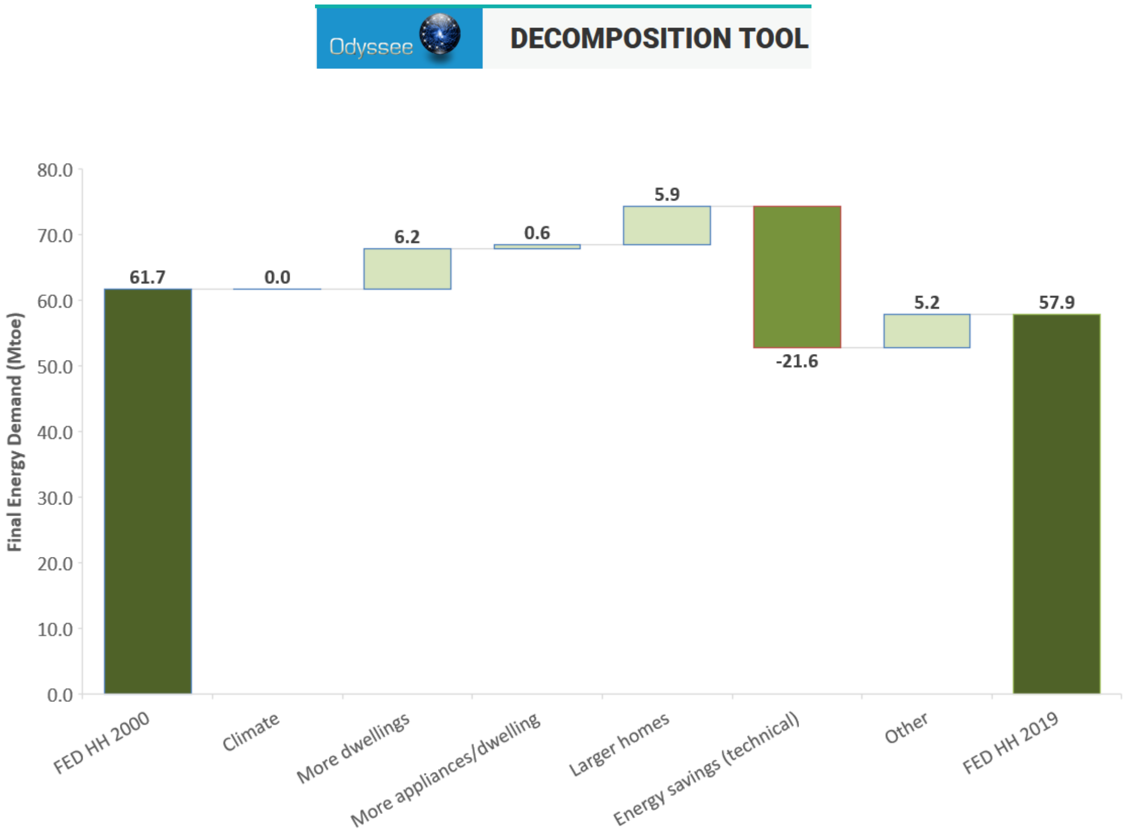
Legend: Target achievement ● (green) likely ● (yellow) not sure ● (red) unlikely

Source: (BMWi 2021a)

ODYSSEE-MURE Project: Analysing Energy Efficiency Trends and Policies

A second important monitoring approach for energy efficiency has been realised in the ODYSSEE-MURE project (www.odyssee-mure.eu), which covers all European countries (including Germany) and energy-uses through a large set of energy indicators and energy efficiency policies. This set of monitoring instruments provides a number of analysis tools such as the **Decomposition Tool** (Figure 23), while helps to understand and interpret changes in energy demand in specific sectors or for specific energy uses on an annual basis.

Figure 12 Decomposition of contributions to the change in residential energy use in Germany



Note: The variation of Household (HH) Final Energy Demand (FED) 2000-2019 is explained by:

- Climatic difference between these two dates ("climate");
- Change in the number of occupied dwelling ("more dwellings");
- Change in appliance ownership ("more appliances per dwelling: electric appliances and central heating");
- Change in average floor area per dwelling ("larger homes");
- (Technical) Energy savings ("gross savings corrected for negative savings due to inefficient behaviour");
- Other effects (mainly change in heating behaviours).

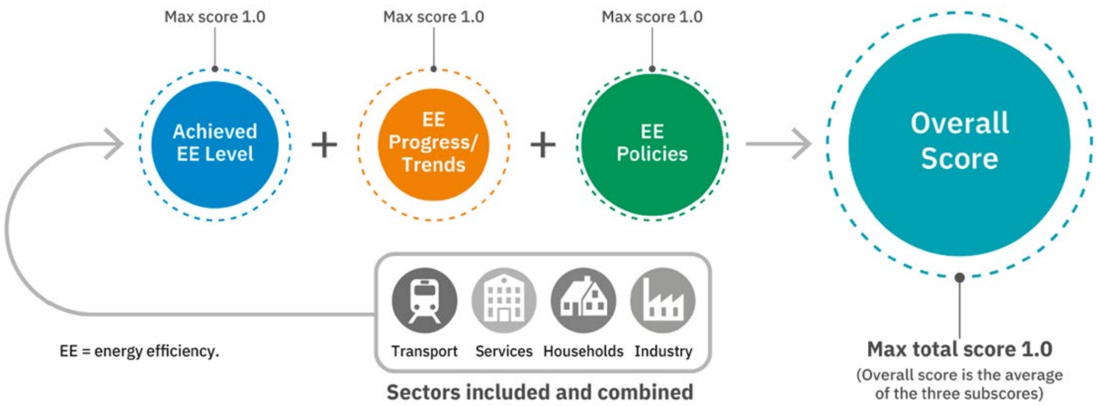
Climatic corrections are made on the basis of national degree days data (Eurostat for the EU).

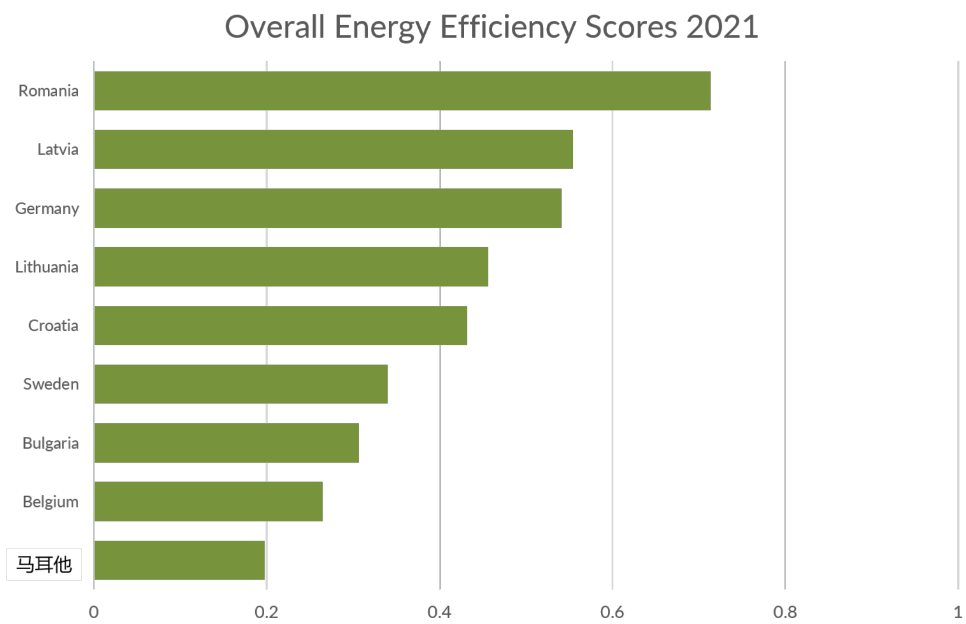
Source: (ODYSSEE-MURE 2021b)

ODYSSEE-MURE Project: Analysing Energy Efficiency Trends and Policies

Another important tool is the **European Energy Efficiency Scoreboard** which ranks countries according to their success in energy efficiency levels, trends and policies (Figure 24).

Figure 13 **European Energy Efficiency (EE) Scoreboard 2021 and Ranking**





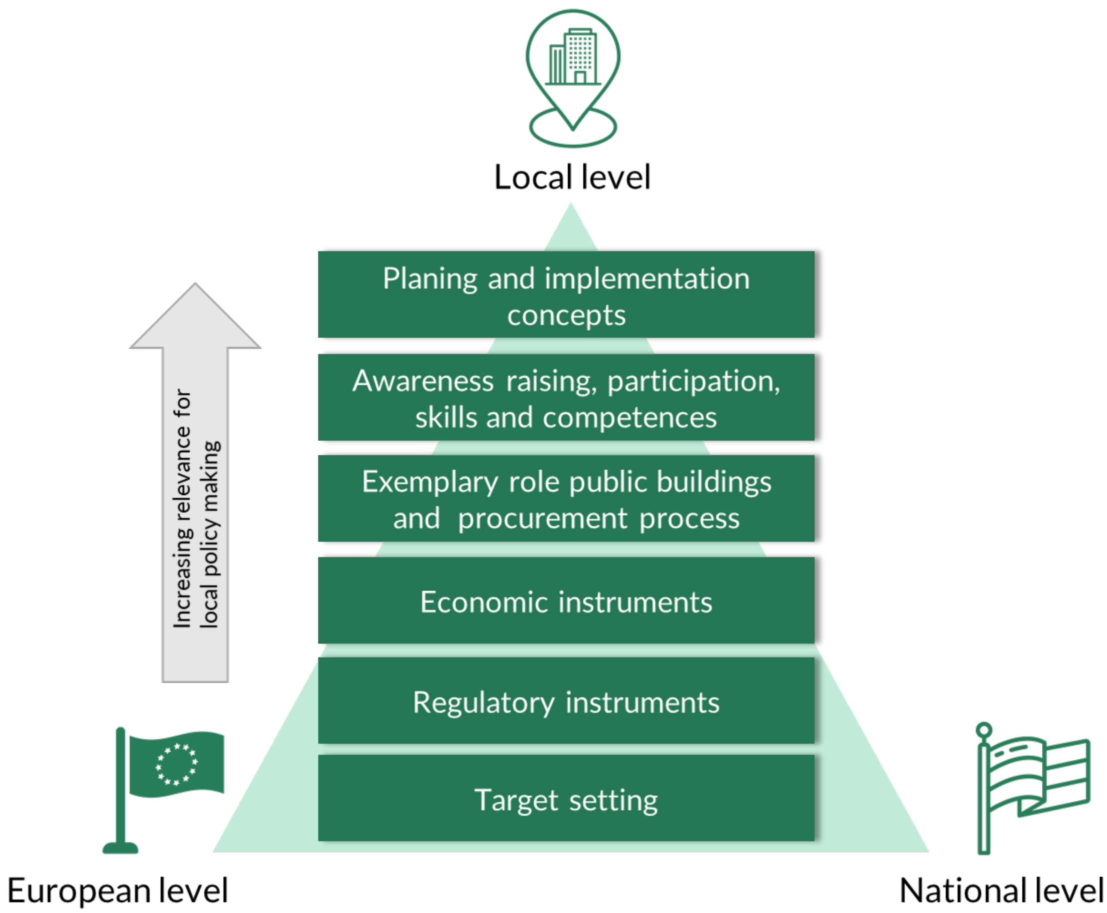
Source: (ODYSSEE-MURE 2021b)

4. Part 3: Local Level and Acceptance

4.1 Local (Municipality/City) Level Policy Making and its Link to National and European Level

Municipalities and local governments are an important actor for implementation integrated energy efficiency and climate protection strategies. Whereas overall target setting and economic and regulatory frameworks are predominately defined on European and national level, energy efficiency policy on local level comprises planning instruments and implementation concepts with detailed potential and scenario analysis for major economic activities and energy consumption of citizen within the administrative area of the respective municipality (Figure 25). Policy and measures addressing information and awareness raising, participation of citizens, and trainings to enhance relevant skills and competences of professionals are also best implemented on local level.

Figure 14: Energy policy areas needed to be addressed on local level



Source: Own depiction IREES based on (Steinbach et al. 2017)

Municipalities also fulfil an exemplary role with their own buildings if ambitious energy efficiency standards are defined and higher renovation rate pursued. Economic activities of municipalities can also influence standards considering the relevance of public contracts for the private sector. Public procurement has an annual volume of about 50 billion EUROS of which 60 % are spent by municipalities (dena 2021). Therefore, an alignment of procurement processes with higher minimum requirements for energy efficiency for products and services is a very effective measure with significant spill-over effects on the total market.

Case Study: Municipal Climate Protection Concepts and Municipal Heat Planning

Municipal climate protection concepts and dedicated climate protection managers in municipalities are funded within the National Climate Protection Initiative of the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety. Since 2008, more than 2600 climate protection concepts and potential analysis have been funded within the program (BMU 2021). Climate protection concepts must identify short-, medium- and long-term targets and measures to reduce greenhouse gas emissions in the respective municipality and thus contribute to the achievement of national climate protection targets at the local level. They will be drawn up with the involvement of all relevant actors and include an energy and greenhouse gas balance sheet, a potential analysis, reduction targets, a catalogue of measures and recommendation for a suitable instrument for controlling and management (BAnz AT 14.08.2020 B7 2020). Concrete projects and measures are developed within the concepts in the areas private households, service sector, industry, municipal institutions as well as mobility and transport (Figure 26).

Figure 15: Components and procedure for the preparation of a municipal climate protection concept

Source: Own depiction IREES

Another planning instrument is municipal heat planning which is considered as essential instrument for achieving not only the targets in building and industry sector but also as prerequisite for overall infrastructure planning. In the state of Baden-Württemberg, municipalities with more than 20 000 inhabitants are obliged to prepare a municipal heating plan.

Municipal heat planning is an instrument used to develop a strategy for the long-term conversion of the heat supply with the goal of climate neutrality. Compared to climate protection concepts, heat planning focuses on heating demand and supply including the local infrastructures such as district heating and gas networks. With regard to the analysis and the underlying data, it requires a higher level of detail. According to the requirements of the Climate Protection Act of the state of Baden-Württemberg, a municipal heat plans comprises the following elements:

- Analysis of heat demand and supply infrastructure
- Potential analysis of renewable energies and waste heat
- Development of climate-neutral target scenario 2040, with intermediate step 2030
- Municipal heat transition strategy with catalogue of measures

Furthermore, the municipal heat plan needs to define at least five measures, the implementation of which is to be started within the five years following publication.

4.2 Distributional Effects of Energy Efficiency Policies

Energy Efficiency and Energy Poverty (Distributional Effects)

Energy poverty is understood as the inability to adequately consume required energy services at affordable cost (Schleich 2019). Currently, about 11% of the EU population cannot afford heating their homes appropriately and about a quarter of people are at risk of energy poverty (BPIE 2014; Pye et al. 2015)

Publications such as Ugarte et al. (2016) describe the relation between low-income status and poor energy performance of dwellings as a vicious cycle because low-income households tend to live in low-priced, non-refurbished buildings, which leads to high fuel costs (Grösche 2010). On top of that, low-income households tend to have fewer financial resources to purchase energy-efficient technologies, as they usually have higher upfront costs than less efficient technologies (e.g. retrofit measures or appliances in top energy classes). Evidence for this pattern was found in several empirical studies for Germany and other EU countries (Schleich 2019).

Low-income households are also more likely to be constrained for credit because they cannot provide adequate collateral. Typically, an unfavourable debt-service ratio prevents them from taking out further loans. In addition, behavioural factors such as debt aversion, risk aversion, loss aversion or impatience may prevent households from adopting energy-efficient technologies (e.g. Schleich et al. 2019; Schleich, Faure, and Meissner 2021). Typically, low-income households are more likely to be debt averse, risk averse, loss averse and impatient.

Energy costs are typically regressive: Low-income households in Germany typically spend a higher share of their income on energy services (e.g. Bach, Harnisch, and Isaak 2018). For example, households in the lowest decile spend on average about 6.5 percent of net income on electricity, but households in the highest decile only spend 1 percent (Bach et al. 2018). However, in contrast to other countries (e.g. France, Romania with high ownership shares), in Germany, the phenomenon of 'poor homeowners' is rare.

Low-income households would especially benefit from cost-effective energy efficiency measures, as those are typically progressive and lead to energy and cost savings in the medium term.

Policies Alleviating Energy Poverty

Ugarte et al. (2016) find only a few policies specifically targeting low-income households in their review of EU Member States' energy efficiency policies. Most policies combine energy audits and low-interest loans or grants earmarked for retrofit measures or boiler replacements while few policies address the replacement of appliances (Schleich 2019).

Attention needs to be paid to the addressed stakeholder, since measures such as low-interest loans or grants for implementing insulation measures or heating systems which only benefit homeowners are likely to be regressive unless specifically targeted at 'poor homeowners'. Similarly, high-income households benefit in particular from tax credits because their marginal tax rate is higher. In general, strongly targeting low-income households specifically limits free riding and can accelerate the take up of energy-efficient technologies.

With the proposal for a new directive on energy efficiency of the European Commission mentioned in section 2.1 and its target to alleviate energy poverty, the mandatory share of energy savings among vulnerable customers and the Social Climate Fund, it can be expected that new policies to address energy poverty will be developed and enforced in the Member States and Europe.

Currently, the German Energy Saving Check programme offers advice to about 50.000 low-income households per year, installs low-cost Energy Efficiency Technologies EETs such as LEDs or connector strips, and offers premiums of up to 150 EUR for the purchase of a refrigerator in the highest energy class. An information programme specifically for financial and legal issues also exists on a federal level in North Rhine-Westphalia called "NRW fights poverty" (Verbraucherzentrale Nordrhein-Westphalen 2021).

Further effective measures for low-income homeowners could be a lowering of interest rates, a longer duration for re-payment of the loan or a larger subsidy (Schleich 2019). Also, low-income households would prefer immediate subsidies to tax credits that are usually received several months later since these stakeholders are less patient.

Another idea are mini-contracting concepts, whereby the energy supplier takes over an investment, financed by a mini-contract credit with a re-payment amount of the size of the saved electricity cost (Luschei, Beckmann, and Schreiner 2016).

Distributional Effects of Energy Efficiency Policies – SWOT-Analysis

Strength – current set of policies	Weakness – policy improvement
First experiences with instruments targeting vulnerable consumer groups: ▪ Financial and legal information campaigns for lower-income households (Verbraucherzentrale Nordrhein-Westfalen, Caritas) ▪ Instalment of low-cost Energy Efficiency Technologies EETs and premiums (Caritas)	▪ free riding if not specified ▪ building-related policies tend to be regressive ▪ few policies focussing on low-income households ▪ mostly neglect behavioural factors ▪ high transaction costs: complex procedure to apply for funding
Opportunities – new policies and policy options	**Threads – barriers and market shortcomings**
▪ Policies targeted at low-income households such as lower interest rates, longer re-payment periods for loans and subsidies ▪ Innovative financing instruments with involvement of different stakeholders ▪ Mandatory fixed rate of energy savings by vulnerable groups (EU)	▪ investor-user dilemma ▪ budgetary constraints ▪ lack of information ▪ low refurbishment rates ▪ split incentives

4.3 Social Acceptance

Reaching a high level of awareness, understanding and acceptance about the importance of energy efficiency and associated policies in society at large and amongst concerned stakeholder groups of more specific policies is crucial to ensure the compliance needed to achieve the potentials of these policies and minimise the energy efficiency gap.

The general acceptance for the energy transition amongst the German population is quite high. According to the annual survey "energy transition barometer" of the German Federal Development Bank, the self-stated readiness to act as well as the share of households that indeed have energy-efficient or renewable energy technologies in their homes has been increasing steadily over the past years. However, concrete measures in the immediate vicinity are often hampered by NIMBY effects (Not In My Backyard). The construction of wind turbines or overland power lines, for example, are oftentimes opposed by the local population who might worry about disturbances in the landscape and noise levels (Römer and Steinbrecher 2021).

It has been suggested in several studies that participation measures can help to increase acceptance. In a report of the project KomMA-P, different participation measures in different contexts are evaluated and give different suggestions on how to improve acceptance by letting people participate in decision processes and financial returns, by transparently communicating the local measures and providing compensation. Especially utilities and municipalities are seen as relevant actors to initiate participation processes (Fuchs et al. 2016).

Aspects of acceptance should also be considered for the design of policy mechanisms to ensure that they are being perceived as fair and adequate and will thereby lead to the desired outcomes. For example, Fanghella et al. (2021) conducted demographically representative discrete choice experiments with individuals in three EU countries (IT, SE, UK), in which they investigated the role of self-interest on citizens' preferences for the distribution of costs and of environmental benefits of energy efficiency policies for policy acceptability. They find that for the burden sharing of costs, the polluter-pays rule is the most popular burden-sharing rule and an equal-amount rule the least popular as well as evidence of self-interest (i.e. individuals prefer policies where they benefit more than others and where they pay less than others). However, since preferences might vary regionally, studies on acceptance of different types of policies in Chinese regions should be considered.

Another facet of policies with a certain target group is the potential influence of other actors in their decision-making process. Especially in the context of energy efficiency in buildings, intermediaries such as craftsmen and installers have been found to play an important role in household decision making (Arning et al. 2020). This can be especially problematic because these actors have often been found to prefer technologies that are more familiar instead of innovative sustainable technologies.

Policies should therefore not only target investors themselves but consider further actors in the innovation system with their specific interests and resources. Similarly, it should be assured that the operators of new, energy-efficient technologies in buildings and enterprises accept and are trained in the handling of these technologies, since oftentimes a lack thereof can lead to an inefficient operation and a gap between the expected and real energy savings (Böhm, Schäfer, and Stadler 2019).

5 Literature

AG Energiebilanzen. 2021. *Auswertungstabellen Zur Energiebilanz Deutschland. Daten Für Die Jahre von 1990 Bis 2020.*

Arning, Katrin;, Elisabeth; Dütschke, Joachim; Globisch, and Barbara Zaunbrecher. 2020. *The Challenge of Improving Energy Efficiency in the Building Sector: Taking an in-Depth Look at Decision-Making on Investments in Energy-Efficient Refurbishments. In: Energy and Behaviour. Towards a Low Carbon Future. Amsterdam: Academic Press, S. 129–151.*

Bach, S. .., M. .. Harnisch, and N. Isaak. 2018. *Verteilungswirkungen Der Energiepolitik – Personelle Einkommensverteilung. Endbericht. Forschungsprojekt Im Auftrag Des Bundesministeriums Für Wirtschaft Und Energie, DIW, Berlin.*

BAFA. 2020. *Leitfaden Zur Erstellung von Energieauditberichten Stand 30.11.2020.*

BAFA. 2021. 'Federal Funding Programme for Energy and Resource Efficiency in the Economy (Bundesförderung Für Energie- Und Ressourceneffizienz in Der Wirtschaft): New Programme November 2021, Previously: Federal Funding Programme for Energy Efficiency in the Economy (Bundesförderung Für Energieeffizienz in Der Wirtschaft).' Retrieved (https://www.bafa.de/DE/Energie/Energieeffizienz/Energieeffizienz_und_Prozesswaerme/energieeffizienz_und_prozesswaerme_node.html).

BAnz AT 04.02.2020 B1. 2020. *Richtlinie Über Die Förderung Der Energieberatung Für Wohngebäude(Vor-Ort-Beratung, Individueller Sanierungsfahrplan Vom 28. Januar 2020.*

BAnz AT 14.08.2020 B7. 2020. *Richtliniezur Förderung von Klimaschutzprojektenim Kommunalen Umfeld „Kommunalrichtlinie" Vom 22. Juli 2020.*

BAnz AT 18.10.2021 B2. 2021. *Richtliniefür Die Bundesförderung Für Effiziente Gebäude– Einzelmaßnahmen (BEG EM) Vom 16. September 2021.*

BAnz AT 18.10.2021 B3. 2021. *Richtliniefür Die Bundesförderung Für Effiziente Gebäude– Wohngebäude (BEG WG) Vom 16. September 2021.*

BAnz AT 18.10.2021 B4. 2021. *Richtliniefür Die Bundesförderung Für Effiziente Gebäude– Nichtwohngebäude (BEG NWG) Vom 16. September 2021.*

BEHG. 2019. *Brennstoffemissionshandelsgesetz Vom 12. Dezember 2019 (BGBl. I S. 2728), Das Durch Artikel 1 Des Gesetzes Vom 3. November 2020 (BGBl. I S. 2291) Geändert Worden Ist".*

BFE. 2021. *Competitive Calls for Tenders – ProKilowatt.*

BMF. 2020. *Seventh Act Amending the Motor Vehicle Tax Act (Siebtes Gesetz Zur Änderung Des Kraftfahrzeugsteuergesetzes).*

BMU. 2021. 'Zahlen Und Fakten Nationale Klimaschutzinitiative Des Bundesumweltministeriums'. *Bundesministerium Für Umwelt, Naturschutz Und Nukleare Sicherheit.* Retrieved 26 November 2021 (https://www.klimaschutz.de/zahlen-und-fakten).

BMWi. 2019. *Energieeffizienzstrategie 2050.*

BMWi. 2020. *Kurzanleitung In 7 Schritten Zum Sanierungsfahrplan.*

BMWi. 2021a. *Energieeffizienz Für Eine Klimaneutrale Zukunft 2045 - Zwischenbericht Roadmap Energieeffizienz 2045.*

BMWi. 2021b. *Gesamtausgabe Energiedaten - Nationale Und Internationale Entwicklung.*

Böhm, U. .., M. .. Schäfer, and M. Stadler. 2019. *Energieeffizienz Im Spannungs-Feld Zwischen Anlagentechnik Und Sozialen Akteuren. Hemmnisse Für Den Effizienten Betrieb Komplexer Heizungsanlagen. TATuP. 28/3.*

BPIE. 2014. *Alleviating Fuel Poverty in the EU. Investing in Home Renovation. A Sustainable and Inclusive Solution. BPIE. May 2014.*

Bundes-Klimaschutzgesetz. 2019. *Bundes-Klimaschutzgesetz Vom 12. Dezember 2019 (BGBl. I S. 2513), Das Durch Artikel 1 Des Gesetzes Vom 18. August 2021 (BGBl. I S. 3905) Geändert Worden Ist.*

Bundesregierung. 2021. *Projektionsbericht 2021 Für Deutschland.*

dena. 2021. 'Energieeffizienz in Der Kommune'. *Deutsche Energie-Agentur Dena.* Retrieved 26 November 2021 (https://www.dena.de/themen-projekte/energieeffizienz/oeffentliche-hand/).

Diefenbach, Nikolaus, Britta Stein, Tobias Loga, Markus Rodenfels, and Karin Jahn. 2018. *Monitoring Der KfW-Programme „Energieeffizient Sanieren" Und „Energieeffizient Bauen" 2017.*

DIW. 2019. *Umweltwirkungen Der Ökosteuer Begrenzt, CO2-Bepreisung Der Nächste Schritt. DIW Wochenbericht 13 / 2019, S. 215-221.*

EEA. 2021. *CO2 Emissions from New Passenger Cars (Dashboard).*

European Commission. 2009. *Regulation (EC) No 1221/2009 of 25 November 2009 on the Voluntary Participation by Organisations in a Community Eco-Management and Audit Scheme (EMAS).*

European Commission. 2021a. *A European Green Deal.*

European Commission. 2021b. *Energy Efficiency Directive.*

European Commission. 2021c. *Energy Efficiency First.*

European Commission. 2021d. *Energy Efficiency Targets.*

European Commission. 2021e. *Energy Efficient Buildings.*

European Commission. 2021f. *Governance of the Energy Union and Climate Action.*

European Commission. 2021g. *Proposal for a Regulation of the European Parliament and of the Council on the Deployment of Alternative Fuels Infrastructure.*

European Commission. 2021h. *Transforming Our Economy and Societies.*

Expertenkommission Energie der Zukunft. 2021. *Stellungnahme Zum Achten Monitoring-Bericht Der Bundesregierung Für Die Berichtsjahre 2018 Und 2019. .*

Fanghella, V. .., C. .. Faure, M. C. .. Guetlein, and J. Schleich. 2021. *What's in It for Me? Self-Interest and Preferences for Distribution of Costs and Benefits of Energy Efficiency Policies. Fraunhofer ISI Working Paper Sustainability and Innovation. .*

FiFo, Fraunhofer FIT, and ZEW. 2019. *Evaluierung von Steuervergünstigungen - Evaluierungsgruppe A: Energie-Und Stromsteuer.*

FOES. 2016. *Stellungnahme Zum Grünbuch Energieeffizienz Des BMWI - Marktkräfte Für Energieeffizienz Nutzen.*

FOES. 2017. *Energiesteuerreform Für Klimaschutz Und Energiewende - Konzept Für Eine Sozial- Und Wettbewerbsverträgliche Reform Der Energiesteuern Und Ein Flächendeckendes Preissignal.*

Fraunhofer ISI / Scheuer. 2021. *Will the Fit for 55 Package Deliver on Energy Efficiency Targets? A High-Level Assessment.*

Fraunhofer ISI, Consentec, ifeu, and TU Berlin. 2021. *Long-Term Scenarios for Climate Neutrality.*

Fuchs, D. .., S. .. Gölz, A. .. Graf, T. .. Gumbert, M. .. Klobasa, M. .. Ruddat, and M. Sonnberger. 2016. *Abschlussbericht. Komplementäre Nutzung Verschiedener Energieversorgungskonzepte Als Motor Gesellschaftlicher Akzeptanz Und Individueller Partizipation Zur Transformation Eines Robusten Energiesystems - Entwicklung Eines Integrierten Versorgungsszenarios (KomMA-P).*

GEG. 2020. *Gebäudeenergiegesetz Vom 8. August 2020 (BGBl. I S. 1728).*

Grösche, P. 2010. *Housing, Energy Cost, and the Poor: Counteracting Effects in Germany's Housing Allowance Program. Energy Policy 38 (1), 93–98. .*

GWS. 2020. *Analyse Der Deutschen Exporte Und Importe von Technologiegütern Zur Nutzung Erneuerbarer Energien Und Anderer Energietechnologiegüter.*

Heinrich, Stephan;, Nora; Langreder, Christoph; Thormeyer, Friedrich; Seefeldt, Lars-Arvid; Dr.Brischke, and Martin; Dr.Pehnt. 2019. *Ex Post-Analyse Des Pilotprogramms STEP Up!*

Hirzel, S., B. Sontag, and C. Rohde. 2011. *Betriebliches Energiemanagement in Der Industriellen Produktion.*

IRENA. 2021. *World Energy Transitions Outlook: 1.5°C Pathway.*

KBA. 2021. *Kraftfahrzeug Bundesamt Statistik - Fahrzeuge - Neuzulassungen.*

Kotin-Förster, Sonja, Marian Bons, and Katja Dinges. 2019. *Evaluation Der Wettbewerblichen Ausschreibungen Für Stromeffizienzmass¬nahmen. Anhang III – Internationaler Vergleich.*

Mai, Michael;, Edelgard; Gruber, Natalja; Ashley-Belbin, Anna; Schulz, Anton; Barckhausen, Gunnar; Will, and Jan-Erik Thie. 2017. *Analyse Der Entwicklung Des Marktes Und Zielerreichungskontrolle Für Gesetzlich Verpflichtende Energieaudits – Schlussbericht an Das Bundesamt Für Wirtschaft Und Ausfuhrkontrolle (BAFA).*

ODYSSEE-MURE. 2021a. 'EU Environmental Economic & Social Multi Benefits Efficiency Tool | ODYSSEE-MURE'. Retrieved

26 November 2021 (https://www.odyssee-mure.eu/data-tools/multiple-benefits-energy-efficiency.html).

ODYSSEE-MURE. 2021b. 'ODYSSEE Database'. Retrieved 26 November 2021 (https://www.indicators.odyssee-mure.eu/energy-efficiency-database.html).

Oeko Institute. 2021. 'Viel Mehr Förderanträge Für Energieeffizienz in Gebäuden 2020: Gut Fürs Klima? - Öko-Institut e.V. Blog'. Retrieved 26 November 2021 (https://blog.oeko.de/viel-mehr-foerderantraege-fuer-energieeffizienz-in-gebaeuden-2020-gut-fuers-klima/).

Pause, F., M. Wimmer, J. Kamm, and J. Nysten. 2021. *Das Fit Für 55-Paket: Updates Und Neufassung Der Energieeffizienz-Richtlinie. Green Deal Erklärt.*

Prognos, Öko-Institut, and Wuppertal-Institut. 2021. *Klimaneutrales Deutschland 2045. Wie Deutschland Seine Klimaziele Schon Vor 2050 Erreichen Kann*.

PWC. 2019. *Evaluation Der Energieberatung Für Wohngebäude*.

Pye, S. .., A. .. Dobbins, C. .. Baffert, J. .. Brajković, Grgurev I., R. .. De Miglio, and P. Dean. 2015. *Energy Poverty and Vulnerable Consumers in the Energy Sector across the EU: Analysis of Policies and Measures, Insight_E Policy Report*. London.

Römer, D. .., and J. Steinbrecher. 2021. *KfW-Energiewendebarometer 2021. Große Zustimmung Trotz Corona – Drohende Investitionslücken Bei Einkommensschwachen Haushalten.*

Schleich, J. 2019. *Energy Efficient Technology Adoption in Low-Income Households in the European Union – What Is the Evidence? Energy Policy 125, 196-206.*

Schleich, J., C. Faure and T. Meissner. 2021. *Adoption of Retrofit Measures among Homeowners in EU Countries: The Effects of Access to Capital and Debt Aversion. Energy Policy 139, 112025.*

Schleich, J., X. Gassmann, T. Meissner and C. Faure. 2019. *A Large-Scale Test of the Effects of Time Discounting, Risk Aversion, Loss Aversion and Present Bias on Household Adoption of Energy Efficient Technologies. Energy Economics 80, 377–393.*

SpaEfV. 2013. *Spitzenausgleich-Effizienzsystemverordnung Vom 31. Juli 2013 (BGBl. I S. 2858), Die Zuletzt Durch Artikel 205 Der Verordnung Vom 19. Juni 2020 (BGBl. I S. 1328) Geändert Worden Ist*.

Steinbach, Jan, Eftim Popovski, Tobias Fleiter, Edith Chassein, and Ignacio Bedoya. 2017. *Policy Recommendations to Decarbonise European Heating and Cooling Systems*.

UBA. 2021a. 'Der Europäische Emissionshandel '. *Umweltbundesamt*. Retrieved 26 November 2021 (https://www.umweltbundesamt.de/daten/klima/der-europaeische-emissionshandel#teilnehmer-prinzip-und-umsetzung-des-europaischen-emissionshandels).

UBA. 2021b. *Previous Year's Estimate of German Greenhouse Gas Emissions for 2020*. Dessau.

UBA. 2021c. *Umwelt- Und Energiemanagementsysteme*.

Ugarte, S. .., B. .. van der Ree, M. .. Voogt, W. .. Eichhammer, J. .. Ordonez, M. .. Reuter, B. .. Schlomann, P. .. Lloret, and R. Villarafila. 2016. *Energy Efficiency for Low-Income Households. European Parliament Directorate General for Internal Policies. Policy Department. Report at the Request of the Committee on Industry, Research and Energy (ITRE).* .

VerZ NRW. 2021. *Das Landesprojekt 'NRW Bekämpft Energiearmut'*.

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