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Energiepartnerschaft
DEUTSCHLAND – KOREA

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STUDY

Energy Efficiency in Industry and Buildings in South Korea and Germany

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and Momo Paula Lühmann

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APEE	Anreizprogramm Energieeffizienz (Energy Efficiency Incentive Programme)
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle
BAU	Business As Usual
BDCES	Building Design Criteria for Energy Saving
BECC	Building Energy Conservation Code
BEEC	Building Energy Efficiency Certification
BEG	Bundesförderung für effiziente Gebäude (Federal Funding for Efficient Buildings)
BEMS	Building Energy Management System
BMBF	Bundesministerium für Bildung und Forschung
BMF	Bundesfinanzministerium
BMI	Bundesministerium des Innern, für Bau und Heimat
BMU	Bundeministerium für Umwelt, Natur und nukleare Sicherheit
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur
BMWi	Bundesministerium für Wirtschaft und Energie
DIHK	Deutsche Industrie- und Handelskammer (German Chamber of Industry and Commerce)
DSM	Demand Side Management
EDAC	Energy Data Analysis Center
EDL-G	Gesetz über Energiedienstleistungen und andere Energieeffizienzmaßnahmen (Energy Services Act)
EERS	Energy Efficiency Resource Standard
EEWärmeG	Erneuerbare-Energien-Wärmegesetz (Renewable Energy Heat Act)
EnMS	Energy Management System
EnEG	Energieeinsparungsgesetz (Energy Conservation Act)
EnEV	Energieeinsparverordnung (Energy Saving Ordinance)
EPBD	Energy Performance of Buildings Directive of the EU
EPC	Energy Performance Contract
EPI	Energy Performance Indicator
ESCO	Energy Service Company
ESD	Effort Sharing Decision
EU	European Union
EU EED	Energy Efficiency Directive of the EU
EU ETS	Emissions Trading System of the EU

EVP-G	Energieverbrauchsrelevante-Produkte-Gesetz (Law on Energy Relevant Products)
FEMS	Factory Energy Management System
KDHC	Korea District Heating Company
KEA	Korea Energy Agency
KEPCO	Korea Electric Power Corporation
KfW	Kreditanstalt für Wiederaufbau
KOGAS	Korea Gas Corporation
KRX	Korea Exchange
GDP	Gross Domestic Product
GEG	Gebäudeenergiegesetz (Building Energy Law)
GHG	Greenhouse Gas
HeizkostenV	Heizkostenverordnung (Heating Cost Ordinance)
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
LEEN	Learning Energy Efficiency Network
LNG	Liquefied Natural Gas
LTRS	Long Term Renovation Strategy
MOLIT	Korean Ministry of Land, Infrastructure and Transport
MOTIE	Korean Ministry of Trade, Industry and Energy
MoE	Korean Ministry of Environment
NAPE	Nationaler Aktionsplan Energieeffizienz (National Action Plan on Energy Efficiency)
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
RD&D	Research, Development and Demonstration
PV	Photovoltaic
SME	Small and Medium Enterprise
SOE	State Owned Enterprise
TFEC	Total Final Energy Consumption
TMS	GHG and Energy Target Management System
TPES	Total Primary Energy Supply
UNEP	United Nation Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
ZDH	Zentralverband des Deutschen Handwerks (German Confederation of Crafts)
ZEBC	Zero Energy Building Certification

1 Introduction

In order to keep the Earth's temperature from increasing more than 1.5°C, global CO_2-emissions have to decrease by 55% by 2030 compared to 2018, according to UNEP (UNEP 2019). Both, Germany and Korea have committed to substantially reducing their CO_2-emissions under the Paris Agreement (see chapter 3.1 and chapter 4.1). Energy efficiency, next to renewable energy is the second main pillar of deep decarbonisation in the energy sector and an important element of both countries' energy transition policies.

Energy efficiency also plays a crucial role for simultaneously procuring sustainable, affordable and secure energy. Both Germany and Korea rely more strongly on industry as pillars of their respective economies than the OECD average (Figure 1). They must keep the expenses for energy at affordable levels to maintain their international economic competitiveness. Both countries also rely on energy imports (see chapter 2). Energy efficiency might also help reducing the import dependence and is crucial in order to facilitate a transition to an energy system based on renewables.

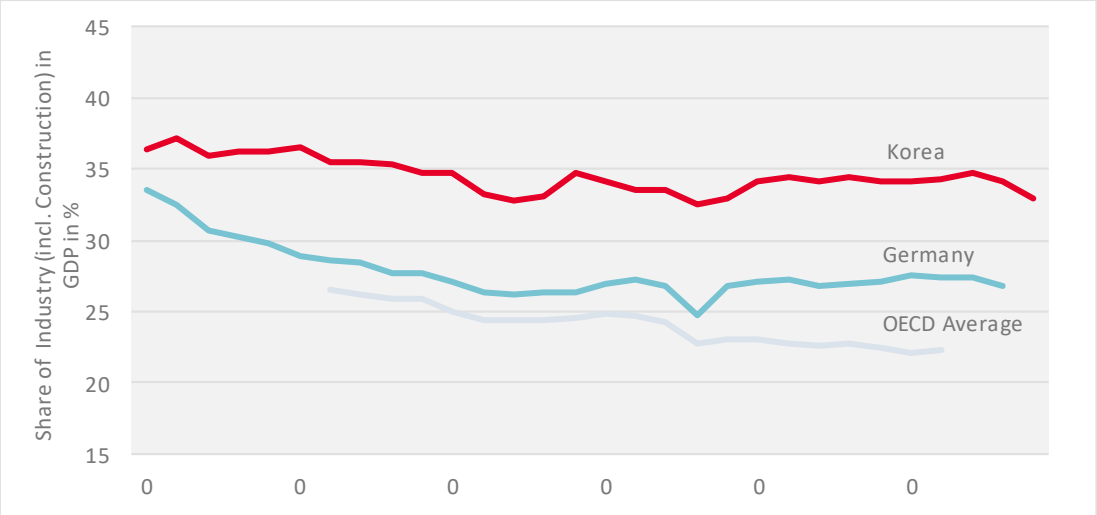

Figure 1: Share of industry (incl. construction) in GDP in Germany and Korea Based on World Bank Database 2020c

Both countries have recognised the significance of energy efficiency in their energy policies. The German Federal Ministry for Economic Affairs and Energy (*Bundesministerium für Wirtschaft und Energie*, BMWi) made *Efficiency First* the core principle of its *Energiewende*. In Korea, the third edition of the Energy Master Plan from 2019 assigns energy efficiency a central role, next to increasing the share of renewable energy sources in the energy mix.

With a focus on the industry and buildings sector, this study gives an overview on the status and objectives of energy efficiency policy in Germany and Korea and compares already implemented and planned measures in both countries. Against this background, it derives opportunities for bilateral collaboration. The study does not make any claim to completeness, but rather seeks to provide an input for discussion between representatives from both countries within the framework of the Korean-German Energy Partnership.

2 Demand and supply in Germany and Korea

Looking at the development of final energy demand from 1990 until present (latest available data is for 2017), Germany and Korea exhibit vastly different trends (Figure 2). Germany's total final energy consumption (TFEC) decreased by 6% between 1990 and 2017. Meanwhile, Korea's TFEC has been on a sharp upwards trend and increased by a factor of 2.8 (iea 2019c). Korea overtook Germany in per capita energy consumption in 2002 (World Bank based on IEA 2020).

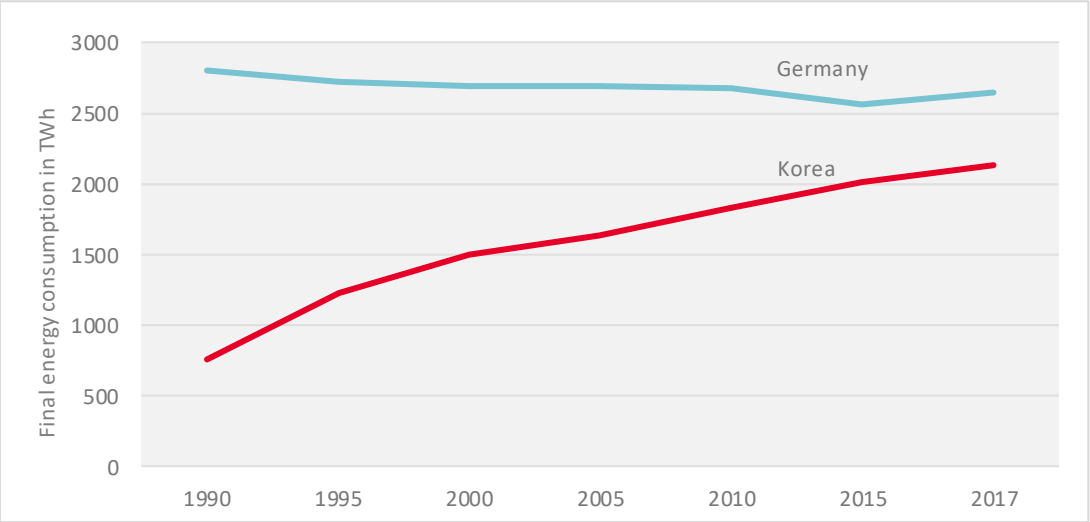

Figure 2: Total final energy consumption in Germany and Korea

Based on iea 2019c

This increase in TFEC did not lead to an increase in energy intensity per unit of GDP in Korea, as the country's GDP rose by a factor of 5.7 over the same period (Figure 3). On the contrary, the country was able to decrease the energy intensity of its economy by 13% between 1990 and 2015. Other OECD countries however managed to decrease it by 30% on average over the same period, indicating that Korea still has room for improvement , (World Bank Database 2020a). Among the 37 OECD countries, Korea has the fifth highest energy intensity (Sung and Birol 2019). Germany's energy intensity is below the OECD average and has sunk by 40% between 1990 and 2015, faster than the OECD average.

In direct comparison, Korea's energy intensity was roughly twice as high as that of Germany in 2018: Germany's energy intensity amounted 3.31 TJ (919.44 MWh)/million USD (2015 PPP) that year while it was 6.76 TJ (1,877.78 MWh)/million USD (2015 PPP) in Korea (Climate Transparency 2019a) (Climate Transparency 2019b).

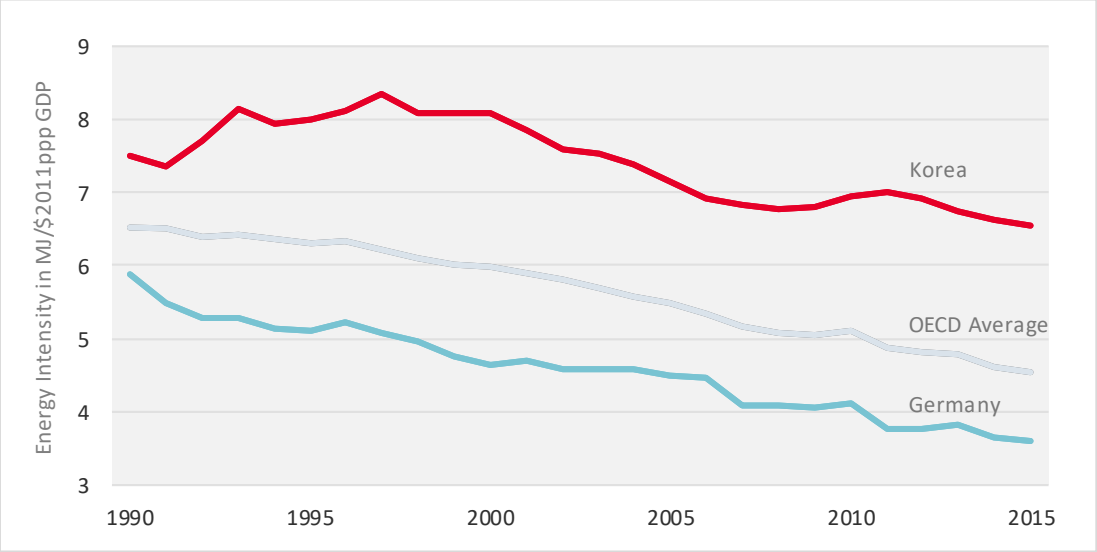

Figure 3: Energy intensity in Germany and Korea

Based on World Bank 2020

The breakdown of the TFEC per sector corresponds to the structure of the two countries' respective economies (Figure 4). In Korea, the shares of final energy consumption by industry and non-energy use together account for 56% of TFEC. In Germany, this share is considerably lower at 35%. The major difference comes from non-energy use of final energy, accounting for 29% of TFEC in Korea. This includes the chemical and petrochemical industry, and Korea's large refining sector has reportedly increased its production of petrochemicals such as ethylene, polyethylene, toluene and benzene (Choi Mun-hee 2020).

For buildings, the situation is reversed: Germany's residential building sector share of TFEC is twice that of Korea, even though it has to be kept in mind that residential living space is also about 50% larger than in Korea (Jiang et al. 2016). Final energy consumption in the commercial and public services and transport sectors does not differ drastically between the two countries.

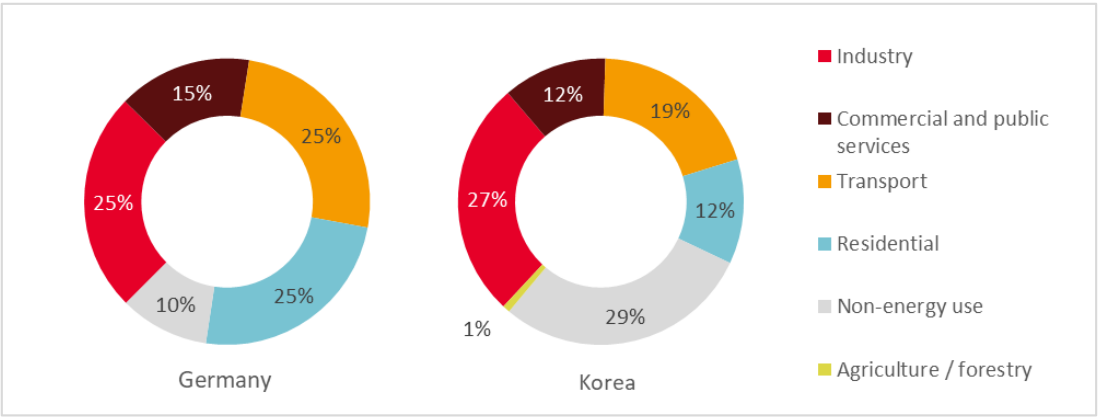

Figure 4: Final energy consumption by sector in Germany and Korea in 2017

Based on iea 2019c

The total primary energy supply (TPES) amounted to 3,512.26 TWh in Germany and 3,361.07 TWh in Korea in 2018, or 2.3% and 2.2% of the World's TPES, respectively. This makes Germany the sixth-largest and Korea the eighth-largest energy consumer (BP 2019).

Oil provides the highest share of TPES for both countries (Figure 5). The higher share of oil in Korea's TPES is partly due to the non-energy use in its large petrochemical sector.

Coal and nuclear supply a larger share of primary energy in Korea than in Germany. These two energy sources have traditionally been the primary energy resource for power production in both countries, but have declined in Germany over the last decade. Both are to be phased out in Germany following political decisions in the course of the last decade: nuclear by 2022 and coal by 2038. Both have also already lost in importance. Nuclear has shrunk by more than half since 2006 (iea 2020d). The share of coal in the German power mix shrunk more recently, from around 45% of total in 2015 to under 30% in 2019 (Fraunhofer ISE 2020). This was primarily due to a decrease in wholesale power prices, an increase in CO_2 certificate prices under the EU Emissions Trading System (EU ETS), and coal's limited load following ability. Korea also plans to reduce the share of coal and nuclear energy in electricity production until 2030 compared to 2017 from 45.4% to 36.1% for coal and 30.3% to 23.9% for nuclear energy (MOTIE 2017). Nuclear energy is to be gradually phased out as the lifespans of existing reactors will not be extended and no new reactors will be built (MOTIE 2019b).

Natural gas consumption has been increasing in both countries. Germany today uses around one-third more natural gas than in 1990, owing especially to its use in the power sector (AGEB 2020a). In Korea, the use of natural gas increased by a factor of 15 in the same time span (iea 2019c). By natural gas consumption, Germany and Korea currently stand at places 8 and 14 in the world, respectively (BP 2020). Korea is also the world's third-largest importer of liquefied natural gas (LNG) behind its neighbours China and Japan (BP 2020).

Hydro, wind, solar, biofuels and waste together account for around 15% of Germany's TPES (iea 2020d). Combined, renewables accounted for 42.1% of total power generation in Germany in 2019 (UBA 2020d). In contrast, only around 3% of Korea's TPES and 8% of the power mix were produced by renewable energy sources in Korea in 2017 and 2018, respectively (MOTIE 2018; iea 2020e).Both countries are dependent on energy imports, but in Korea's case, this issue is extreme as it imports 95% of its TPES (Sung and Birol 2019). Germany has had a steady TPES self-sufficiency rate of around 40% since the late 1990s, owing primarily to domestic coal production and a rising share of solar and wind electricity in the power mix during the last decade (iea 2020d).

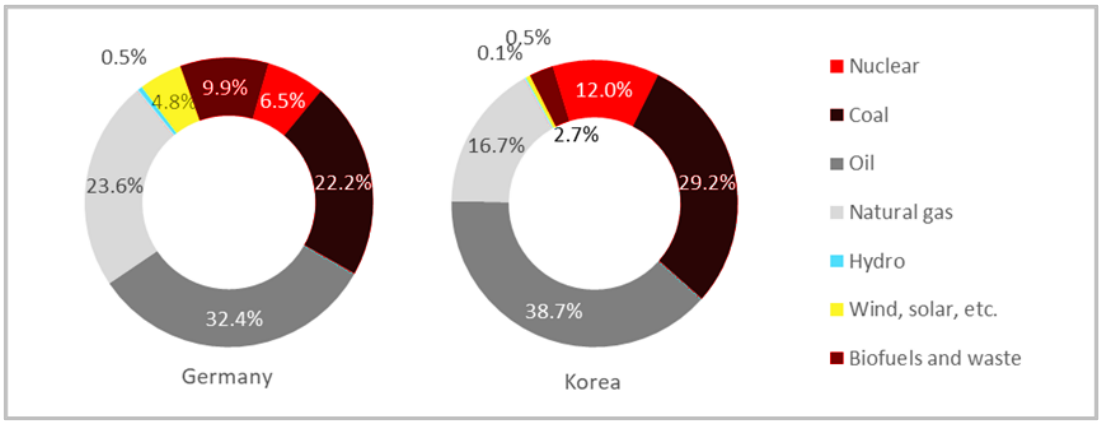

Figure 5: Primary energy supply by source in Germany and Korea in 2018

Based on iea 2019c

3 Energy efficiency in Germany

3.1 Energy efficiency strategy as part of climate and energy policy

With its 2030 climate and energy framework and the 2050 long-term strategy, EU policy sets the framework for Germany's energy policy. Under the Paris Agreement, the EU's current GHG emissions reductions pledge stands at 40% by 2030; as part of the EU's **Green Deal**, increasing the reductions to 50% - 55% has been proposed. By 2050, the EU aims to be climate neutral. These goals are to be achieved by a combination of bottom-up and top-down measures. On one hand, EU strategies and directives such as the **Energy Efficiency Directive (EU EED)**, the **EU Heating and Cooling Strategy**, the **Energy Performance of Buildings Directive (EPBD)** and the **Ecodesign and Energy Labelling Directive** regulate a wide range of areas relevant to energy performance and efficiency. On the other hand, the EU ETS, covering the power sector and energy intensive industries, and the effort sharing decision (ESD), covering the rest of the GHG emissions, lay out the total emissions reduction pathway for each member state. Germany is to reduce its GHG emissions, which fall under ESD by 38% by 2030 compared to 2005. In addition to emissions reductions targets, the EU 2030 targets specifically address energy efficiency and set a collective improvement target of at least 32.5% (European Commission 2018).

In November 2016, the German government adopted the **Climate Action Plan 2050** (*Klimaschutzplan 2050*) which maps out Germany's overarching climate goals: Germany's objective is to become extensively GHG-neutral by 2050, with the interim target of lowering the GHG emissions by 55% by 2030 on the 1990-basis. The plan specifies the action areas and sector targets for 2030 for the power sector (emission reduction goal of 61%-62%), industry (49%-51%), buildings (66%-67%) and transport (40%-42%), agriculture (31%-34%) as well as for forestry and land-use (BMU 2016). The *Klimaschutzplan 2050* further lists measures to be implemented and establishes a process for monitoring and adjusting the policies and measures (BMU 2020).

The **Climate Action Programme 2030** *(Klimaschutzprogramm 2030)*, passed in October of 2019, substantiates the climate protection goals and measures set by the Climate Protection Plan 2050, laying out a broad package of both sector-related and cross-cutting instruments (Bundesregierung 2019). Most importantly, the programme introduces a national CO_2 levy starting with 2021 for transport and heating sector, which is to transition into an emission trading system after 2026 as a complement to the existing EU ETS. The *Klimaschutzprogramm 2030* also introduced an important governance feature: in the case of a sector failing to meet its CO_2-emissions reduction targets, the ministry responsible for it has to elaborate a set of immediate measures to bring it back on track within three months of confirmation of emissions data by an expert commission. To this end, a monitoring system is to be implemented. The **Climate Protection Act** *(Klimaschutzgesetz)*, passed in October of 2019, anchors the most important elements of the Climate Action Programme 2030, including its annual reduction targets, into law (Bundestag 2019).

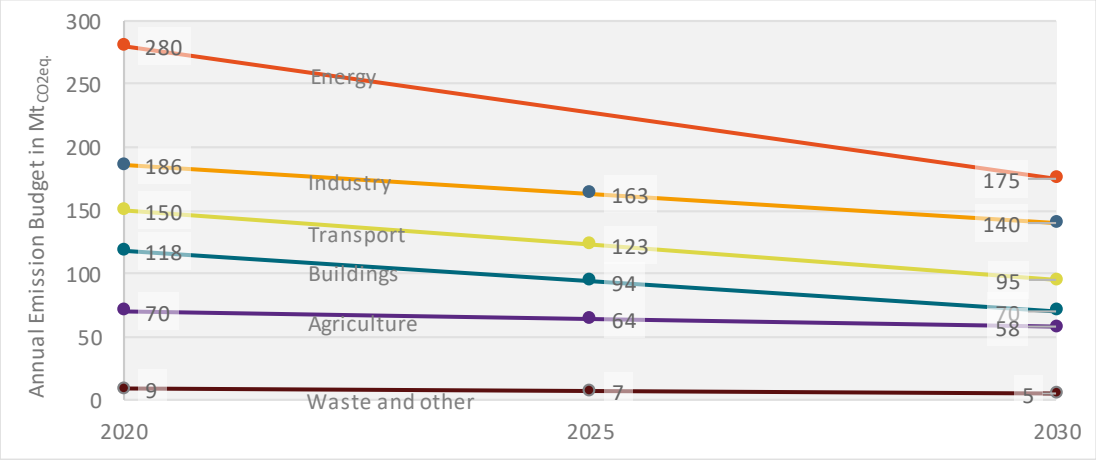

Figure 6: Annual emission budgets as defined in Climate Protection Act

Based on Bundestag 2019

Energy efficiency is indispensable for reducing GHG emissions. Germany has acknowledged this by making *Efficiency First!* a core principle of its energy transition next to renewable energies and sector coupling (BMWi 2019c). Responsibility for energy efficiency is shared among different German federal ministries. The BMWi is primarily in charge of the energy efficiency policy in the industrial sector. The Federal Ministry for Environment, Nature Conservation and Nuclear Safety (*Bundeministerium für Umwelt, Natur und nukleare Sicherheit*, BMU) is responsible for energy efficiency for end-use applications such as home appliances. The Federal Ministry of the Interior, Building and Community (*Bundesministerium des Innern, für Bau und Heimat*, BMI) as well as the Federal Ministry for Economic Affairs and Energy are responsible for energy efficiency in buildings. The Federal Ministry of Transport and Digital Infrastructure (*Bundesministerium für Verkehr und digitale Infrastruktur*, BMVI) is responsible for energy efficiency in the transport sector. The Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung*, BMBF) is in charge of funding RD&D activities, including on energy efficient technologies and concepts. In addition, the Federal Ministry of Finance (*Bundesfinanzministerium*, BMF) is involved in fiscal and tax policies, including those addressing energy efficiency. Several funding programmes are coordinated by the Federal Office for Economic Affairs and Export Control (*Bundesamt für Wirtschaft und Ausfuhrkontrolle*, BAFA) and by the German state-owned development bank (*Kreditanstalt für Wiederaufbau,* KfW) (iea 2020d).

The **Energy Concept** from 2010 sets the primary energy reduction target of 20% by 2020 and 50% by 2050 compared to 2008 (BMWi 2010) (Table 1). The Energy Concept additionally specifies sector-specific energy consumption targets. Power consumption is to decrease by 10% by 2020 and 25% by 2050 compared to the 2008 level. Final energy consumption for heating is to sink by 20% by 2020 and primary energy demand in buildings by 80% by 2050 compared to the 2010 level and the renovation rate should increase to 2% p.a.[1] The transport sector is to cut its final energy consumption by 10% by 2020 and 40% by 2050 compared to the 2005 level. Other sectors, most notably in industry, are not assigned sector-specific energy consumption targets (despite industry having a GHG emissions reduction target under Climate Action Plan 2050, see above).

[1] In addition, the Energy Concept from 2010 also specifies targets for the share of renewable energy in the total primary energy consumption and in the electricity mix

Table 1: Germany's energy consumption and efficiency targets

Category	Current status	Target		
		2020	2030	2050
Total primary energy consumption (vs. 2008)	-12% (2019) (AGEB 2019)	-20%	-30%	-50%
Gross electricity consumption (vs. 2008)	-6.7%* (2019) (BMWi 2020j)	-10%		-25%
Primary energy demand in buildings (vs. 2010)	-18.8% (2017) (BMWi 2019f)			-80%
Primary energy consumption for heating (vs. 2008)	-17% (2018) (AGEB 2020b)	-20%		
Primary energy demand (non-renewable) buildings (vs. 2008)	-21,2% (2018)** (AGEB 2020b)		-55%	
Buildings renovation rate	~1.0% p.a. (2017) (DIW 2019)	Doubling of renovation rate: 1.0% → 2.0% p.a		
Transport final energy consumption (vs. 2005)	+4.6%* (2018) (UBA 2020a)	-10%		-40%

*Preliminary data, including transmission losses and own consumption

**Counts heating, cooling, lighting, and hot water, excluding energy from renewables, district heating, and electricity.

Own calculations based on sources stated in the table. Target information from BMWi (2010).

The **National Action Plan on Energy Efficiency** (*Nationaler Aktionsplan Energieeffizienz*, NAPE) from 2014 lays out a total of 33 measures designed to meet the targets from the Energy Concept, covering sectors industry (incl. trade and services), buildings and private residences. The measures were based on information & communication campaigns, financial incentives and regulation. NAPE also outlined further work processes for all sectors including transport (BMWi 2014). Germany's public financial support for energy efficiency between 2016 and 2020 amounted to 17 billion EUR (iea 2020d). However, as Table 1 shows, the energy savings fell short of their targets.

To close the gap, a revamped NAPE has been developed, called NAPE 2.0. Together with the Roadmap Energy Efficiency 2050, it forms the **Energy Efficiency Strategy 2050**, published in 2019. The strategy keeps the 2050 goal of a 50% primary energy consumption reduction based on 2008 levels, and adds a 2030 goal of 30% reduction. Sector-specific energy consumption reduction targets from the Energy Concept are not repeated, as the Climate Action Plan 2050 and the Climate Protection Act already specify the necessary yearly sectoral emissions reductions targets and stipulate that additional measures are to be implemented should these not be achieved (see above).

NAPE 2.0 lists a total of 43 sector-specific measures for the period 2021 – 2030: 17 for buildings, 13 for industry, 12 for transport and one for agriculture (BMWi 2019c). Seven further measures are crosscutting. Special attention is given to heat and cooling demand in different sectors, as these account for almost half of the entire final energy demand in Germany. These measures are based on the Climate Protection Programme 2030 from 2019, on a consultation process initiated by the **Green Paper on Energy Efficiency from 2016** as well as on the

Energy Efficiency Strategy for Buildings from 2015.[2] For the period 2020 – 2024, federal funding of around **4.3 billion EUR** will be available annually for all support programmes in the field of energy efficiency (BMWi 2019c).

The second part of the Energy Efficiency Strategy 2050 is a broad dialogue process called *The Roadmap Energy Efficiency 2050*. It is to be started in 2020 in order to determine the exact role energy efficiency will play in reaching long-term climate goals as well as a socially, politically and economically viable pathway to a 50%-reduction of primary energy consumption. The dialogue between experts, consumers and civil society is to take place in working groups for the sectors industry, buildings (incl. trade, services and residential buildings) and transport, as well as for the overarching topics of digitisation and workforce. A final paper will be developed which will identify the challenges and propose concrete actions (BMWi 2019c).

In June 2020, the German federal government passed the **Building Energy Act,** consolidating various existing laws into a single set of rules governing the energy requirements of new and existing buildings, including energy efficiency and use of renewable energies for heating and cooling.

Following an EU requirement to submit a national renovation strategy to the EU Commission, the German government adopted its **Long Term Renovation Strategy (LTRS)** in June 2020. It includes a roadmap for achieving the energy and climate objectives for the national building sector, including measures for supporting energy renovation of the national building stock. The LTRS envisions a reduction in the consumption of non-renewable energy in buildings by 55% by 2030, compared to 2008. The strategy also states that Germany will set its milestones for 2040 and 2050 once the necessary decisions have been taken at national and European level (Bundesregierung 2020b; BMWi 2020b).

In 2017, the Federal government spent around 1.01 billion EUR on research, development and demonstration of modern energy technologies. Around 80% of the funds were invested in research on renewable energies and energy efficiency. Energy research in Germany is broadly based and interlinked and includes numerous measures also including energy efficiency in industry and buildings. The government supports research and development in the field of future-oriented energy technologies and solutions, for instance, through the **Energy Research Programme**, which currently in its seventh phase (BMWi 2018).

The government's policy instrument mix aims to improve energy efficiency in buildings, products and appliances, industry and transport. It encompasses financial incentives, taxation, regulation, information and consultation as well as funding of research and development. This study concentrates on the industry sector and the buildings sector, including residential as well as non-residential buildings and will describe measures in these sectors in the following chapters.

[2] The Energy Efficiency Strategy for Buildings integrates the areas electricity and heating and outlines existing and planned measures for increasing energy efficiency and renewable energy in buildings.

3.2 Energy efficiency in industry

Industry plays a crucial role in Germany's economy. Value added from manufacturing and industry including construction accounted for 19.4% and 26.8% of Germany's GDP in 2019, respectively (World Bank Database 2020d). At the same time, industry is the country's largest final energy consumer, with 35% for energy and non-energy use in 2017 (iea 2020d). Natural gas, oil and electricity dominate the final energy consumption in industry with respective shares of 29%, 28% and 25% in 2017 (iea 2020d). Process heat accounts for two-thirds of final energy consumption in industry. Mechanical energy, used to operate motors or machines, accounts for around a quarter of consumption, while space heating only accounts for a small proportion (UBA 2020b). Industry is also Germany's largest electricity consuming sector with 42.9% of total electricity consumption (iea 2020d).

Splitting the final energy consumption by sub-sectors shows that basic metal industry consumed 27% of manufacturing TFEC in 2017, the chemical industry 23%, non-metallic minerals 10%, and paper, pulp and print 8% (iea 2020a). This breakdown excludes non-energy uses, since this approach fits the topic of energy efficiency better. However, especially the petrochemical industry, but also steel and non-metallic minerals manufacturing, consume large amounts of petroleum products for non-energy purposes.

While Germany has some of the highest power prices in the world, the costs for energy only make out about 2% of the gross production costs across the entire industry sector (BMWi 2019c). At the same time, high energy prices also lead to high costs savings potential. As IEA (2019c) notes, the German government has seen energy efficiency as an opportunity to improve the industry's competitiveness in the international context.

Despite that, the government has traditionally avoided regulatory measures to boost energy efficiency in industry. In contrast to buildings and the transport sector (Table 1), the government has also not defined a sector-specific energy efficiency target for industry. Instead, companies are offered extensive support for their voluntary engagement in improving energy efficiency in the form of information campaigns and financial and fiscal incentives, as the following chapters show.

Similar to Germany's climate policy, its energy efficiency policy is shaped extensively by the EU framework, laid out in various EU directives, which must be transposed into national law by all Member States. For industry, the most central piece of EU legislation is the EU EED from 2012.

3.2.1 Regulatory measures and standards

Mandatory energy audits

With its Energy Services Act (*Gesetz über Energiedienstleistungen und andere Energieeffizienzmaßnahmen*, EDL-G) from 2010, Germany transposed the EU EED into national law. It requires all non- small and medium-sized enterprises (non-SMEs) to undergo an **energy audit** every four years. Considered non-SMEs are all companies employing at least 250 people or reaching both 43 million EUR of yearly revenue and 50 million EUR on yearly balance sheet. Exempt are companies with energy consumption of no more than 500MWh over the last 12 months before their audit (de minimis limit), as well as companies with a certified **energy or environmental management system** (ISO50001 or EMAS, respectively).

No formal requirement for implementing the identified energy saving measures exists, but various subsidy schemes and other voluntary mechanisms are available to help the companies with implementation of energy efficiency measures (see chapter 3.2.2 and chapter 3.2.4). In addition, since 2019, the companies are required to report the most relevant identified measures, their expected annual savings and necessary investments to BAFA. This is intended as quality insurance for the energy audits and for providing the BMWi with insights required to develop further the industrial energy efficiency policy.

Infobox: EU Ecodesign Directive and Energy Labels

The **EU Ecodesign Directive** works by setting minimum efficiency requirements for products such as household appliances, information and communication technologies, but also for industrial equipment such as electric motors, substations, air conditioners, pumps, etc. The EU directive was transposed into national legislation in 2008 with the Law on energy-related products (*Energieverbrauchsrelevante-Produkte-Gesetz*, EVP-G). An extension of minimum standards to additional product groups is planned to include further cross-cutting technologies with high relevance for industry such as electric welding equipment, cooling equipment, compressors etc. (BMWi 2019c).

The **EU Energy Label** was first introduced for a number of household appliances in 1994 and expanded to further appliances in 2004. The labels characterise products according to their energy efficiency on a scale from A (most efficient) to G (least efficient). Thereby, they help consumers to consider energy efficiency in their purchase decision. At the same time, the system provides incentives to manufacturers to develop energy efficient products and be ranked in the highest category compared to competitors (European Commission 2020).

3.2.2 Market-based instruments

EU ETS

The EU ETS (see chapter 3.1) has been in place since 2005. Apart from the energy sector, it covers the energy-intensive industries such as chemical, steel, pulp and paper as well as non-iron metals and refineries. Around 900 companies from these branches fall under EU ETS and are responsible for around two-thirds of Germany's overall industrial GHG emissions (UBA 2019). After a period of low prices for emissions allowances between 2013 and mid-2017, these climbed to almost 30 EUR/tCO_2 emitted in 2019 before falling again to around 16 EUR/tCO_2 with the onset of Corona crisis (Bocklet and Hintermayer 2020).

Carbon pricing

Even though the national CO_2 levy, passed as part of the Climate Action Programme 2030 in 2019 (see chapter 3.1), primarily aims at the transport and heating sectors, it will also cover the remaining third of industrial GHG emissions, since it will be applied to gasoline, diesel, natural gas and heating oil. The levy will start at 25 EUR/tCO_2 in 2021 and increase stepwise to 55 EUR/tCO_2 in 2025; in 2026, the CO_2 levy it will morph into a cap-and-trade system with a set price corridor of 55 to 65 EUR/tCO_2 (Bundesregierung 2020a).

3.2.3 Financial support and tax concessions

Grants for energy audits

SMEs, which are not required under the EU EED to carry out periodic energy audits, can receive grants from the BAFA for covering up to 80% of the costs if they perform a voluntary energy audit. The grant is used to cover the energy auditor's fee (BMWi 2020h).

Funding programme Federal support for energy efficiency in the economy

This programme combines and further develops five previously existing funding programmes: highly efficient cross-sectional technologies, climate-friendly production processes, waste heat avoidance and use, energy management systems (EnMS) and process heat from renewables. It is open to all sectors and technologies and support is given via a grant or a low-interest loan with partial debt relief (BMWi 2019c, 2020i). The subsidy rates amount generally to 30%-40% (BMWi 2019b).

Competitive tendering programme

Even higher subsidy rates – up to 50% – are offered via the competitive tendering programme (BMWi 2019b). It addresses innovative, more complex and more ambitious energy saving projects by allocating the funds on a competitive basis. The funding amount which is applied for is put in relation to the expected CO_2 savings; the better the ration, the higher the chances for funding (BMWi 2020a).

Pilot programme Energy saving meters

The aim of this programme is to make energy savings (electricity, oil, gas, biomass, heating or cooling) visible to customers through a before/after comparison based on measurements. Eligible for funding are companies that wish to test efficiency services and smart systems for saving energy at their end customers in private households, trade, commerce and services, industry or others. The subsidy rate is 25%-50% of the project costs (BMWi 2019d).

Reliefs from the renewable energy levy and the electricity and energy tax

Two of the major concessions to the Germany's manufacturing and industry – the relief from the renewable energy levy and from the electricity and energy tax – are based on a company's efforts to improve its energy efficiency. The **partial exemption from the renewable energy levy** (*Besondere Ausgleichsregelung*) is intended to prevent German companies from being undercut by their foreign competitors enjoying lower electricity prices. There are however some conditions. Companies have to be part of certain industry branches and be considered energy intensive based on the ratio between their electricity costs and added value they create. They furthermore have to implement and certify an EnMS according to ISO 50001, an environmental management system according to EMAS, or in some cases, a slimmed-down EnMS developed especially for this purpose.

Companies from the manufacturing sector can also be **relieved from the electricity and energy tax** (so-called *Spitzenausgleich*/ peak compensation). Non-SMEs have to implement and certify an EnMS according to ISO 50001, an environmental management system according to EMAS, or a slimmed-down EnMS to qualify for this exemption. SMEs also have an alternative option to carry out an energy audit instead of implementing a full management system. The *Spitzenausgleich* is furthermore linked to the achievement of pre-set energy productivity improvement targets for the German production industry as a whole.

Currently, over 13.000 German sites are certified under ISO 50001, accounting for around 30% of all certified sites worldwide (ISO 2020).

3.2.4 Information, advice and training

SME initiative energy transition und climate protection

The government is both initiating and supporting various information, communication and consultation campaigns on the topic of energy efficiency for companies. For instance, the *Mittelstandsinitiative Energiewende und Klimaschutz* (SME initiative energy transition and climate protection) helps SMEs to improve their energy efficiency. Organised by the Association of German Chambers of Industry and Commerce (*Deutsche Industrie- und Handelskammer*, DIHK), German Confederation of Skilled Crafts (*Zentralverband des Deutschen Handwerks*, ZDH), BMWi and BMU, the initiative provides support through offering expert information and training (DIHK Service and ZDH 2020).

Initiative Energy Efficiency Networks

Established in 2014 by the BMWi and leading German industry and trade associations, the *Initiative Energieeffizienz-Netzwerke* (Initiative Energy Efficiency Networks) sets itself the goal of starting 500 energy efficiency networks by the end of 2020. Between 8 and 15 companies typically form an energy efficiency network with a duration between 2 and 3 years. The companies conduct energy audits and make use of qualified energy consulting services to identify opportunities for energy savings. Based on these, they each set their non-binding energy savings target, as well as a joint target for the network. They then meet on a regular basis, share their practical experience, and help each other overcome any hurdles for implementing the necessary measures and achieving their targets. Accompanying monitoring has shown that the targets are typically achieved. As of September 2020, around 280 networks have been implemented. Due to extensive efficiency measures taken by the companies, the overall CO_2 savings target of five million tonnes by the end of 2020 might already be achieved with 295 networks. The initiative was recently prolonged until 2025 with the target of establishing another 300 to 350 networks and achieving CO_2 savings of five to six million tonnes (Geschäftsstelle der Initiative Energieeffizienznetzwerke 2020).

Efficiency analysis tools for energy audits

The government also plans to improve the information value of energy audits through the gradual development of a digital database-supported online system that provides industry-specific information. Free access to the databases will enable energy consultants and energy managers to formulate company-specific efficiency measures for each audit (BMWi 2019c).

Qualification offensive for energy consultants in the area of efficient use of renewable energies for process heat supply

Replacing fossil fuels for industrial heat production with electricity from renewable energy sources requires a high level of expertise. In its Energy Efficiency Strategy 2050 (see chapter 3.1), the German government announced a qualification offensive for energy consultants for efficient use of renewable energies for process heat supply to start in 2020. Additionally, the government plans to support specific trainings in the field of resource efficiency in order to stimulate innovations and use investments in this area appropriately. Apart from energy efficiency, companies, in particular SMEs, will also be able to benefit from information and consulting services with focus on development and exploitation of innovations in resource efficiency and material substitution (BMWi 2019c).

3.3 Energy efficiency in buildings

Combined, the residential (25%) and commercial sector (15%) make up 40% of total final energy consumption in Germany, consuming 1046.7 TWh in 2017. This consumption is mainly attributed to energy consumption in buildings, with the largest share used for space and water heating (iea 2020d). Natural gas (36%) and electricity (27%) are the main energy sources in the residential and commercial sectors, followed by oil (21%), biomass (10%) and district heating (6%) (iea 2020d). In the trade, commerce and services sectors, space-heating accounts for half of the TFEC. Electricity is the dominant energy source due to high use of lighting and mechanical energy (UBA 2020b). For private households, over 80% of TFEC is used for space and water heating (iea 2020d). The most used energy sources are natural gas and oil. Electricity accounts for around one-fifth of TFEC and is used mainly for process heating (washing, cooking etc.) and cooling (refrigeration, freezing etc.) (UBA 2020c).

In residential buildings, opposing trends have been observed in the last decade. On one hand, a higher total number of households, larger living space and fewer members per household drives the energy consumption higher. On the other hand, this is counteracted by the improved energy standards for buildings as well as renovations of old buildings (UBA 2020c). In addition, winters have generally been getting milder (Deutscher Wetterdienst 2020). All in all, final energy consumption for heating per unit of living space has fallen by around 10% since 2008 (UBA 2020c), and the 5-year average for total final energy demand for heating has been 6% lower between 2013 and 2017 compared to the previous five-year period. In contrast, the commercial sector has seen the average 5-year energy final energy demand rise by 2%, as a consequence of increased economic activity (iea 2020d).

64% of Germany's residential building stock was constructed before the first energy efficiency regulation in 1977 (Bundesregierung 2020b). Next to efficiency standards for new buildings, refurbishing the existing building stock is therefore crucial if Germany wants to achieve an 80% TFEC reduction by 2050 (see chapter 3.1). The current renovation rate of about 1.0% p.a. has been too low and is partly responsible for achieving only around 19% reduction in buildings TFEC by 2019 (compare Table 1 in chapter 3.1). The German government aims at increasing the renovations rate to 2.0% has recently adopted several documents outlining the strategies to achieve this: The Energy Efficiency Strategy 2050, the Building Energy Act and the Long-Term Renovation Strategy (see chapter 3.1).

Germany's buildings energy efficiency policy is also significantly shaped by the EU framework, especially by the EPBD from 2010. Germany's mix of mandatory requirements, standards, financial support measures and information campaigns will be described in the following chapters.

Infobox: Investment and employment effects of energy efficiency in buildings

The energy efficiency in the building sector also is a promising business accounting for the largest share of worldwide energy efficiency investments (approx. 60%) (iea 2019d). In 2017, Germany has invested 46.3 billion EUR to increase energy efficiency in buildings. The increase in investment led to a growing demand of related products and services. The turnovers in the renovation section alone accounted for 76 billion EUR in the respective year (BMWi 2019b). Furthermore, in 2017, the employment associated with the investments for energy-efficient renovation of existing buildings amounted to around 573,000 employees (BMWi 2019c).

3.3.1 Regulatory measures and standards

The Bundestag passed the Building Energy Act (*Gebäudeenergiegesetz*, GEG) in June 2020, bundling all the energy-relevant legislation in a single regulatory act, covering both the energy efficiency and use of renewable energy for the buildings sector. The GEG comes into force on 1 November 2020. It replaces the contents of and formally repeals the Energy Conservation Act (EnEG), the Energy Saving Ordinance (EnEV) and the Renewable Energies Heat Act (EEWärmeG). The GEG also replaces the EnEV as the legislative act that transposes the EPBD into German legislation.

Minimum requirements for energy efficiency

The GEG remains a combination of performative and prescriptive standards, similarly to the EnEV that it replaces. On one hand, it sets a maximum allowed primary energy consumption as 75% of that of a hypothetical reference building (performative) for new buildings as significant refurbishments. On the other hand, it sets requirements for minimum heat insulation of the building envelope as a whole as well as for individual components and parameters such as windows, heat bridges and air tightness (prescriptive). For residential buildings, heating, cooling, hot water and ventilation factor into the primary energy consumption; for non-residential buildings, energy consumed for lighting is also taken into account (Bundestag 2020). In the future, a further shift towards a performative standard is expected, with primary energy consumption as the only criterion. In some cases, a simplified procedure for proving that the building fulfils the requirements can be used instead of the comparison to a reference building in the GEG.

One of the main reasons for introducing the GEG is that the EPBD requires that from 2021 all new buildings fulfil the nearly zero-energy standards. For non-residential buildings owned or used by public authorities this requirement has been in place since 2019. Before the GEG was adopted, the expectation was that a nearly zero-energy standard would be significantly stricter than the then-existing minimum energy performance standard laid out in the EnEV (the aforementioned 75% of the primary energy consumption of the reference building). However, the GEG adopted this same standard as the definition of the nearly zero-energy building. This led to heavy criticism by the energy efficiency community and some NGOs, since in practice, significantly more ambitious building practices have already established themselves on the German market. Controversial is also the so-called innovation clause of the GEG, which according to its critics is a step backwards as it allows substantial deviations from the minimum insulation requirements if the building GHG emissions are reduced in other ways, for example by using low-CO_2 energy sources.

Renewable energy use in buildings

The GEG maintained the binding minimum requirements for the usage of renewable energy in buildings that the EEWärmeG introduced in 2009. They depend on the respective renewable source: The energy consumption must be covered at least 15% by solar energy, 50% by biomass, 30% by biogas or 50% by geothermal energy. Alternatively to the use of renewable energy, the usage of industrial waste heat, district heating or combined heat and power production with a certain efficiency standard is possible (Bundestag 2020).

The GEG also includes some important novelties. Now the requirement to partly cover the energy consumed by renewables can be fulfilled by installing 1kW PV power plant for every 50 m^2 of living space, insofar it is installed close to the building itself. Fuel cells powered with renewable fuels can also contribute to fulfilling the renewable energy requirement. Extra percentage points are awarded if an electric battery is installed next to PV.

Role model function of federal buildings

Public authorities have been designated to play a role model function already under the EPBD from 2010. The Energy Efficiency Strategy 2050 now stipulates that from 2022 onwards, new buildings used by the German federal authorities will have to comply at least with the EH 40 standard, which implies an energy self-sufficiency rate of 40% or better. Additionally, binding renovation targets for the existing federal building stock for 2030 and 2050 will be set by an energy efficiency decree. This requires that all new major renovation and modernisation projects from a date yet to be defined will be based on at least a EH 55 standard (BMWi 2019c).

Heating costs

The **Heating Cost Ordinance** (*Heizkostenverordnung*, HeizkostenV) intends to encourage consumers to save energy by ensuring that a significant proportion of heating costs are dependent on the user's actual consumption rather than being allocated in other ways, for example based on the size of their apartment. The government plans an amendment of this ordinance to incorporate new requirements of the EU EED (in particular consumption information), the interoperability of meter systems and create a more transparent design of billing information (BMWi 2019c).

3.3.2 Market-based instruments

Carbon pricing

The national carbon pricing scheme which starts in 2021, will also cover the heating sector. Through a national emissions trading scheme, the CO_2-emission of fossil fuels used for heating and transport (heating oil, natural gas, petrol and diesel) will receive a price that will gradually increase in the next years (see chapter 3.2.2).

3.3.3 Financial support and tax concessions

CO_2 Building Refurbishment Programme

The CO_2 Building Refurbishment Programme (*CO_2-Gebäudesanierungsprogramm*) consists of the promotional programmes Energy-Efficient Construction and Energy-Efficient Renovation managed by KfW. It provides incentives to house owners, companies, municipalities or social institutions for energy efficient renovation as well as energy efficient construction of new buildings in form of low-interest loans and investment grants. Prerequisite for funding is that the building exceeds the energy efficiency requirements of the GEG (and before that, the EnEV). In January 2020, the funding conditions were further improved; for instance, the repayment grants in the loan programmes increased by 10% - 12.5%. This leads to repayment grants for refurbishments of up to 40%. The maximum loan amount increased by 20,000 to 120,000 EUR (KfW 2020). The higher funding also benefits housing companies offering serial refurbishments based on the *Energy Sprong* principle, where buildings are brought up to the NetZero[3] standard in a digitalised and industrialised construction process in a short time and at affordable costs (dena 2020).

[3] The buildings produce all necessary energy for heating, warm water and electricity by themselves.

Market incentive programme Heating with Renewable Energies

House owners – citizens, companies, municipalities, cooperatives and other organisations – can receive investment grants or low-interest loans for deploying renewable energy systems for heating and cooling under the Market Incentive Programme Heating with Renewable Energies. Funding is available, amongst other things, for solar thermal systems, biomass plants, efficient heat pumps and gas hybrid heating systems, and amounts to up to 35% of the eligible costs. Maximum eligible costs for residential buildings are up to 50,000 EUR and up to 3.5 million EUR for non-residential buildings (BMWi 2020g). Since January 2020, citizens who replace their old oil boilers with a new, energy-efficient and climate-friendly heating system can receive a subsidy of up to 45% of the investment costs (BMWi 2020e). The installation of oil boilers in buildings will no longer be permitted after 2026 (BMWi 2019c).

Energy Efficiency Incentive Programme

In addition to the promotion via the Market Incentive Programme, house owners can receive grants via the Energy Efficiency Incentive Programme (*Anreizprogramm Energieeffizienz*, APEE) for the replacement of old inefficient heating and ventilation systems with modern efficient systems including fuel cell heating systems (iea 2020d).

Heating Optimisation Programme

The Heating Optimisation Programme promotes the installation of modern, highly efficient pumps or the implementation of hydraulic balancing, which optimally distributes building heat. The subsidy amounts up to 30% of the net investment costs (BMWi 2019a). Under the Federal Funding for Efficient Buildings (BEG, below), this will be upgraded with an exchange premium of up to 40% for replacing oil boilers with new, more efficient heating systems (BMWi 2019c).

Federal Funding for Efficient Buildings (*Bundesförderung für effiziente Gebäude,* BEG)

The BEG bundles the existing investment promotion programmes in the building sector into a single, comprehensive programme and optimises their content. The funding amount was increased and entitled recipients expanded (BMWi 2019c). The BEG includes the Market Incentive Programme, CO_2 Building Refurbishment Programme, APEE and parts of the Heating Optimisation Programme.

Heating Network Systems 4.0

This pilot programme promotes planning and construction of highly innovative multivalent heating networks for the environmentally friendly and efficient provision of heating and cooling using renewable energies or unavoidable waste heat (BMWi 2019c).

Urban Energy Renovation

The aim of the KfW support programme Urban Energy Renovation is to promote climate protection and adaptation in inner-city districts including energy-related refurbishments.

Tax concessions for energetic building refurbishments

Since January 2020, individual measures to improve energy efficiency and heating with renewable energies implemented on owner-occupied housing have been tax-deductible. These include replacing a heating system, installing new windows or insulating roofs and external walls. For these measures, 20% of the expenses (maximum 40,000 EUR per residential property) are deductible from the income tax. In the case of energy-related construction supervision and specialist planning up to 50% of the costs are tax-deductible. The tax subsidy can be claimed as an alternative to the existing subsidy from the investment programmes of BAFA or KfW (BMWi 2020f).

3.3.4 Information, advice and training

Energy efficient construction and renovation consulting

In addition to the aforementioned financial incentives, KfW offers financial support with consulting for energy efficient construction for new buildings or for renovation of previously uninhabited and unheated buildings (such as old stables). Along with funding for the construction itself, the KfW supports energy consulting and construction advice by a licensed energy expert with up to 50% or 4,000 EUR (BMWi 2020c). A list of all license experts can easily be found online.

On-site energetic renovation consulting for residential buildings

The government provides 80% of the consultancy fees for on-site energy consulting for residential buildings to identify renovation needs and possible renovation measures and to show how these are financially supported by the government. The energy consultant creates a comprehensible overview of the renovation measures with the individual renovation roadmap (*Individueller Sanierungsfahrplan für Wohngebäude*). It is a software-supported instrument for the step-by-step energetic renovation of buildings. In addition to energy saving potentials and the possible use of renewable energies, the necessary investments are estimated and the savings in heating costs and CO_2-emissions are shown (BMWi 2020e).

Refurbishment calculator

The BMWi's refurbishment configurator is an online tool with which homeowners can receive recommendations for refurbishment options on their PC, based on information about their home (BMWi 2020e).

Energy Checks

The government also promotes energy advice for tenants and flat and house owners via the consumer advice centre. The basic check is free; all other checks cost 30 EUR each. For low-income households all offers are free of charge. Tenants, and private house and flat owners can get a quick overview of their electricity and heat consumption, their equipment and simple ways to save energy in a 1-hour Basic Check. The Building Check is aimed particularly at owners and landlords and complements the basic check with an assessment of the heating system and the building shell. During the Heating Check, the energy consultant will check the heating system and give tips on efficiency optimisation. In the Solar Heat Check, the setting and efficiency of the solar thermal system are checked and recommendations for optimisation are given. The Solar Suitability Check provides homeowners with information on the possibilities of using a solar thermal system for hot water and/or heating and to produce electricity with a PV system (BMWi 2020d). The government also plans to introduce a Heating Suitability Check, which is intended to show building owners which new heating system for their building appears to be the most sensible with regard to the development of energy source costs and possible subsidies from an ecological point of view (BMWi 2019c).

Contracting of expert services

In some cases, consulting an expert is obligatory under the new GEG. For example, when a building is sold, the new owner is required to carry out a free-of-charge consultation carried out by an independent, qualified expert in order get informed on any potential energy savings measures. The costs of this service are borne by the state.

Online tools for efficiency checks

Information and a number of software tools also have been developed to increase the efficiency potential of large air-conditioning and ventilation systems in non-residential buildings, particularly in existing buildings. For instance, the QuickCheck Refrigeration and Ventilation on the BMWi website intends to provide a quick overview of possible savings potential and to stimulate interest in an inspection. The efficiency calculator for air-conditioning and ventilation on the website of the „Federal Office for Energy Efficiency" (*Bundesstelle für Energieeffizienz*) supports energy consultants and inspectors in an in-depth evaluation of systems and, with the help of a national energy label, in communicating with operators (BMWi 2019c).

***Deutschland macht's effizient* Campaign**

Most of Germany's initiatives to distribute information and educate on energy efficiency are part of the campaign of *Deutschland macht's effizient* (Germany Makes It Efficient). It provides a free hotline, which informs consumers of energy efficient behaviour; it launched several influencer campaigns to address a younger audience as well; it operates consumer advice centres and provides support to the Energy Checks initiative explained above. Additionally, this campaign included the National Top Runner Initiative that helped to promote the purchase of energy efficient household appliances by information campaigns, retailer trainings and producer workshops to help innovative product creation (iea 2020d).

Energy efficiency labels for heating systems and boilers

Apart from efficiency labels for new heating systems and boilers as part of the EU Energy Labelling Regulation, the government also introduced a compulsory efficiency label on boilers older than 15 years since 2016 (iea 2020d).

Energy performance contracting

Germany is a leading market for energy performance contracts (EPCs), offered by energy service companies (ESCOs), in Europe. Demand for EPCs has also been enhanced by government initiatives for information preparation and dissemination to end users. For instance, model contracts for EPCs have been developed and led to "standardised offerings and increased trust and transparency in the marketplace". The IEA recommends that the government should work to maintain and develop the dynamic in this area (iea 2020d). The government plans to further increase the demand for energy performance contracting, especially in the public sector. Measures to be taken are the promotion of at least ten energy performance contracting model projects in public sector properties by 2021, improvement of the legal framework and the development of competence in the field of EPC for the public sector (BMWi 2019c).

4 Energy efficiency in Korea

4.1 Energy efficiency strategy as part of climate and energy policy

As declared in its **Intended Nationally Determined Contributions (INDC)** towards achieving the objective of the UNFCCC, the Korean government aims at reducing GHG emissions by 37% as compared to the BAU scenario by 2030 across all economic sectors (UNFCCC 2016). This target equals a 22% reduction below 2012 GHG levels (ICAP 2020).

Korea's **Second Master Plan for Climate Change Mitigation** from 2019 outlines measures for achieving the emission reduction targets for 2030. It also sets sectoral goals: emissions in the industrial and building sector are to be reduced by 20.5% and 32.7% compared to BAU, respectively. Further, emissions in the sectors transport, waste and agriculture should be decreased by 29.3%, 28.9% and 7.9%, respectively, while emissions in the public sector are required to be reduced by 25.3% (MoE 2019).

Korea is currently developing its **long-run low-carbon development strategy with a horizon 2050** (Energy & Environment News 2020). In September 2020, the Korean Parliament declared climate emergency and committed to the non-binding target of achieving net-zero emissions by 2050 (Ha 2020).

The current Korean government under president Jae-in Moon in 2017 initiated Korea's energy transition. It placed an emphasis on increasing renewable energies from 5% to 20% until 2030 while reducing nuclear power and coal. The **Third Energy Master Plan**, published in June 2019, further sets the target to increase the share of renewables to 35% until 2040 and additionally puts a stronger emphasis on the role of energy efficiency (MOTIE 2019b; Lim and Kim 2019).

In Korea, the Ministry of Trade, Industry and Energy (MOTIE) is principally in charge of formulating energy efficiency policies and the establishment of energy efficiency standards. The Korean Energy Agency (KEA), established in 1980, is assigned with the efficient implementation of the governments energy use rationalization projects (MOTIE and KEA 2015) (KEA 2020v). The Ministry of Land, Infrastructure and Transport (MOLIT) is involved with regard to energy efficiency in the building and transport sector.

The **Framework Act on Low Carbon, Green Growth (2010)** requires the Korean government to formulate an Energy Master Plan that defines the energy policy direction for a 20 year planning horizon every five years (Cho and Kim 2019). The Third Energy Master Plan aims at decreasing energy intensity by 38% as compared to 2017 (from 1.31 MWh/million KRW to 0.81 MWh/million KRW) and final energy consumption by 18.6% compared to the BAU scenario until 2040 by improving energy efficiency. Furthermore, compared to 2017, energy intensity in the building sector is targeted to be reduced by 38% by 2040, and by 21% in the industry sector. Several measures for reaching these targets are outlined in the Third Energy Master Plan. These include a stronger focus on zero-energy buildings and support for SMEs in establishing Factory Energy Management Systems (FEMS) (MOTIE 2019b).

The **National Plan for Energy Efficiency Innovation** from August 2019 sets targets for 2030 compared to BAU, aiming at a reduction of final energy consumption by 14.4% and at decreasing energy imports by 10.8 trillion KRW (approx. 8 billion EUR). It also outlines support measures for reaching these goals. Energy efficient innovations are to optimise demand side

management (DSM) in the industry, building as well as the transport sector and to create 69,000 new employment opportunities (ChosunBiz 2019) (MOTIE 2019a).

The **Act on Rational Energy Use** from 1979 aims at strengthening the Korean economy, increasing national welfare and mitigating climate change by stabilising energy supply and demand, as well as promoting the rational and efficient usage of energy (MOTIE 1979). Based on it, the Korean government has elaborated a **Basic Plan for Rational Energy Use** in 1993, which is revised every five years, and embraces policy instruments and programmes (Boo 2019). In August 2020, MOTIE published the **Sixth Basic Plan for Rational Energy Use** for the period from 2020 to 2024 which lays out targets and regulatory measures concerning energy use and energy efficiency in accordance with the Third Energy Master Plan. It aims at reducing energy intensity by 13% by 2024 as compared to 2020, from 0.126 to 0.109 MWh/million KRW, and energy consumption by 9.3% compared to BAU from 2264.36 TWh to 2052.7 TWh (MOTIE 2020).

According to the **Electric Utility Act** (2000, last updated in 2017), MOTIE is in charge of formulating the basic plan for electricity supply and demand (Cho and Kim 2019). It represents the government's strategy with regard to the electricity market with a 15-year horizon. The **Eighth Basic Plan for Electricity Supply and Demand** from 2017 sets the objective of reducing the peak electricity demand by 12.3% and total power consumption by 14.5% by 2031 by means of increased energy efficiency and expansion of DSM. Concrete measures include strengthening of minimum energy performance standards, a further dissemination of EnMS, as well as the introduction of Energy Efficiency Resource Standards (EERS) and an Energy Champion System (MOTIE 2017).

The targets of the Korean government with regard to energy efficiency are summarised in Table 2.

Table 2: Korea's energy efficiency targets

	Target		
Category	**2024**	**2030**	**2040**
Energy intensity	-13% (vs. 2020)		-38% (vs. 2017)
Final energy consumption	-9.3% (vs. BAU)	-14.4% (vs. BAU)	-18.6% (vs. BAU)
Peak electricity demand		-12.3% (vs. 2016 by 2031)	
Electricity consumption		-14.5% (vs. 2016 by 2031)	
Energy intensity in buildings			-38% (vs. 2017)
Energy intensity industry			-21% (vs. 2017)
Fuel Efficiency			2 times higher for passenger vehicles, 1.5 times higher for heavy-duty vehicles (vs. 2017)

Based on MOTIE 2017, 2019a, 2019b, 2020.

In order to provide financial support for the implementation of energy efficiency measures, Korea established an **Energy Use Rationalization Fund** which is managed by the Korean Energy Agency (KEA) (Jung et al. 2018).

In 2020, MOTIE aims to invest 916.3 billion KRW (approx. 653 million EUR) **in energy R&D**. This represents an increase of 19% compared to the previous year. A focus is on investments in energy storage systems and energy efficiency in local industries (Yonhap News Agency 2020). According to estimates by the IEA, Korean **public energy efficiency RD&D** budget accounted for 200 million USD (2019 PPP) (approx. 172 million EUR) in 2018 – the same amount as the German government spent (iea 2020c).

4.2 Energy efficiency in industry

Korea's economy is very energy-intensive, in particular the production of steel, electronic devices, passenger vehicles and petrochemicals (Boo 2019). The value added of the manufacturing sector has accounted for roughly one-third of overall GDP since 1988 (Jung et al. 2018). In 2019, manufacturing value added was reported at 25.4% of GDP, while overall industry incl. construction accounted for 33% of GDP (World Bank Database 2020d).

Industry accounts, by far, for the largest share of final energy consumption (61% in 2018, KEEI 2019). Final energy consumption in Korea's industry increased from around 1,209.52 TWh in 2007 to 1,674.72 TWh in 2017 (KEEI 2019). Split up by subsectors, in 2017 the basic metal industry accounted for the largest share of energy consumption (313.78 TWh), followed by the chemical industry (98.69 TWh), non-metallic minerals (60.58 TWh), and paper, pulp and print (24.39 TWh) (iea 2020a).

The Third Energy Master Plan with the horizon 2040 aims at reducing energy intensity of the industrial sector by 21% from 1.85 MWh/1,000 KRW in 2017 to 0.138 MWh/1,000 KRW (MOTIE 2019b). In order to reduce GHG emissions and overall energy consumption of the industrial sector, the government has promoted several measures to increase energy efficiency. In most cases, KEA is in charge of the implementation.

4.2.1 Regulatory measures and standards

Mandatory energy audits

Based on the Act on Rational Energy Use (Article 32), since 2007, energy-intensive companies that consume more than 2,000 toe (23,260 MWh) per year are required to undergo an energy audit every five years (KEA 2019, 2020d). This addresses approximately 3,600 facilities (KEA 2020t).

GHG and Energy Target Management System (TMS) for industry and the power sector

In 2012, the Korean government introduced a mandatory TMS for industrial companies and power plants that surpass a certain threshold for three-year averages for GHG emissions and energy consumption. This critical threshold currently stands at 50,000 tCO_2e and 200 TJ (55,600 MWh) for companies and 15,000 tCO_2e and 80 TJ (22,200 MWh) for individual business premises and sites.

The government and the respective companies negotiate individual targets for the reduction of GHG emissions and energy conservation. The governmental supervisory body for the TMS is MOTIE. It controls the targets and imposes fines if the companies fail to achieve them.

In 2018, the TMS addressed 168 companies from industry and in the power sector (KEA 2019).

Energy Use Plan

Furthermore, it is mandatory for companies to present an Energy Use Plan showing how energy efficiency is intended to be increased prior to the implementation of a land development, energy development, port, railway, airport or factory construction project if its size exceeds a certain threshold (in terms of property size and/or energy consumption). The aim is to improve the energy efficiency and reduce greenhouse gas emissions through prior consultation on energy supply and demand. KEA is in charge of providing respective consultancy and negotiating the plan (KEA 2019, 2020q) .

Mandatory Demand-side Management (DSM) investments

To stabilise energy supply and demand, since 1995 the three state-owned enterprises (SOEs) in the electricity, gas and heating sector (KEPCO, KOGAS and KDHC) are legally required to formulate and implement investment plans for DSM. This embraces programs to improve energy efficiency and to ensure an efficient energy supply by levelling the energy load, e.g. by minimising peak and generating base load (including rate discounts). The energy supplier submits the DSM project plan to MOTIE after prior consultation with the regulatory agency by end of October each year, and the respective verification of the project implementation by the end of February every year. MOTIE then evaluates and communicates the results (KEA 2020n).

Energy Efficiency Resource Standards (EERS)

The EERS introduced in 2018 as a pilot project stipulates an annual energy saving target for the national energy suppliers KEPCO, KOGAS and KDHC, and obliges them to implement projects for improving energy efficiency, e.g. by disseminating highly efficient devices to their customers. The annual mandatory energy reduction target under EERS for KEPCO was 0.15% in 2018 and 0.2% in 2019 and 2020. For KOGAS and KDHC it was 0.02% and 0.15% in 2019 and 2020, respectively (KEA 2019, 2020t). The Second Master Plan for Climate Change Mitigation aims to increase the mandatory energy reduction target under the EERS (MoE 2019). For KEPCO, it will increase to 1% for the period from 2021 to 2031, while it is yet to be determined for KOGAS and KDHC. The obligatory targets for energy reduction and the projects implemented by the three energy suppliers are summarized in Table 3.

Table 3: Yearly obligatory targets for energy reduction under EERS and projects implemented in 2019

	Obligatory targets for energy reduction				Projects implemented in 2019
	2018	2019	2020	until 2031	
KEPCO	0.15%	0.20%	0.20%	1% until 2031	15 projects: Heat pump boilers, regenerative braking systems, premium motors, constant temperature dampers, social welfare support, transformers, turbo blowers, LEDs, inverters, coolers, pumps, EnMS, ESCO agents, etc.
KOGAS	-	0.02%	0.02%	Yearly target ratio determined later	5 projects: Decentralized combined heat and power generators, heat efficiency improvement for vulnerable groups, boilers for industrial buildings, boilers for homes, and demand information about smart gas meters
KDHC	-	0.15%	0.15%	Yearly target ratio determined later	5 projects: Thermal equipment education, heat exchanger for warming up of water heater, Pressure differential control valve repair, changing old heating piping for users, energy diagnosis of user facilities

Based on KEA 2019; MoE 2019; KEA 2020t

Infobox: Energy standards and labelling programs

Korea has three **energy standards and labelling programs**. According to the **Energy Efficiency Standard and Labelling Programme** introduced in 1992, manufacturers are required to attach an energy efficiency label to highly-disseminated energy-intensive appliances. The label ranks the products from 1 to 5 which corresponds to the minimum energy performance standard. If an appliance does not meet the minimum energy performance standard, its production and sale are banned. The programme covers 33 appliances including home appliances and lighting products (MOTIE and KEA 2015; KEA 2020f, 2020t).

The **High-efficiency Appliance Certification Programme** introduced in 1996 is a voluntary certification scheme that seeks to promote the dissemination of high-efficiency equipment, e.g. appliances that outperform the standard set by the government. The programme issues certificates for high-efficiency equipment, and allows the manufacturers to indicate this by marking their products correspondingly. The incentive for producers consists in the opportunity to clearly distinguish their products on the market from less efficient ones. It covers 22 items including appliances and equipment of industrial usage (lighting, insulation and electricity equipment, as well as boilers and cooling and heating equipment). Demand for appliances and equipment that are certified as high-efficient is further supported by public procurement programmes as well as tax deductions (MOTIE and KEA 2015; KEA 2020l; Jung et al. 2018).

Since 1999, the **E-Standby Power Programme** that covers 21 products requires manufacturers to report the standby energy consumption of their products (KEA 2020j). If a product's energy consumption does not fulfil a certain standard, the product is labelled with a warning (Jung et al. 2018).

4.2.2 Market-based instruments

Korean Emission Trading System (ETS)

The TMS allowed for the collection of verified emission data and training in the monitoring, reporting and verification processes of TMS entities, which helped the design of the Korean ETS. The Korean ETS was launched in 2015 as East Asia's first nationwide mandatory ETS and the second-largest carbon market after the EU-ETS. Currently, the TMS and ETS coexist. Companies whose annual GHG emissions surpassed 125,000 tCO_2e or whose individual facility emitted more than 25.000tCO_2e per year are subject to the ETS. The calculation takes place on the basis of a three-year average (KEA 2020c). The ETS covers 639 of the country's largest emitters from the heat and power, industrial, transport, building, and waste sectors, or roughly 70% of Korea's GHG emissions (KEA 2020t; ICAP 2020). The average secondary market price from Korea Exchange (KRX) in 2019 (per tCO_2e) was 29,821.54 KRW (25.59 USD) per tCO_2e (ICAP 2020).

4.2.3 Financial support

Soft loan programme

Since 1980, KEA provides long-term, low-interest rate loans for investments in energy conservation equipment in facilities. The soft loan programme covers the entire construction and material costs including equipment, labour expenses, overhead expenses and general administrative expenses (KEA 2020u).

It provides loans for companies that aim to install or replace the types of facilities which are listed in the programme's guidelines (e.g. boilers, waste heat recovery heat pumps, etc.). Supported ESCO projects include insulation retrofit projects for buildings older than 10 years, energy conservation projects on existing buildings, and plants utilizing information and communication technology. Additionally, projects that are able to reduce GHG emissions or energy consumption by at least 5% according to energy audits are eligible for this soft loan program.

The interest rate is quarterly adjustable and linked to the average rate of return of three-year negotiable Korean Treasury bonds. The loans are payable in instalments within 5 years with a three-year grace period or in instalments within 7 years with a three-year grace period in the case of ESCO projects. Maximum credit amounts 15 billion KRW (approx. 11 million EUR) per entity (KEA 2020u, 2020h, 2020t).

Subsidies for SMEs

The Korean government grants subsidies for the installation of energy efficient equipment in facilities that help decrease GHG emissions, such as waste heat recovery facilities and inverter-controlled compressors to SMEs of the industrial and power sectors which are subject to the ETS (KEA 2019).

Energy audit assistance for SMEs

KEA offers a 30% subsidy to cover energy audit costs to SMEs with an energy consumption between 2,000 toe and 10,000 toe (23,260 MWh and 116,300 MWh, respectively) (KEA 2020y, 2020t).

Financial support for Factory Energy Management Systems (FEMS) in SMEs

In order to decrease the energy consumption of SMEs in the industrial and power sectors, the government financially supports the application of FEMS in SMEs. FEMS are real-time monitoring systems for energy consumption and manufacturing status that aim to identify energy saving potentials. The government aims at introducing FEMS to over 1,500 SMEs until 2030 (MOTIE 2019b). Currently, the government also supports FEMS in seven industrial complexes that were selected as leading smart green industrial complexes (KEA 2019).

4.2.4 Information, advice and training

Energy management systems (EnMS): Certification and installation support

In 2006, KEA has established the certification of EnMS and the ISO 50001 certification between 2011-2017. KEA also promotes the implementation of the international EnMS standard ISO 50001 in order to improve energy efficiency of industrial and power generating facilities as well as of large commercial buildings. KEA offers support in the form of pre-consultation and the installation of measuring and monitoring instruments (KEA 2020g).

Energy Supporter Programme for SMEs

Within the framework of its **Energy Supporter Programme**, KEA supports SMEs without energy professionals and capital by providing technical expertise. KEA sends out energy experts (energy supporters) to the companies in order to analyse their energy consumption patterns, evaluate the performance of their major facilities, and facilitate the transfer of energy conservation technologies. In this way, the programme provides tailored support to each SME which can be combined with other KEA programs, such as the financial support offered by KEA for energy conservation facilities, ESCO investment projects, and EnMS (see chapter 4.2.3) (KEA 2020i).

Green Growth Partnership Programme

With the Green Growth Partnership Programme**,** KEA facilitates knowledge exchange between conglomerates and SMEs. Conglomerates that possess advanced expertise in energy management methods share their know-how with SMEs, thus helping them to strengthen their competitiveness (KEA 2020k).

Learning Energy Efficiency Networks (LEENs)

In 2020, Korea initiated the operation of two LEEN pilot programmes inspired by the German concept (see chapter 3.2.4). A LEEN is a local network comprised of around ten small- and medium-sized companies. It further involves local governments, KEA and its respective regional headquarters, energy auditing service providers and energy efficiency experts. A LEEN is operated over two to three years. After undergoing an initial energy audit, the LEEN members select an energy efficiency project and set an energy saving target with the support of the experts. The selected projects are matched with respective government support programs. Regular group meetings allow for mutual learning and knowledge exchange. The outcomes of the efforts to increase energy efficiency by the individual companies as well as by the overall network are monitored on a yearly basis. KEA as the operating agency evaluates the overall results according to the final report. As an incentive, especially successful networks as well as the individual participating companies are designated as excellent and awarded with certain benefits by the government (e.g. receiving a certificate and the possibility of overseas study). The Korean government plans the diffusion of LEENs and aims to establish around 40 networks by 2030 (KEA 2020p).

National heat map

In 2020, the Korean government initiated the creation of a national heat map that includes all residual heat energy from power plants, incineration facilities, district heating facilities, fuel cells, and industrial facilities. The map aims to facilitate wasted heat utilisation and accelerate energy efficiency improvements (iea 2019b). The heat map is completed in three steps, the second of which was finalised in April 2020 (Electimes 2020).

4.2.5 Other incentives for voluntary energy efficiency initiatives

Energy Champion Certification

Companies with a yearly energy consumption over 2,000 toe (23,260 MWh) which voluntarily improve their energy efficiency can apply to be certified as "Energy Champion". It provides them access to certain benefits**,** e.g. company representatives are able to participate in study trips abroad (KEA 2019, 2020w).

Pilot Project Voluntary Energy Efficiency Agreements

In 2020, the Korean government has launched a pilot project for Voluntary Energy Efficiency Agreements between companies and the government as a complement to the mandatory TMS. While the TMS focuses on GHG emissions and energy use as indicators, the voluntary agreements address energy intensity (KEA 2020t). The agreements have a five-year horizon in order to incentivise large-scale and capital-intensive energy efficiency investments that are associated with long amortization periods. If companies succeed in improving their average annual energy intensity by at least 1% as compared to the base year, they benefit from soft incentives such as an extension of one cycle of the mandatory energy audit, overseas training and business promotion (KEA 2020o). The existent Energy Champion System described is to be integrated and operated under the Voluntary Energy Efficiency Agreements (KEA 2020t).

4.3 Energy efficiency in buildings

In 2018, the building sector accounted for 17.1% of Korea's final energy consumption (KEA 2020c). Around 73% of all buildings are 15 years or older and 28% of the overall building stock is older than 35 years (KEA 2020c). Although the annual building growth rate stagnated lately, overall energy consumption of the building sector is still increasing in Korea as well as the average size of newly constructed buildings (KEA 2020c). Energy consumption of commercial and public buildings is expected to increase annually by 1.8% and energy consumption by residential buildings is estimated to grow annually by 0.1% until 2030 (KEA 2020c). Overall final energy consumption in the residential and commercial sector increased from 418.68 TWh in 2007 to 465.2 TWh in 2017 (KEEI 2019). As in Germany, heating accounts for the largest share of energy consumption in the building sector. In 2018, heating amounted to 110.8 TWh in the residential sector and 75.8 TWh in the services sector, accounting for around 68% and 43% of the respective sectors' final energy consumption. In contrast to Germany, where space cooling plays a minor role, in 2018, cooling accounted for 67.8 TWh or around 39% of final energy consumption in Korea's services sector, with lighting accounting for the remaining 30.8 TWh or 18%. In the Korean residential sector, 50.2 TWh or around 31% were consumed by appliances and 1.6 TWh or less than 1% for space cooling in 2018. In 2018, the residential sector accounted for the greatest share of final consumption of natural gas, followed by industry (iea 2020a).

The **Third Energy Master Plan** (4.1) aims at reducing energy intensity of buildings by 38% from 337.27 kWh/million KRW in 2017 to 209.34 kWh/million KRW by 2040 (MOTIE 2019b).

The **Green Building Construction Support Act**, which entered into force in 2013, serves to implement the objective of the Framework Act on Low Carbon, Green Growth from 2010 (see chapter 4.1) in the building sector (MOLIT 2019a). It represents the basis for various green building policies such as the energy-saving design standard, building energy efficiency level certification, zero energy building certification and green building certification system (KEA 2020c). According to Art. 54 of the Framework Act on Low Carbon, Green Growth green buildings are thereby defined as "buildings with high efficiency in the use of energy, a high ratio of new and renewable energy, and minimum greenhouse gas emission" (Government of the Republic of Korea 2010). According to the Green Building Construction Support Act, MOLIT is in charge of formulating a national master plan for green buildings every five years. This plan assesses the current state of green buildings and sets energy and GHG reduction targets. The provincial governor is in charge of formulating a respective composition plan (KEA 2020c; MOLIT 2019a). The master plan determines the direction of policies and support with respect to green building certifications, higher education and training of experts, R&D and demonstration projects. It also determines the promotion of enterprises specialised in manufacturing and construction of green buildings, green building centres, green refurbishment, international standardisation and increased international cooperation. Further, the Green Building Construction Support Act stipulates the dissemination of Building Energy Management Systems (BEMS) and zero energy buildings, which are being defined as "green building(s) in which energy requirement is minimized by minimizing the energy load needed for the building and by utilizing new and renewable energy" (MOLIT 2019a). The **Second National Plan for Green Buildings** was published in December 2019 and expands pre-existing objectives and measures for increasing energy efficiency of new and existing buildings (e.g. by gradually tightening energy consumption standards) (MOLIT 2020b).

The policy instruments introduced by the Korean government to increase energy efficiency in the building sector are described in more detail in the following chapters. They can be characterised as a mix of mandatory and voluntary measures based on regulation, certification schemes, incentives mechanism and financial support.

4.3.1 Regulatory measures and standards

Minimum requirements for energy efficiency

In Korea, different energy efficiency and saving standards exist for different types of buildings. Generally, the Building Energy Conservation Code (BECC) first introduced in 1980 plays the central role in this regard. It prescribes the minimum requirements for building thermal envelope and building systems, differentiating by building type and geographic region (Park et al. 2015). With the introduction of the aforementioned Green Building Construction Support Act, the existing regulations were integrated in this wider framework. The regulations specified there now apply to all buildings with a gross area of over 500 m². In the case of an application for a building permit for new construction or a use change of such buildings, the developer must submit the building's energy saving plan. A local authority is in charge of issuing the building permits, with KEA assessing the adequacy of the plan and advising the local authorities (KEA 2019). Renovation of existing buildings is however excluded (Government of the Republic of Korea 2020a).

The energy saving plan consists of complying with the updated Energy Saving Design Standards for Buildings (MOLIT 2017), as well as submitting Energy Performance Indicators (EPI). The Design Standards set minimal requirements for individual design features of building envelope and systems, including for instance different matters related to insulation and shading. The EPI addresses the same aspects beyond these minimum requirements and assigns each one a grade and a weight, calculating an overall EPI. In addition to the minimum requirements, private buildings must achieve an EPI of at least 65 and public buildings of at least 75 from the maximum of 120 (KEA 2020a). Such an EPI assessment is however not necessary if a building holds either the Building Energy Efficiency or Zero-Energy Building Certification (see below). In the period from 2003 to 2019, more than 158,000 energy saving plans were reviewed (KEA 2020c, 2020t).

The EPI approach offers the planners a certain degree of freedom when complying with the Design Standards. The Standards also include a performance-based part for office buildings and research or educational facilities with a floor area larger than 3,000 m^2, as well as for public buildings over 500 m^2. This performance-based aspect requires the planners to calculate and submit the building energy consumption using Korea's official building energy simulation program ECO2-OD. While no maximum building energy consumption values currently exist, they are expected to be introduced in the future (Park et al. 2015).

In addition, the Housing Law prescribes that all buildings with more than 30 households, or 50 in some exceptional cases, have to submit a business plan and need to be constructed as "eco-friendly houses" (Government of the Republic of Korea 2020b). This means that are not required to comply with the aforementioned Design Standards, but instead need to submit a different energy saving plan according to the details laid out in the Construction Standards for Eco-friendly Housing. These Construction Standards include some mandatory prescriptive standards, but also allow for additional flexibility. Beyond the mandatory standards, an applicant can choose to either fulfil additional prescriptive requirements or choose a performance-based option. For the latter, the status of "eco-friendly house" is determined by a relative reduction of CO_2 or energy consumption by more than 60% compared to a reference value multiplied by a regional coefficient (MOLIT 2020a). In both cases, the energy saving plan or energy saving performance plan must be submitted to the local authorities, which are assisted by KEA (KEA 2019, 2020r).

Zero-energy Construction Road Map

In 2016, the government decided on the "zero-energy construction road map", which was revised concerning its implementation in 2019 (MOLIT 2019b). According to this roadmap, buildings gradually have to become zero-energy consuming. New public buildings over 1,000 m^2 have to become zero-energy starting in 2020. New public buildings over 500m^2, new private buildings over 1,000 m^2 and multi-family buildings with more than 30 households follow in 2025 (public buildings over 500m^2 from 2023 already). Starting in 2030, all new buildings over 500m^2 have to be zero-energy consuming. In order to follow this roadmap, existing schemes for energy efficiency in the building sector are expanded (Kwag et al. 2020). This means in particular that the existing Building Energy Efficiency Certification as well as the Zero Energy Building Certification, which are described below, now apply to more buildings.

Certification Schemes

Three certification schemes foster energy efficiency in the building sector. They are currently mandatory either for public buildings in general or for those of a certain size, whilst being voluntary, but recommended, for private ones.

(1) Building Energy Efficiency Certification (BEEC)

The BEEC was introduced in 2001 in order to provide information on a building's energy consumption for heating, cooling, hot water, lighting, and ventilation, as well as on its GHG emissions. The calculations are based on the building's design documentation but buildings can also be re-assessed after completion (Park et al. 2015). Certification levels range from 7 to level 1+++. The latter indicates the highest building energy efficiency level and requires an energy consumption below 60 kW/m^2/year for residential buildings and below 80 kW/m^2/year for non-residential buildings.

New public buildings larger than 1,000 m^2 must obtain an energy efficiency certification of level 1++ or higher which implies an energy consumption less than 140 kWh/m^2 per year. The programme is further applicable to existing and new buildings for all purposes including individual housings, apartments, and dormitory buildings, buildings with cooling or heating areas greater than 500 m^2, and office buildings. A certification level of 1++ is already recommended for buildings with more than 30 households, but will become mandatory as part of the goal to reach zero-energy buildings starting in 2025 (Kwag et al. 2020).

Between its introduction in 2001 and 2019, 11,820 preliminary certifications were issued (KEA 2020c, 2020b; iea 2019a; KEA 2020t).

(2) Zero Energy Building Certification (ZEBC)

Established in 2017, the Zero Energy Building Certification System aims to promote zero-energy buildings starting in the design and construction phases by following passive house design principles and technology. It extends the BEEC through additional requirements.

For obtaining this certification, the building is required to achieve a building energy efficiency level greater than 1++ (<140 kWh/m^2 per year) as a precondition. Additionally, it must be equipped with a BEMS or an electronic remote meter reading system. The third criteria for the Zero Energy Building is its level of energy self-sufficiency: 100%, 80-100%, 60-80%, 40-60% and 20-40% self-sufficiency are necessary for achieving level 1 (best) to 5, respectively. Incentives for voluntarily attaining the certification consist in a relaxation of building code, e.g. allowing for a greater floor area, lower infrastructure contributions, subsidies for renewable energy installations ranging from 30-50%, as well as the provision of technical consultancy by the Zero Energy Support Center (KEA 2020c). As part of the zero-energy road map, achieving a level 5 zero-energy certification is currently required for public buildings larger than 1,000 m² and, starting in 2023, will also be required for public buildings over 500 m² and, from 2025, for residential buildings with more than 30 households or 1,000 m² (Kwag et al. 2020). In 2030, it will become mandatory for all buildings over 500 m².

By the end of 2019, 71 buildings were classified as zero energy buildings (KEA 2020t).

(3) Green Building Certification Scheme

The Green Building Certification Scheme addresses new and existing buildings and is mandatory for public building projects over 3,000 m² (also applying to several buildings within the same project), while being recommended and incentivized, e.g. via tax breaks, for private buildings. The objective is an integrated evaluation of the building elements and processes in order to decrease the building's environmental burden, i.e. energy and resource usage as well as emissions. Based on an assessment, the certification as well as a grade from 1st class (best), to 4th class (general) is awarded. The certification standards for existing buildings were last revised in 2016, resulting e.g. in the introduction of a green refurbishment certification standard. 10,841 certifications were issued between 2002 and 2018 (KEA 2020c).

Building Energy Management Systems (BEMS)

Since 2012, MOTIE and KEA have been promoting the standardization of BEMS that collect and analyse data and enable efficient control, management and operation of integrated building energy systems. For new public buildings larger than 10,000 m^2, installing BEMS is mandatory (KEA 2020c).

GHG and Energy Target Management System (TMS) for Buildings

Analogous to the TMS for industry and power sectors (4.2.1), companies which exceed the threshold of three-year average annual GHG emissions and energy consumption are required to agree to energy saving objectives with the government for the next year. Since 2014, the critical threshold is the same as for the TMS for industry and power plants: 50,000 tCO_2e and 200 TJ (55,600 MWh) for companies and 15,000 tCO_2e and 80 TJ (22,200 MWh) for businesses premises or sites (KEA 2020c).

The companies are incentivised to achieve the agreed goals by receiving support for the implementation of relevant measures, and face penalties in case of missing their targets. MOLIT is the supervisory body in charge of setting the target setting and for supporting the companies in the target realisation.

By 2019, 11 companies and 47 business premises were addressed by the Building Energy and GHG Target Management System (KEA 2019). The assignment of the respective company or business premises to one of the two TMS systems - TMS for industry and power plants or TMS for buildings - depends on the entry in the commercial register.

4.3.2 Market-based instruments

Korean ETS

The Korean ETS outlined in section 4.2.2 also covers the building sector (ICAP 2020).

4.3.3 Financial support

Private Green Remodelling Interest Support

The government provides a 5-year interest rate subsidy on privately financed expenses associated with private refurbishment initiatives of existing buildings. The greater the energy efficiency improvement, the higher the subsidy provided. Depending on the attained performance improvement ratio with regard to cooling and heating, an interest rate support of 2%, 3% or 4% is granted for an improvement of 20-25%, 25-30% or greater than 30% respectively. In this way 28,676 green remodelling projects were supported within the period 2014 to 2018 (KEA 2020c).

Soft loan programme

The soft loan programme for investments in energy conservation facilities (see chapter 4.2.3) addresses different types of measures in the building sector, e.g. ESCO projects such as insulation retrofit projects for buildings older than 10 years or IT-based energy conservation projects in existing buildings (KEA 2020u, 2020c). The government also provides financial support for the installation of renewable energy facilities such as solar and geothermal energy in buildings (KEA 2020c).

Local tax rebate

Depending both on the Green Building Certification Level and the Building Energy Efficiency Level Certification (see chapter 4.3.1), a local tax rebate can be obtained ranging from a minimum of a 3% property and 5% acquisition tax reduction to a 10% acquisition tax reduction. With a zero-energy building certification an acquisition tax reduction can be obtained ranging from 15 to 20% (KEA 2020c).

Subsidies for renewable energy installations

Depending on the level of energy efficiency certification, buildings are awarded additional 1~2 points (granted according to the certification acquisition rate) when evaluating the application for building support and convergence support among the subsidies for installing renewable energy. Subsidies for renewable energy installations are available up to 50% (KEA 2020c).

High-Efficiency Electric Product Subsidy

Since 2001, KEA promotes the use of high-efficiency electric devices to reduce electricity consumption and peak power as part of the government's DSM policies. The programme subsidises high-efficiency equipment (LED lamps with interior/exterior converter, inverters, coolers), as well as electricity load management equipment such as cold storage systems, remote controlling systems of cooling and heating equipment, peak electricity control system, district cooling systems and gas cooling systems. In the framework of the programme, KEA also replaces old lighting systems with high-efficiency devices for free to low-income groups and to social welfare facilities (KEA 2020m).

The National Plan for Energy Efficiency Innovation foresees, for the further promotion of high-efficiency appliances and lightening, to select the most efficient household appliances each year and reimburse consumers a part of the purchase price (e.g. 10%) (ChosunBiz 2019).

4.3.4 Information, advice and training

Campaigns

KEA organizes energy campaigns and energy conservation activities that target companies, NGOs, local governments, public institutions and civil society (KEA 2020e). For instance, the 'Energy Saving Store Campaign' was launched in 2020 in order to encourage stores to reduce their energy demand by keeping optimal indoor temperatures (summer 26, winter 20) and by using efficient cooling/heating systems, amongst others.

Advice

Further, KEA provides advice for reducing energy consumption for household electronics and devices such as electric air conditioners, television sets, electric washing machines etc. The website also offers a calculator to compare the energy demand and cost for different specific brands and products as well as an overview of available support programs such as tax deductions (KEA 2020x).

Public institutions as role models

The Rationalization of Energy Use by Public Institutions initiative aims to spread awareness for energy conservation in the public by encouraging public institutions to promote energy conservation measures. The policy includes the reduction of energy use in areas such as lighting, cooling and heating, elevators etc. (KEA 2019).

Energy Data Analysis Center (EDAC)

KEA's EDAC develops energy efficiency indices by building type and operational variables (occupancy, open hours, etc.) and provides energy data analyzing services online and free of charge. At the online platform the building owners can access the report about their building's energy efficiency level compared to same building type (KEA 2019, 2020t).

Zero Energy Support Centre

KEA has established a Zero Energy Support Centre that provides technical support for the planning of buildings which are to be certificated as Zero Energy Buildings (see chapter 4.3.1) (KEA 2020c).

Education and training programmes

KEA provides three professional education and training programmes with respect to the building sector, the Building Energy Auditor Training, the Building Energy Efficiency Rating Programme Training, and the Building Energy Efficiency Rating Certification Agency Training (KEA 2020s).

5 Comparison of energy efficiency policy in Germany and Korea

5.1 Status, strategies and targets

As shown in chapter 2, Germany and Korea belong to the world's biggest energy consumers, standing at places six and eight, respectively. However, while Germany's TFEC decreased by 6% between 1990 and 2017, Korea's TFEC increased by a factor of 2.8 in the same period. Korea's per capita final energy consumption is higher than Germany's and its energy intensity was almost double that of Germany's in 2018, ranking fifth-highest among the OECD countries. Korea's energy consumption per GDP was considerably above the average of the 30 IEA member states in 2015, while Germany ranked below the country average (iea 2020d).

Both Germany and Korea are committed to reducing their GHG emissions and have defined sectoral emission reduction targets as part of their respective climate policies. Energy efficiency represents a crucial part of both countries' energy transition policies and is part of several strategic documents, plans, and laws.

Both countries set themselves targets for increasing their energy efficiency. Germany aims to reduce its total primary energy consumption by 30% until 2030 and by 50% until 2050 (vs. 2008). Korea strives for a reduction in final energy consumption by 14.4% until 2030 and 18.6% until 2040 (vs. BAU), and aims to decrease its energy intensity by 38% by 2040 (vs. 2017). While both countries have specific targets concerning energy efficiency improvements in buildings, only Korea sets a target for the industry sector as well (see chapter 4.2).

5.2 Energy efficiency in industry

Industry plays a significant role in overall economic activity in both Germany and Korea. Final energy consumption by industry and non-energy use likewise accounts for the largest share of TFEC in both countries. The share is higher in Korea (56%) than in Germany (35%) (see Chapter 2). Energy intensity in manufacturing is also higher in Korea, amounting 5.0 MJ/USD (2010 PPP) compared to 3.5 MJ/USD (2010 PPP) for Germany in 2017 (iea 2020a, 2020b). This does not necessarily imply that Korea's industry as a whole is less energy efficient than Germany's, as structural differences at least partly explain the discrepancy. South Korea, smaller than Germany with regards to its population and economy, produces more of several energy-intensive goods in absolute terms, according to the latest available data: Almost twice as much steel, about 50% more cement, and has a chemical industry only 15% smaller than Germany's in terms of revenue, with paper being one of the few energy-intensive products of which Germany produces more than Korea (World Bank Database 2020b; Cembureau 2020; World Steel Association 2019; VCI 2020; Cefic 2020; World Paper Mill 2019).

In terms of **sector targets**, Korea defined an explicit energy efficiency target for industry, aiming at a 21% reduction in energy intensity by 2040 compared to 2017 and set a sectoral emission reduction target for industry of 20.5% compared to BAU for 2030 (see chapter 4.1). Germany only defined a target for industry in terms of its GHG emissions, which are to decrease by 49 – 51% by 2030 (see chapter 3.1).

In contrast to Germany, the Korean government introduced **regulatory measures on the supply side.** It demands that the three state-owned enterprises in the electricity, gas and heating sector (KEPCO, KOGAS and KDHC) achieve **state-set annual mandatory energy reduction targets** under the EERS scheme. In addition, the three Korean state-owned energy distributors are also required to carry out **DSM investments** (see chapter 4.2.1). No comparable obligation exists in Germany.

On the **energy consumption side**, companies of a certain size fall under obligation to perform **mandatory energy audits** in both countries**.** In Korea, companies with annual energy consumption of more than 2,000 toe (23,260 MWh) are required to undergo an energy audit every five years. This relatively high threshold translates into a comparatively low number of companies affected by this obligation – about 3,600 in total. In Germany, all non-SMEs employing at least 250 people or reaching both 43 million EUR of yearly revenue and 50 million EUR on yearly balance sheet need to undergo an energy audit every four years. Exemption from the audit obligation exist for companies which have installed a certified EnMS or an environmental management system according to EMAS or if their energy consumption did not surpass 500MWh over the last 12 months preceding the audit. In effect, around 50,000 companies in Germany are obligated to perform recurrent energy audits, many more than in Korea even after taking into account the difference in the size of respective national economies (BMWi 2019e). In Germany, companies are also required to report the most relevant identified measures of the audit, their expected annual savings and necessary investments to a government agency. In both countries, translating the recommendations of the audits or EnMS into action is optional. However, voluntary mechanisms seek to encourage the implementation of the recommendations and various subsidy schemes for implementing energy efficiency measures are available.

In addition, Korea also has the **GHG and Energy TMS** in place, under which companies and sites with exceptionally high energy consumption and GHG emissions have to negotiate individual reductions targets with MOTIE. Similarly, based on the company's predicted energy consumption or size, an **Energy Use Plan** must be provided to KEA in order to obtain the project development permission (see chapter 4.2.1). Again, no comparable measure can be found in Germany.

Germany and Korea both employ **minimum equipment energy efficiency standards** addressing the most common equipment types (lighting, motors, pumps, cooling equipment etc.). Yet, only one certification programme in Korea also covers industrial equipment: The High Efficiency Appliance Certification Program. This program is not mandatory and incentivized by tax deductions and public procurement. Germany on the other hand has transposed the EU Ecodesign directive into national law, which implies a mandatory energy efficiency certification for a range of products, including some industrial equipment.

In both countries, the industry and the power sector are addressed by an **ETS**. In Germany, the national CO_2 levy starting in 2021 will cover the remaining third of industrial GHG emissions not covered by the EU ETS.

Both countries also rely on **voluntary measures**, often backed by **financial and fiscal incentives**. In Germany, the *Besondere Ausgleichsregelung* allows energy intensive companies to be **partially exempt from the renewable energy levy** in return for implementing and certifying an EnMS according to ISO 50001, an environmental management system according to EMAS, or in some cases, a slimmed-down EnMS developed especially for this purpose. In addition, the *Spitzenausgleich* allows companies from the manufacturing sector to be **relieved from the electricity and energy tax.** The first condition is that non-SMEs implement and certify an EnMS according to ISO 50001, an environmental

management system according to EMAS, or a slimmed-down EnMS to qualify for this exemption. For SMEs, carrying out an energy audit instead of implementing a full management system suffices. The second condition linked to *Spitzenausgleich* is that companies achieve a certain predetermined joint target for improving their energy productivity (see chapter 3.2.3). In Korea, companies with energy consumption large enough to fall under obligation to conduct energy audits can be deemed energy champions if they voluntarily improve their energy efficiency; as reward, its employees can participate in study trips abroad. Apart from that, companies required to participate in the TMS can voluntary agree to improve their energy productivity and in return receive a one-off extension of the energy audit cycle, overseas training and assistance with promotion of their business (see chapter 4.2.5).

Financial support for energy efficiency measures is available in both countries, whereby Germany follows a broader approach with different forms of financing and grant levels. The German government offers financial support in the form of grants or low-interest loans with partial debt relief that are open to all sectors and technologies. Subsidy rates are typically in the range from to 30% to 40%. Projects that are more complex can also participate in the competitive tendering programme, which offers a higher subsidy rate of up to 50% (see chapter 3.2.3). In Korea, KEA's **soft loan programme** provides long-term, low-interest rate loans for investments in energy conservation facilities.

Germany and Korea offer special financial support for SMEs. In Germany, SMEs that voluntarily undergo an energy audit can apply for an up to 80% subsidy to cover the energy audit costs (see chapter 3.2.3). The Korean government provides a subsidy of 30%. Korea also subsidises the installation of energy efficient facilities in certain SMEs of the industrial and power sectors, and provides financial support for the application of FEMS in SMEs (see chapter 4.2.3). **Both countries also provide support in the form of technical expertise for SMEs.** In Germany, this is part of the *Mittelstandsinitiative Energiewende und Klimaschutz,* which offers SMEs expert information and training (see chapter 3.2.4). Korea does something similar with its Energy Supporter Programme, sending energy experts to SMEs to provide tailored recommendations based on an analyses of their energy consumption and efficiency potentials (see chapter 4.2.4).

Both countries facilitate knowledge exchange on energy efficiency amongst companies. With its *Initiative Energy Efficiency Networks,* which started in 2014, Germany set itself the goal of establishing 500 networks by 2020 with around 280 networks having been implemented as of September 2020. The initiative recently was prolonged until 2025 with the target of achieving another five to six million tonnes of CO2 savings (see chapter 3.2.4). Korea's LEEN, based on the German pilot of the same name, has the goal of establishing 40 networks by 2030. Apart from that, Korea also facilitates knowledge exchange on energy management methods between conglomerates and SMEs in the frame of the *Green Growth Partnership Programme* (see chapter 4.2.4).

5.3 Energy efficiency in buildings

As shown in chapter 2, the shares of commercial and public services in TFEC were similar between Germany and Korea in 2017, whereas the share of the residential sector in TFEC in Germany was twice as high as in Korea (25% vs. 12%). The residential sector in Germany used around 7.82 TWh per million inhabitants in 2017 compared to 4.83 TWh per million inhabitants in Korea (own calculation based on iea 2019c). As the residential energy intensity per m^2 floor area was equal in both countries, the difference in final residential consumption is

at least partly due to residential living spaces per capita in Germany being about 50% larger than in Korea (Jiang et al. 2016).

In both countries, heating makes up the largest share of energy consumption in buildings, accounting for 80% of residential final energy consumption in Germany and 70% in Korea. Space cooling plays a much more significant role in Korea than in Germany, especially in the services sector where it accounts for around 34% of final energy consumption. Another important difference between both countries is the age of the building stock: In Germany, 64% of the residential building stock is older than 40 years, while in Korea only 28% of the overall building stock is older than 35 years (see chapter 3.3 and chapter 4.2.5). Refurbishment of old buildings thus plays a very important role in Germany for achieving significant reductions in energy demand.

In Germany, final energy demand for residential space heating has been decreasing in recent years due to improved energy standards, refurbishment and mild winters. In Korea, the energy consumption of buildings is still rising, which can be partly explained by the increasing sizes of newly constructed buildings (see chapter 3.3 and chapter 4.2.5).

Both, Germany and Korea have set themselves targets for increasing energy efficiency in their building sector. In Germany, the primary energy demand in buildings is to sink by 80% by 2050 compared to 2010 and non-renewable primary energy demand in buildings by 55% until 2030 compared to 2008. One of the ways Germany intends to achieve this is by doubling its renovation rate from currently around 1% to 2% p.a. (see chapter 3.1). Korea aims at reducing the energy intensity of buildings by 38% until 2040 compared to 2017 (see chapter 4.1).

Both countries have mandatory minimum energy efficiency standards for building energy performance, but their approach differs in some important aspects. **In Germany, the minimum standards apply regardless of building size and purpose.** As outlined in chapter 3.3.1, the GEG takes the performance-based approach. It determines the maximum primary energy consumption of new buildings and substantial refurbishments as 75% of that of the reference building. It simultaneously uses a prescriptive approach by setting minimum requirements for heat insulation of building envelope and energy performance of individual building components. This also corresponds to Germany's definition of the zero-energy building standard which all new buildings will have to meet from 2021 onwards.

By contrast, Korea's Energy Saving Design Standards only apply to buildings with a floor area larger than 500 m². However, it has to be kept in mind that the housing situation in the two countries is very different. While in Germany 65.1% live in buildings with only one unit (LSN 2014), 74.5% of Korean residential buildings consist of several units (Kostat 2016). The Design Standards use a prescriptive approach, specifying the requirements for individual building components, in combination with more flexible EPIs. Apart from this, large as well as public buildings have to meet additional requirements. Public buildings over 500 m^2 as well as office buildings and research and educational facilities above 3,000 m^2 must have their energy consumption calculated by Korea's official tool. Residential buildings with more than 30 apartment units must comply with a stricter set of criteria, also including an optional performance-based approach, and have to be built as "eco-friendly houses". Following the Korean roadmap concerning zero energy buildings, stricter regulations will be introduced over the following years. This implies that, in addition to the mandatory Energy Saving Design Standards, buildings also have to reach high certification levels as part of a performance approach. Namely, public buildings over 500 m² and private buildings with more than 1000 m² or 30 households have to achieve a ZEBC certification level of 5 or more starting in 2025. After 2030, these certifications will become mandatory for all buildings over 500 m² (see chapter 4.3.1).

Both countries assign a role model function and higher building standards to public buildings. In Germany, new non-residential buildings owned or used by public authorities are already required to fulfil nearly zero energy standards since 2019. These will only become mandatory for all new buildings from 2021. Starting in 2022, all new federal buildings will have to comply with an even stricter standard EH 40 (maximum of 40% of the primary energy consumption of the reference building). Additionally, binding 2030 and 2050 renovation targets for the existing federal building stock are to be set by a decree, where the EH 55 standard will have to be achieved (see chapter 3.3.1). In Korea, all new public buildings over 1,000 m² already have to meet the Zero Energy Building standard and the Green Building Certification Scheme is only mandatory for public buildings (see above, and chapter 4.3.1). With its "Rationalization of Energy Use by Public Institutions Initiative", the Korean government also encourages reducing energy use in public buildings, e.g. in lighting and cooling and heating (see chapter 4.3.4). In terms of **carbon pricing**, the Korean ETS already covers the building sector, while in Germany the sector will be addressed by the national carbon pricing scheme starting in 2021 (see chapter 3.3.2 and chapter 4.3.2).

Both countries apply a broad variety of financial incentives and support programmes. Germany offers low-interest loans and investment grants for energy efficient construction and renovation and for deploying renewable energy systems for heating and cooling. Grants are also provided for replacements of inefficient heating and ventilation, for installing highly efficient pumps and hydraulic balancing and for the replacement of oil boilers. Further, individual energy efficiency measures in owner-occupied housing, including energy-related construction supervision and planning, are tax-deductible since 2020 (see chapter 3.3.3). In Korea, local tax rebates are available for the property and acquisition tax depending on the building's BEECS and Green Building Certification level. Subsidies are available for renewable energy installations in certified Zero Energy Buildings, and for high-efficiency electric devices (e.g. for inverters, LED lamps with converters and electricity load management equipment). Soft loans are available for companies that invest in energy conservation measures in their buildings; for private initiatives aiming at reducing heating and cooling consumption of existing buildings, a 5-year interest rate subsidy is provided by the government (see chapter 4.3.3).

Both countries provide **professional advice and support** for energy efficiency measures in buildings. In Korea, the Zero Energy Support Centre provides technical support for planning of new buildings aiming for a Zero Energy Building certification (see chapter 4.3.4). **In Germany, supported consulting services are more extensive**: For the construction of new energy efficient buildings, 50% or up to 4,000 EUR in energy efficiency consulting fees are paid by KfW. Furthermore, 80% of the consultancy fees for a comprehensive on-site energy consulting is provided for all existing residential buildings undergoing refurbishment; subsidised energy advice is also provided for tenants and owners, at no cost for the basic check and other checks for 30 EUR. In some cases, e.g. when the building is sold, energy advice is mandatory with the costs being borne by the state (see chapter 3.3.4).

Korea and Germany both offer **online tools** that provide building owners with information on their building's energy efficiency. In Germany, the refurbishment calculator also provides concrete recommendations for refurbishment options based on the evaluation. In addition, several software tools are available which provide information of the efficiency potential of large air conditioning and ventilation systems in non-residential buildings (see chapter 3.3.4 and chapter 4.3.4). Both countries also provide **advice** for reducing energy consumption in household electronics and organize **campaigns** for educating and informing the public on energy efficiency and conservation. Examples include the *Friendly Store Campaign* in Korea and *Germany Makes it Efficient* in Germany (see chapter 3.3.4 and chapter 4.3.4).

6 Summary and recommendations for Korean-German cooperation

By comparing the respective energy efficiency policies of Germany and Korea in the industry and buildings sectors, this study has shown that both countries use a similar set of policy instruments. These consist of regulatory measures, market-based instruments such as subsidies and financial incentives, provision of information and trainings, and other voluntary measures. However, the emphases, scopes, and details vary.

With regard to energy efficiency in industry, Germany makes wide use of obligatory regular energy audits. While Korea also uses mandatory energy audits, it also demands its three energy distributors to achieve mandatory yearly reduction targets, holding them responsible for energy efficiency reductions, which is different from the German solution. Germany could have chosen a similar approach when transferring Article 7 of the EU EED to the national law, but opted instead for a policy mix with less obligations and a stronger emphasis on voluntary measures.

The Korean government goes even further in using regulatory, hands-on approaches. For example, it mandates the largest companies (168 in total in 2018) to participate in the Energy Target Management System and negotiate individually the GHG and energy reduction targets with the government. Korea also requires companies aiming to develop a new site to present and negotiate their Energy Use Plan before work can begin.

Both Germany and Korea have implemented an ETS covering the energy-intensive industries and for Korea, amongst others, the building sector. Germany, in addition to the EU ETS, implemented a national CO_2 pricing system that will start in 2021. It primarily aims at the transport and heating sectors and will morph into a national emissions trading scheme in 2026.

In summary, Korea's toolbox of regulatory measures addressing energy efficiency in industry is more diversified and also includes instruments addressing the energy supply side. In addition, it employs a stricter regulation of energy intensive companies and projects. Germany is focusing on the demand side and relying more on obligatory energy audits than Korea.

Another important difference can be observed with regard to the incentives both countries are offering to its companies for implementing voluntarily energy efficiency measures. With its very broad approach of different forms of financing and high grant levels as well as its renewable energy levy and energy tax exemptions for energy intensive companies (*Besondere Ausgleichsregelung*) and companies from the manufacturing sector (*Spitzenausgleich*), respectively, Germany provides a significant amount of different incentives. Korea provides a lower level of financial compensation in its incentive programmes. Furthermore, the renewable energy levy exemption in Germany is only linked to implementing an environmental or energy management system, not to actually improving energy performance.

In Germany, the 2016 Climate Action Plan 2050 introduces yearly sectoral GHG emission reduction targets. The *Klimaschutzprogramm 2030* obliges the responsible ministry to promptly implement corrective measures if a sector fails to meet them. These corrections might induce a stronger emphasis on regulatory measures in the future. Then, an exchange about Korea's experiences could be helpful, even though the relationship between the government and business has traditionally been different in Korea.

In addition, Germany can look towards Korea for further voluntary approaches, as Korea is currently employing a wider set of incentives. Two examples with potential relevance would

be the Energy Champion and the Pilot Project Voluntary Energy Efficiency Agreements that reward companies willing to improve their energy performance more than required.

Korea could also take a closer look at some German approaches, for example, the comparatively wider deployment of obligatory energy audits that offer a wide range of synergies with other instruments, such as subsidies for implementing energy efficiency measures or energy efficiency networks. Furthermore, it could be potentially interesting to consider the instruments that incentivize companies to implement and certify an environmental or energy management system. Except for energy efficiency, future German (and European) efforts to create a regulatory environment for decarbonizing industrial sectors could also be interesting. For instance, the efforts for greening the steel industry, and to ensure competitiveness might be of special interest, due to Korea's large steel sector with its prominent role for exports.

Also, with regard to the energy efficiency policy in the building sector, both countries use a similar set of instruments. They are based on the minimum energy efficiency requirements laid out in the respective building codes. Both countries also have a CO_2 pricing mechanism covering the building sector; employ energy efficiency standards for buildings; prescribe a role model-function for public authorities; and are in the process of making zero energy buildings the minimum standard.

A notable difference is that in Korea, the minimum energy efficiency requirements do not apply to buildings with a gross living area under 500 m^2. As the average energy consumption of buildings in Korea is on an upward trend, further measures or the further strengthening of existing instruments might be required. While Germany has a long-standing experience with performance-based approaches such measures have only recently been extended in Korea. Therefore, an exchange might be helpful, in order to improve the systems further.

Both countries apply a broad variety of financial incentives for energy efficient construction and refurbishments, e.g. in form of low-interest loans and subsidies. One challenge particular to Germany is its comparatively older building stock that needs an increase of refurbishment rates to achieve the building sector's GHG emission reductions targets. Therefore, the German government is providing generous financial support for expert consulting services. In some cases, they are obligatory, e.g. for new owners of residential buildings. In contrast, Korea's financially supported consulting services concentrate more on new buildings, which are supported in Germany as well. As the refurbishment of the existing building stock is also important for Korea to achieve its climate goals, Germany's experiences in this field might be of interest.

In summary, both Germany and Korea have recognised the importance of energy efficiency and have implemented sophisticated policies to pursue improvements in the industry and buildings sector. Energy efficiency also was selected as one of the focus topics of the **Korean-German Energy Partnership** established in December 2019. With this in mind, the following cooperation opportunities in the industry sector have been identified for the two countries:

- Sharing of experiences and joint assessment on the design, monitoring and results of **mandatory energy audits** in both countries;
- Sharing of experience and comparative assessment of voluntary approaches including **financial and fiscal incentives, e.g.**
    - Comparison of the levels, conditions and addressees of grants and low-interest loans;

  - Knowledge-transfer regarding the **competitive tendering programme,** where the German experience might be of interest for Korea to incentivize ambitious and complex projects with efficient resource allocation;
  - The (partial) exemption from taxes and levies or some different kind of tangible incentive **as reward for implementing and certifying an energy management system according to ISO 50001** or equivalent. A strong enough incentive might help spur the generally lagging implementation of energy management systems in Korea (Germany currently has over 13,000 ISO 50001 certified sites, while Korea has 107; ISO 2020); in addition, by contributing to efficient energy use, it would help to keep the energy expenses down even if the prices increase in the future.

- Sharing of experiences and insights on impacts of **support options for SMEs**, as both countries provide financial support as well as subsidised technical expertise;
- Establish a **bilateral energy efficiency network** or a slimmed-down version where existing energy efficiency networks of both countries can (regularly) share experiences and insights on state-of-the-art technological solutions and expertise.

With regard to energy efficiency in the buildings sector, the following cooperation opportunities have been identified:

- Sharing of experience on the **design of energy efficiency standards and certification systems** for new and existing buildings in both countries;
- Comparison and impact assessment of **financial incentives and support programmes** for increasing energy efficiency in buildings;
- Sharing of experience on designing professional **advice and support services** for energy efficiency measures. Here, consulting services for refurbishments for tenants and building owners in Germany might be of interest for Korea, while the Zero Energy Support Centre for new buildings in Korea might be interesting for Germany. In addition, a comparison of implemented **online tools** for building owners that provide information and recommendations on refurbishment options could be a relevant topic for both sides. Similarly, an exchange on existing **information campaigns on energy efficiency and conservation** for the public might also be valuable for both sides.

Finally, a set of overarching topics, also addressing but not being limited to the sectors industry and buildings, offer some possibilities for cooperation as well:

- Sharing of experience on the existing **ETS schemes and carbon pricing**
- Sharing of technical and policy insights on further measures for **decarbonizing the heating of buildings as well as industrial heat** such as residual heat utilisation, renewable heat, heating networks and seasonal heat storage;
- **Sector coupling**, hydrogen technologies and synthetic fuels in industry and buildings;
- **Energy efficiency in the transport sector**, which was not part of this study, could be discussed and evaluated in a separate comparative study.

In addition to bilateral workshops on the mentioned (sub)topics, a joint show-case project might also present an opportunity for cooperation within the Korean-German Energy Partnership. One possibility could be, for instance,

- to refurbish an old public building (a school, university building, town hall, etc) in Korea with German companies providing guidance and expertise;
- to jointly develop a zero-energy building that could be, used for a purpose related to the energy transition (e.g. information centre on energy efficiency and support).

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