

# The European Union – Kazakhstan Sustainable Energy Days 2024

Lectures on Sustainable Energy for Teachers and Students

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## The contribution of the German building sector to achieve the 1.5 °C target

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76131 Karlsruhe, Germany  
<https://www.tmb.kit.edu/english/index.php>

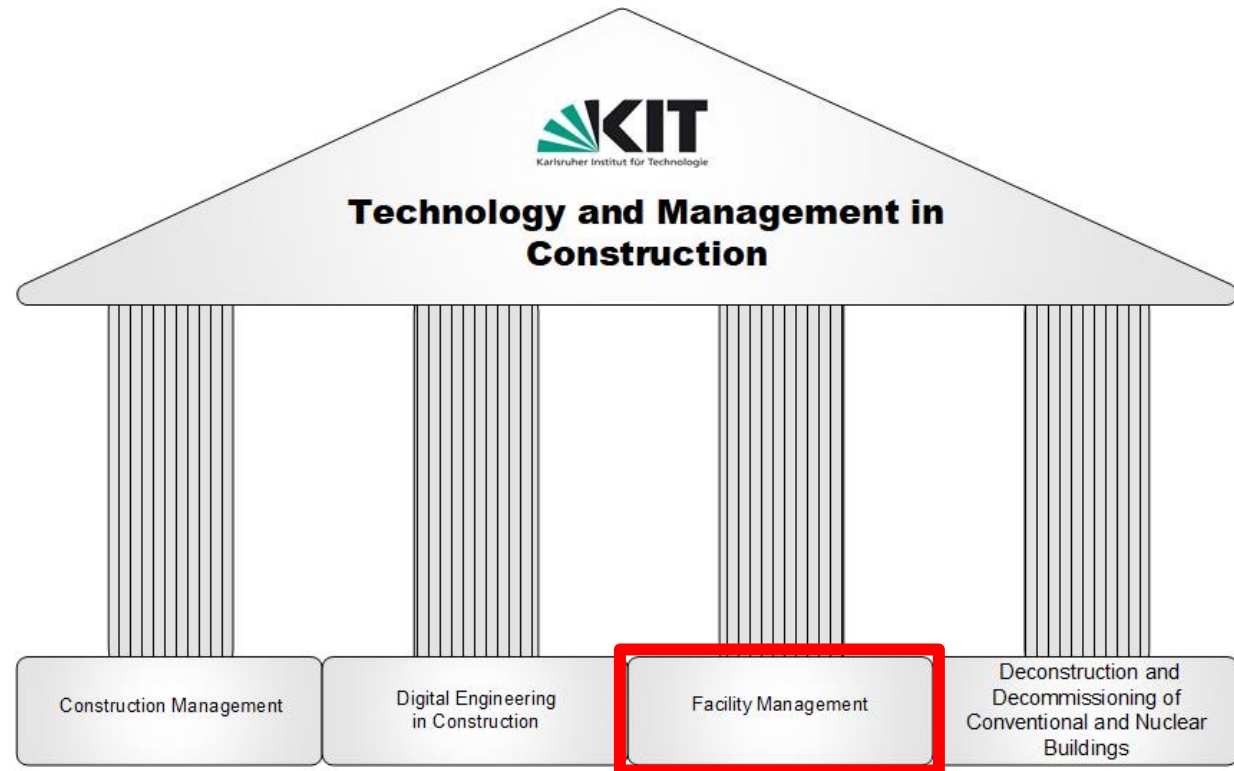


# Contact details



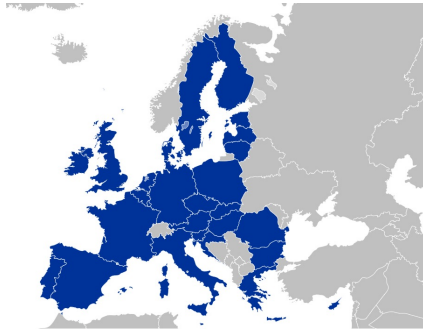
**Institute of Technology and  
Management  
In Construction (TMB)  
Karlsruhe Institute of  
Technology (KIT)  
Professorship Facility  
Management**

Building 50.31  
Gotthard-Franz-Str. 3,  
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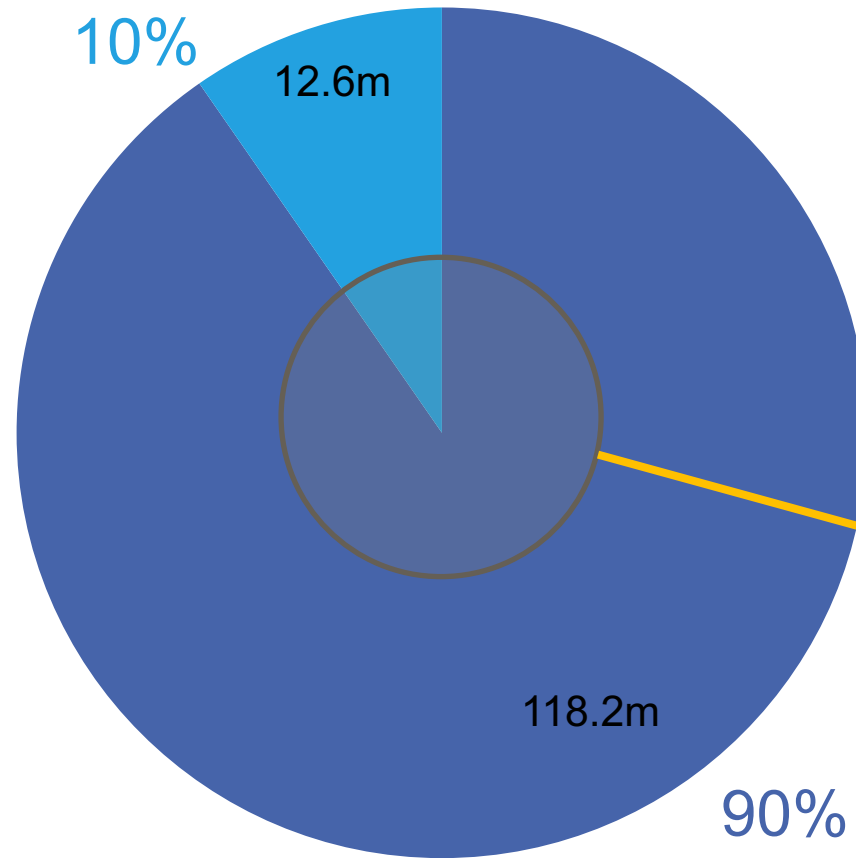
# Building Stock EU and Germany

EU-28



[https://commons.wikimedia.org/wiki/File:EU28-2013\\_European\\_Union\\_map.svg](https://commons.wikimedia.org/wiki/File:EU28-2013_European_Union_map.svg)

Number of buildings (Total of 130.9m)

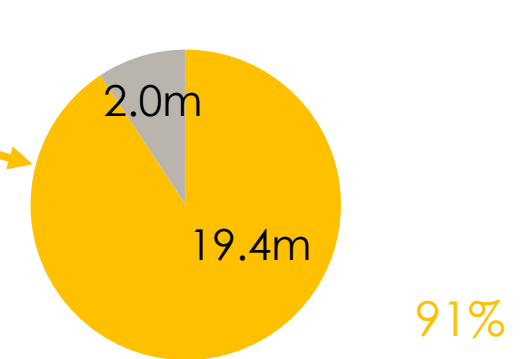


■ residential ■ non-residential

Germany



Number of buildings (Total of 21.4m)

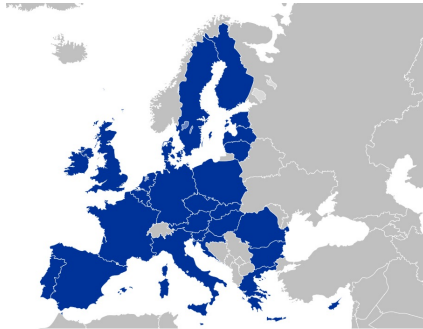


■ residential ■ non-residential

Source: see [Appendix B](#)

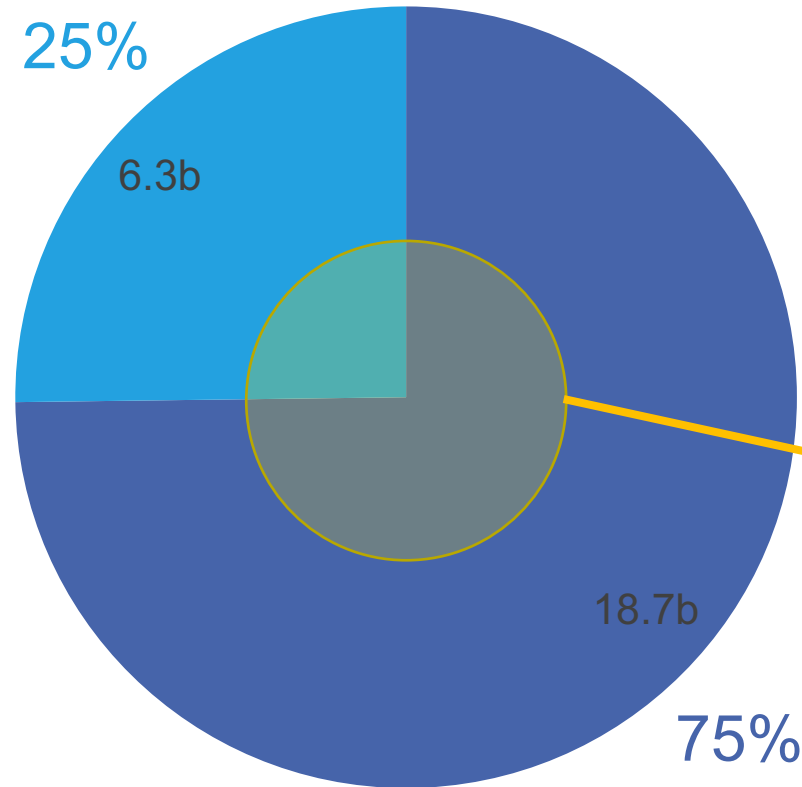
# Building Stock EU and Germany

EU-28



[https://commons.wikimedia.org/wiki/File:EU28-2013\\_European\\_Union\\_map.svg](https://commons.wikimedia.org/wiki/File:EU28-2013_European_Union_map.svg)

m<sup>2</sup> useful floor area (total of 25b m<sup>2</sup>)

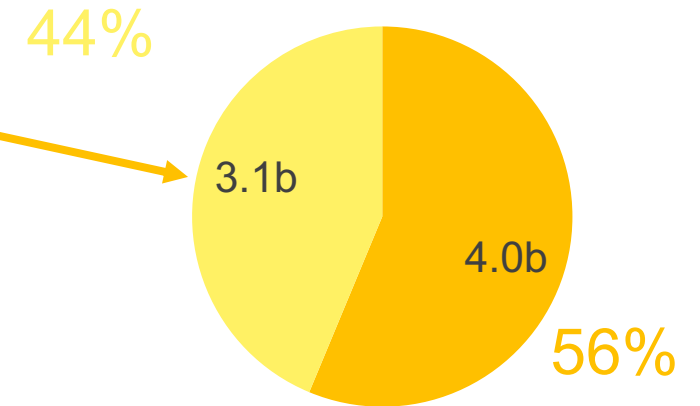


■ residential ■ non-residential

Germany



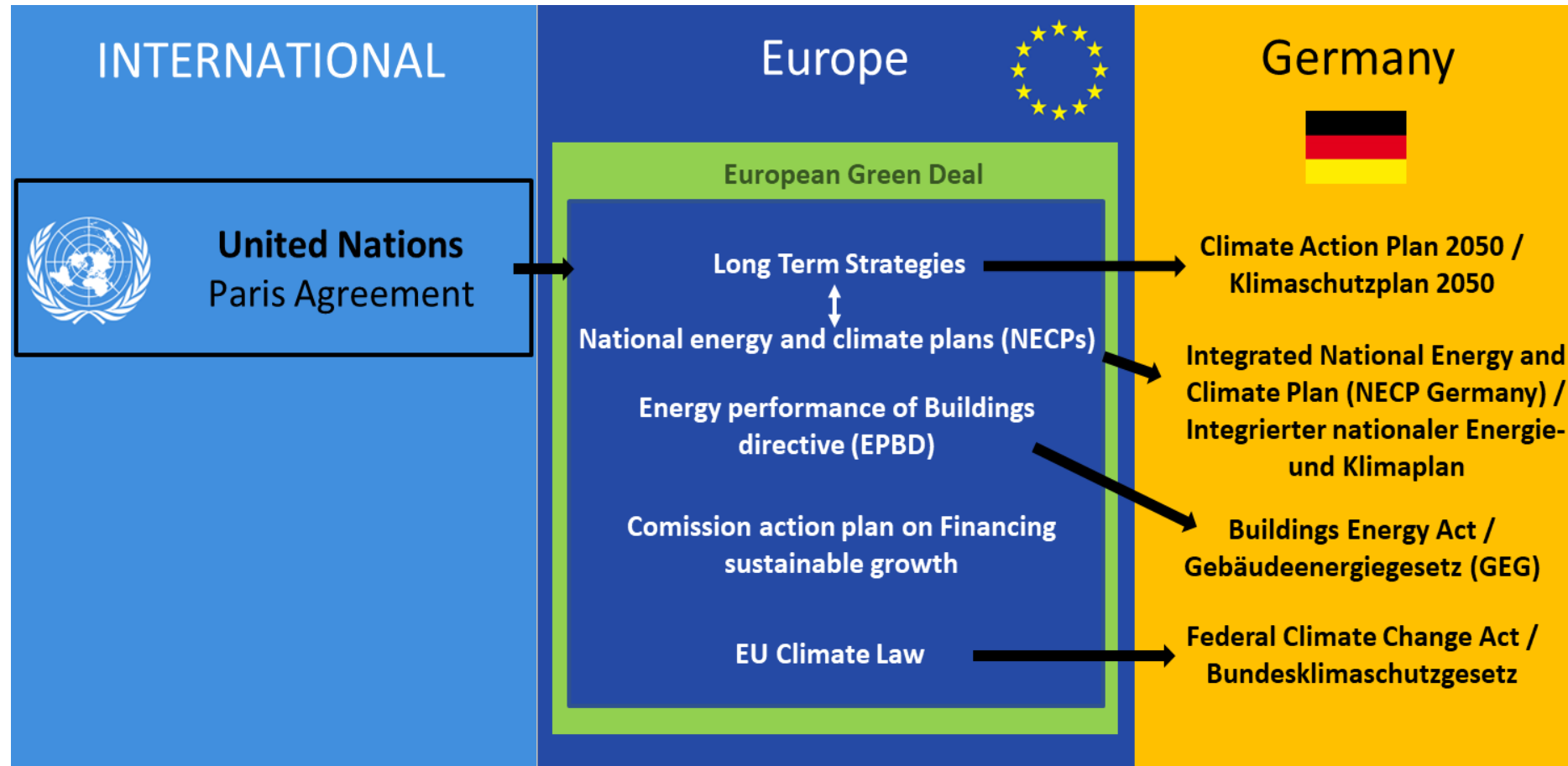
m<sup>2</sup> useful floor area (total of 7.1b m<sup>2</sup>)



■ residential ■ non-residential

Source: see [Appendix B](#)

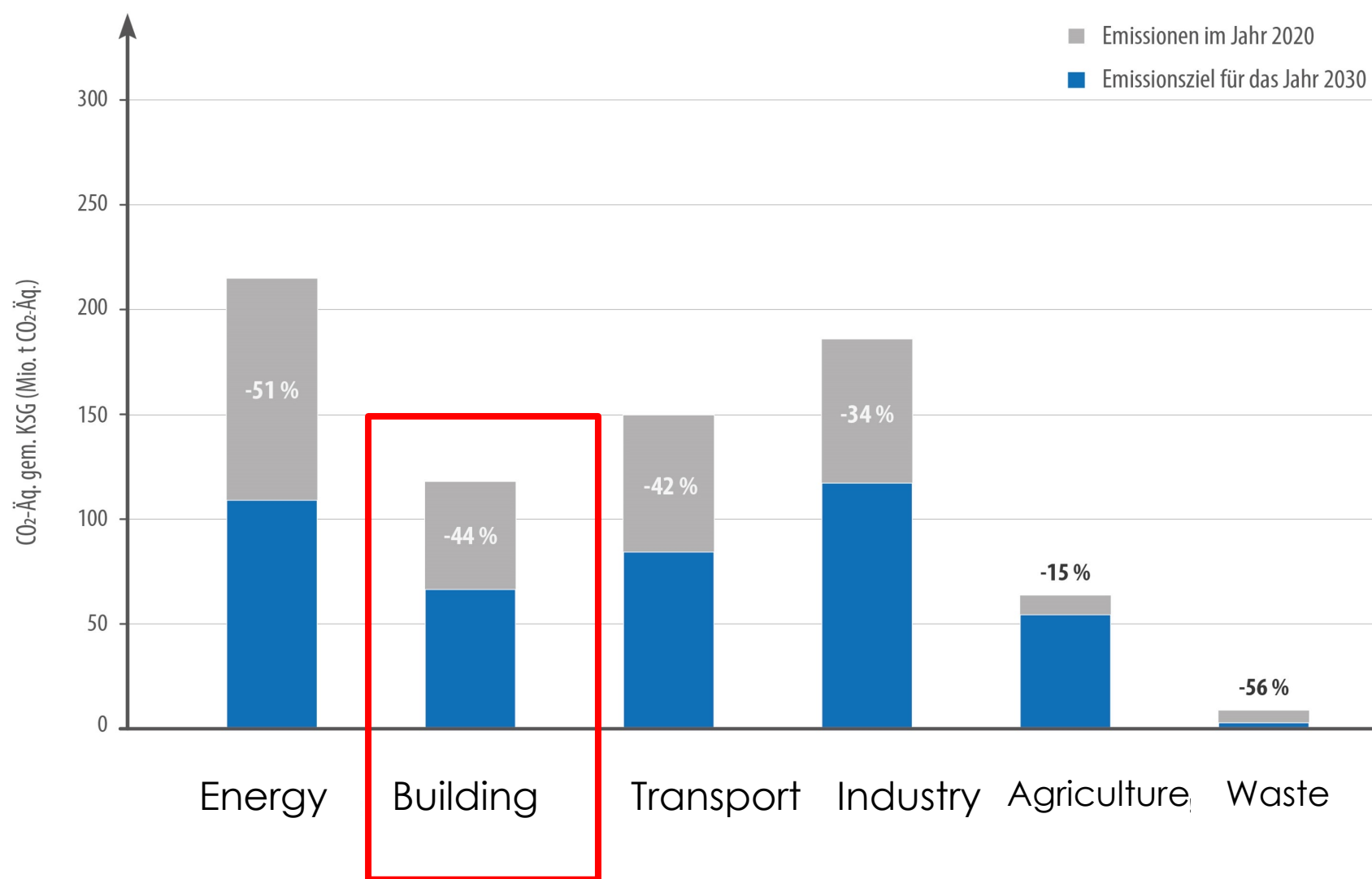
# International and national procedures – German perspective\*



\*simplified illustration, not complete

Source: see [Appendix B](#)

# GHG emissions reduction goals according to the Federal German Climate Change Act (Version 2021)

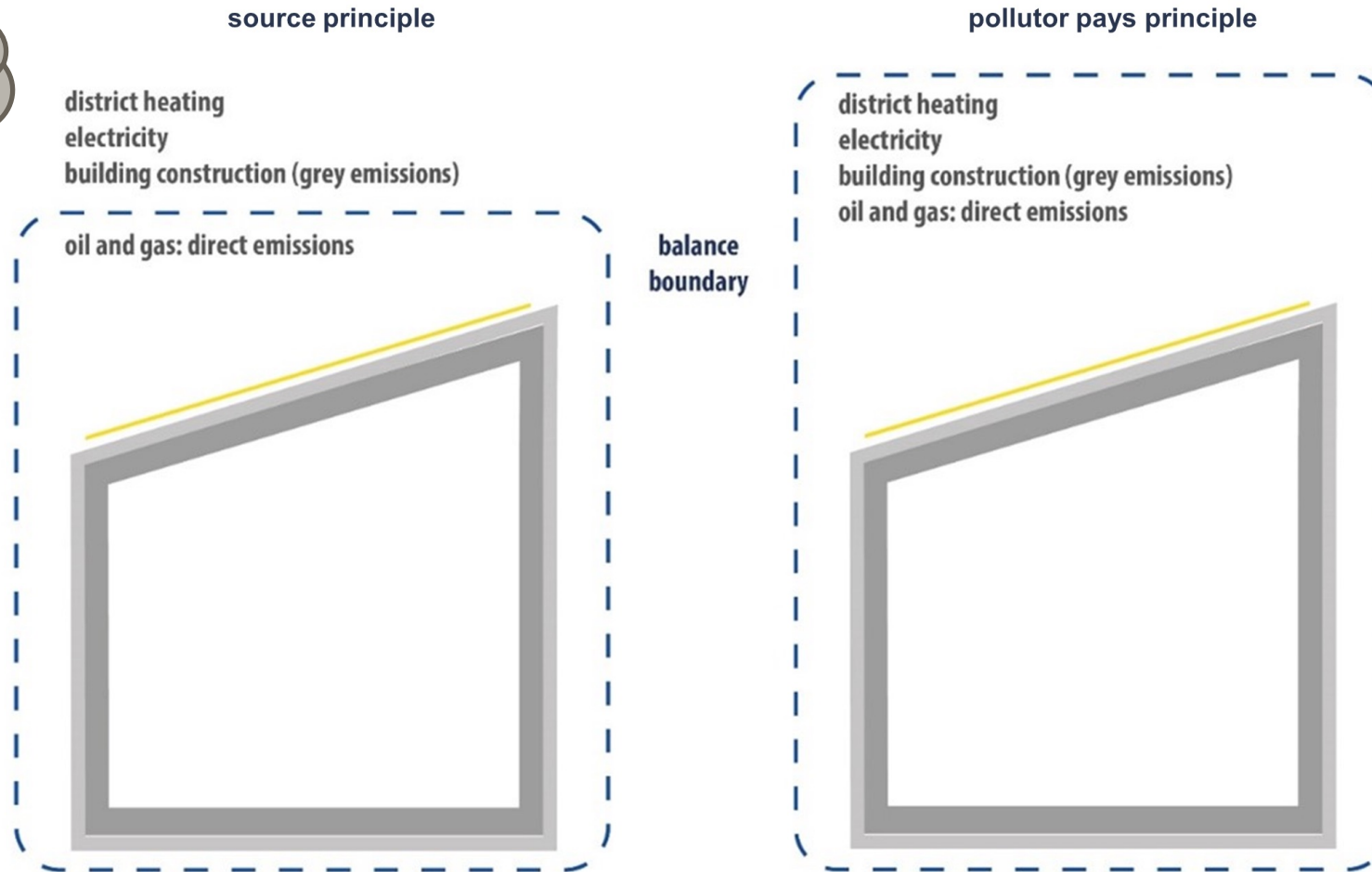


“Climate neutral by 2045“

Source: see [Appendix A](#)

# Illustration of emissions assessment framework under source and polluter pays principle for the building sector

Where is the chimney located?



Source: see [Appendix A](#)



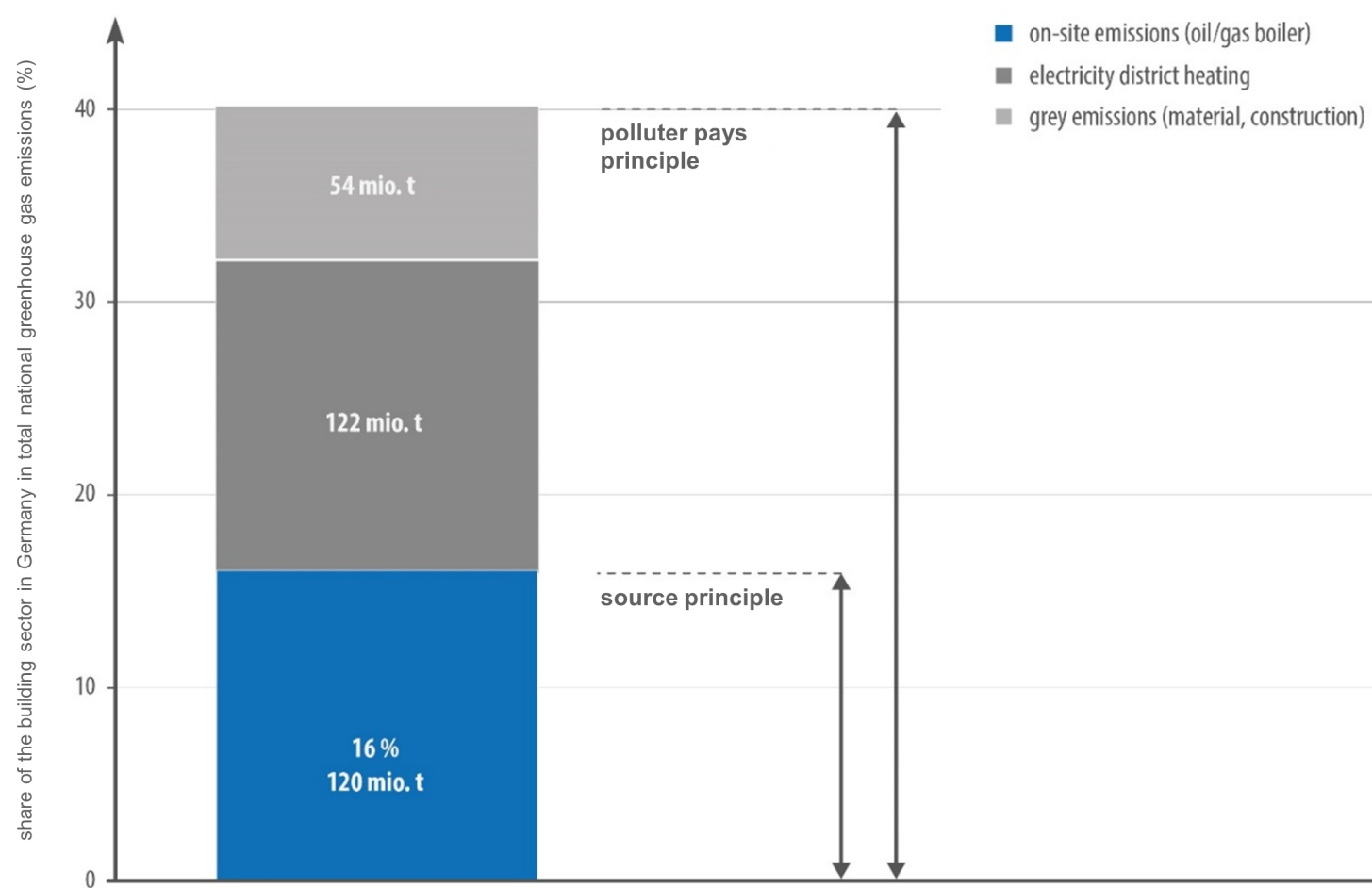
# GHG emissions in the building sector differentiated according to the source principle and the polluter pays principle and their share in total national GHG emissions in 2020

Total GHG emissions in Germany (2020): 739 mio. t

GHG emissions building sector according polluter pays principle: 296 mio. t

\*This share of 40% explicitly does not include the electrical user-specific applications in non-residential buildings which go beyond heating, ventilation, cooling and lighting.

Source: see [Appendix A](#)



Data from:  
<https://www.bmuv.de/pressemitteilung/treibhausgasemissionen-sinken-2020-um-87-prozent>

[https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?\\_\\_blob=publicationFile&v=3](https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?__blob=publicationFile&v=3)

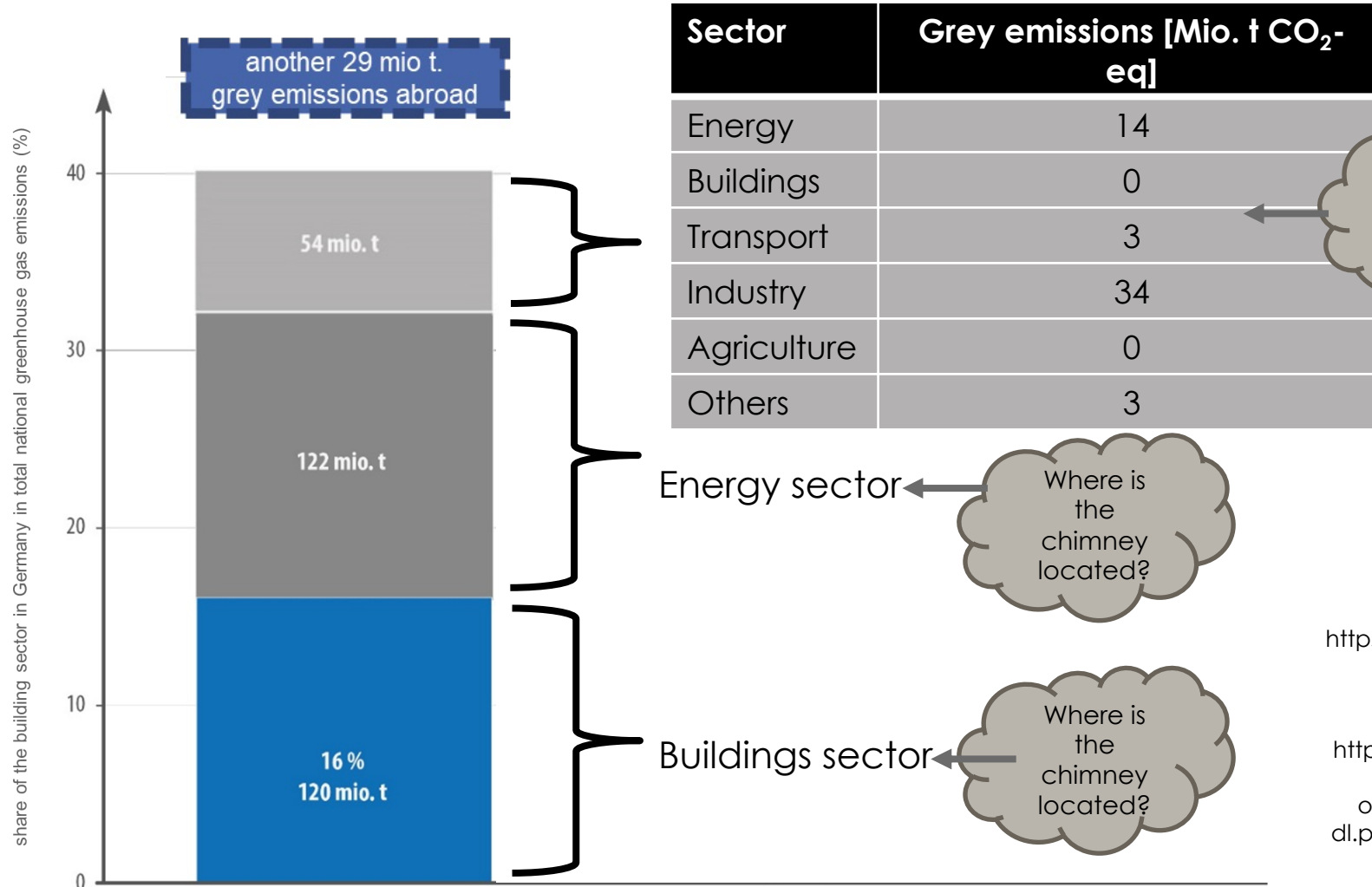
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Source: see [Appendix A](#)



Where is the chimney located?

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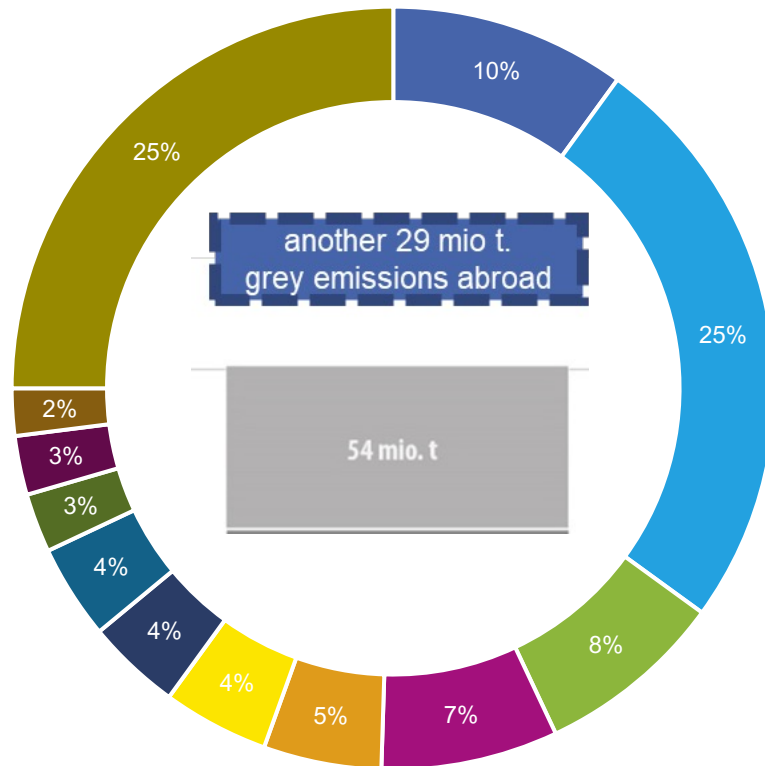
Where is the chimney located?

Data from:  
<https://www.bmuv.de/pressemitteilung/treibhausgasemissionen-sinken-2020-um-87-prozent>

[https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?\\_\\_blob=publicationFile&v=3](https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?__blob=publicationFile&v=3)

# GHG emissions in the building sector differentiated according to the source principle and the polluter pays principle and their share in total national GHG emissions in 2020

Share within Grey Emissions



- Direct emissions on site
- Production of cement, lime and adhesives
- Production of plastic products
- Production of metal products
- Production of electrical machines and devices
- Power production with coal
- Petroleum Refineries
- Recycling of ash in clinker
- Production of wood and wood products
- Mining of sand and clay
- Steam and hot water supply
- Other supply chain

Data from:

[https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?\\_\\_blob=publicationFile&v=3](https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2020/bbsr-online-17-2020-dl.pdf?__blob=publicationFile&v=3)

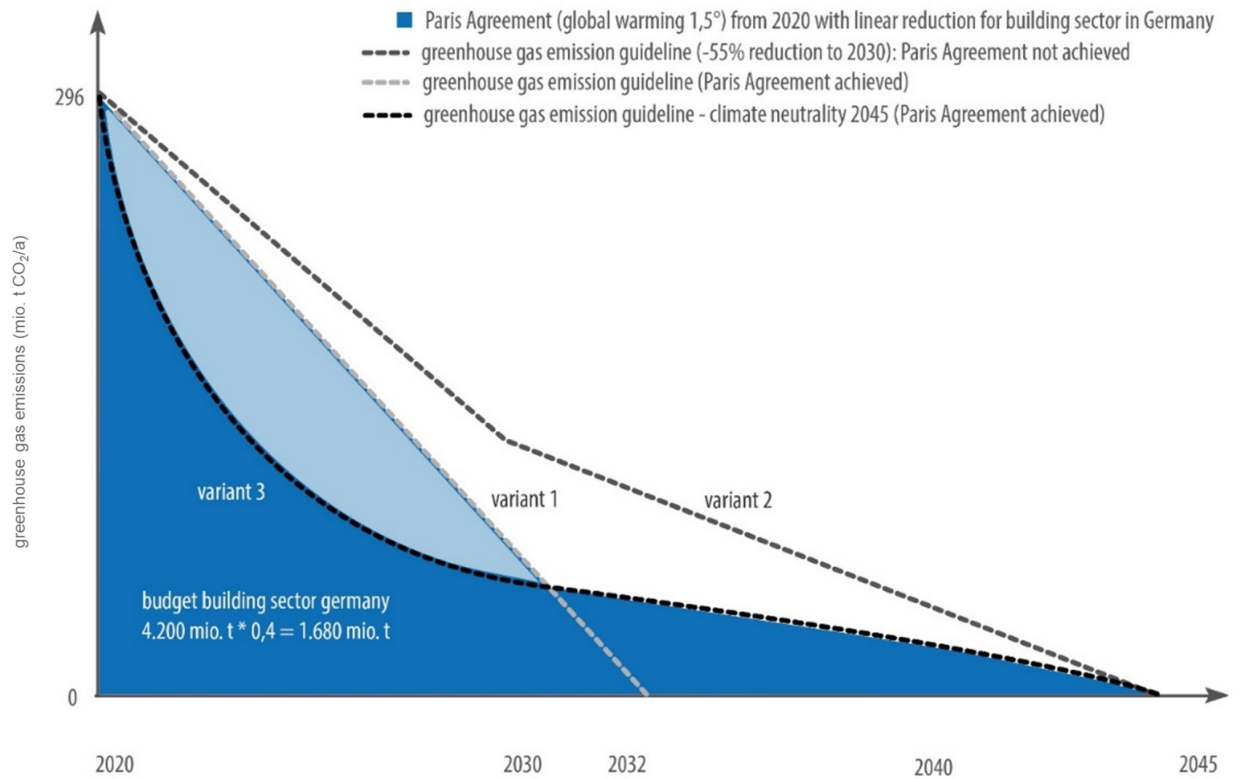
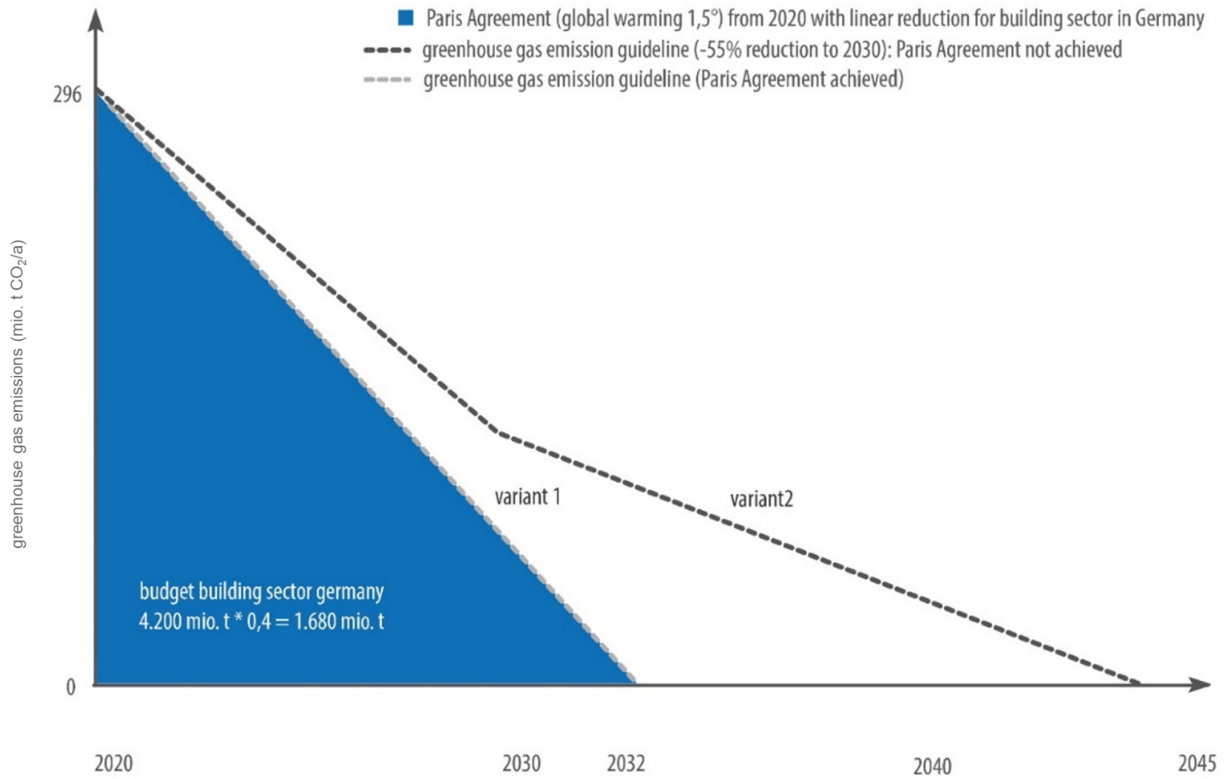
# Building sector transformation recommendations for action sorted by their main addressed subjects

1. Simplify and adjust regulations	2. Introduce GHG emissions budgets	3. Do not enforce stricter requirements on building envelopes	<b>Basic Framework</b>
4. Focus on renovation	5. Bring renovation roadmaps into broad application		<b>Renovation Strategy</b>
6. Decarbonise heating			<b>Linking sectors</b>
7. Fund fast-acting measures	8. Offer a special bonus for emission reductions actually achieved		<b>Funding</b>
9. Take the shortage of skilled workers and resources into account			<b>Ressources</b>
10. Achieve transparency by digitalisation using the Smart Rediness Indicator (SRI)	11. Set up a transparent national database of buildings		<b>Digital Transformation</b>

Source: see [Appendix A](#)

# GHG emissions paths to comply with Paris climate protection targets in Germany (schematic)

## 2. Introduce GHG emissions budgets

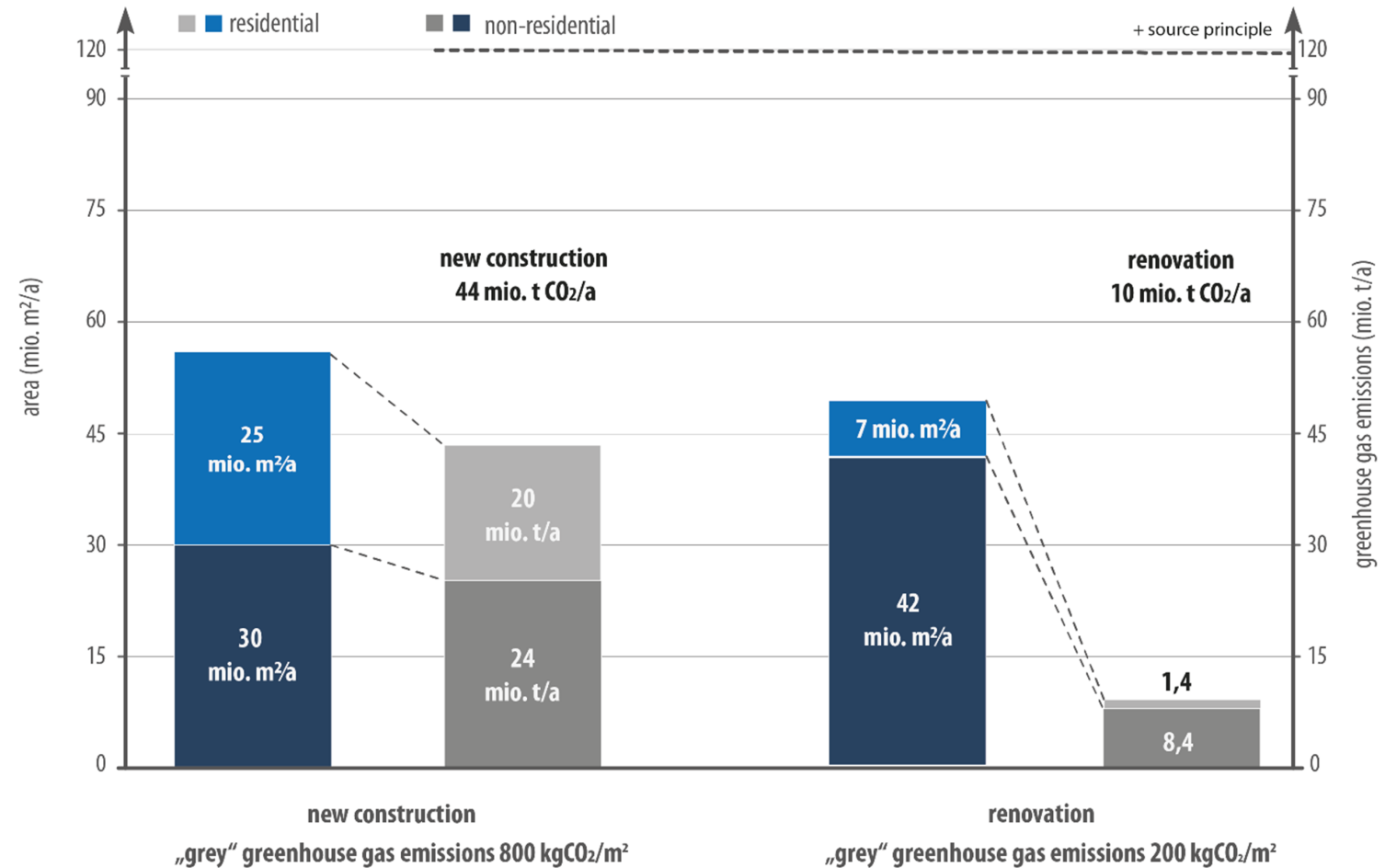


Source: see [Appendix A](#)

# Grey GHG emissions in the building sector in 2020, comparison of new buildings and renovation

4

4. Focus on renovation

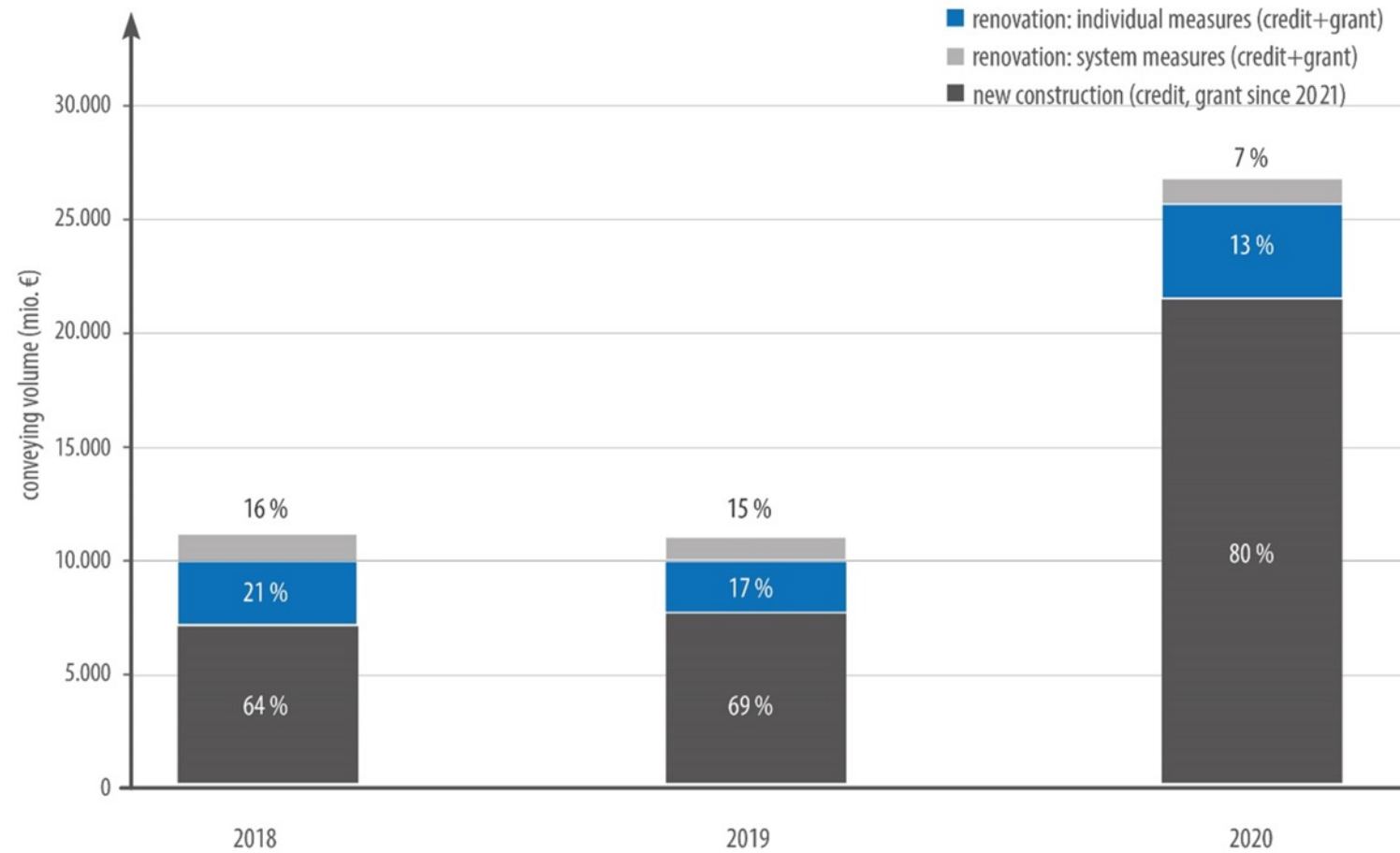


Source: see [Appendix A](#)

# Development of annual investment volume for energy-efficient buildings (systemic measures) for renovated, new buildings and individual measures in renovation

4

4. Focus on renovation

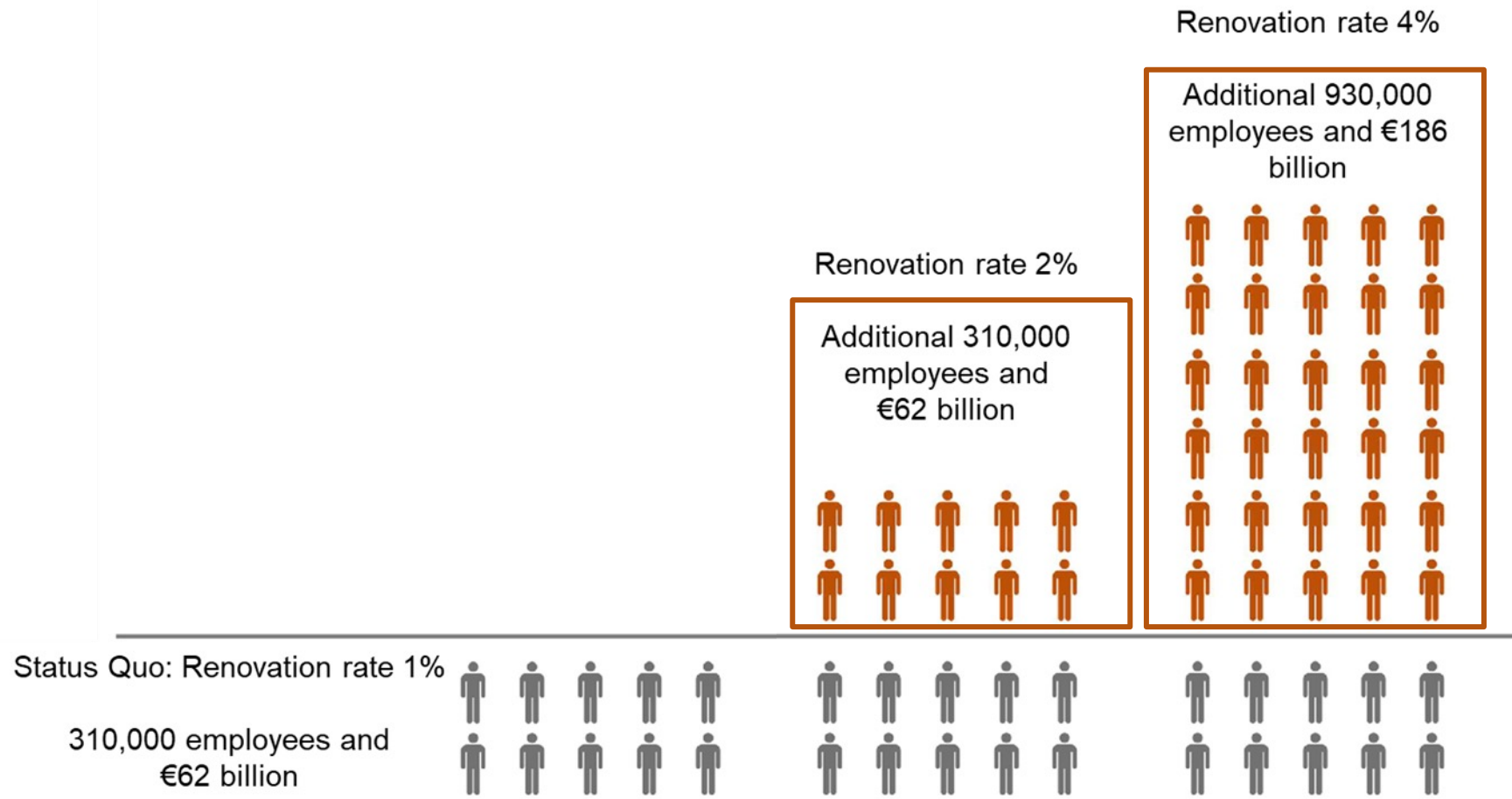


Source: see [Appendix A](#)

# Take shortage of skilled workers and resources into account - employees and construction volume

9

9. Take the shortage of skilled workers and resources into account



Source: see [Appendix A](#)



9

9. Take the shortage of skilled workers and resources into account

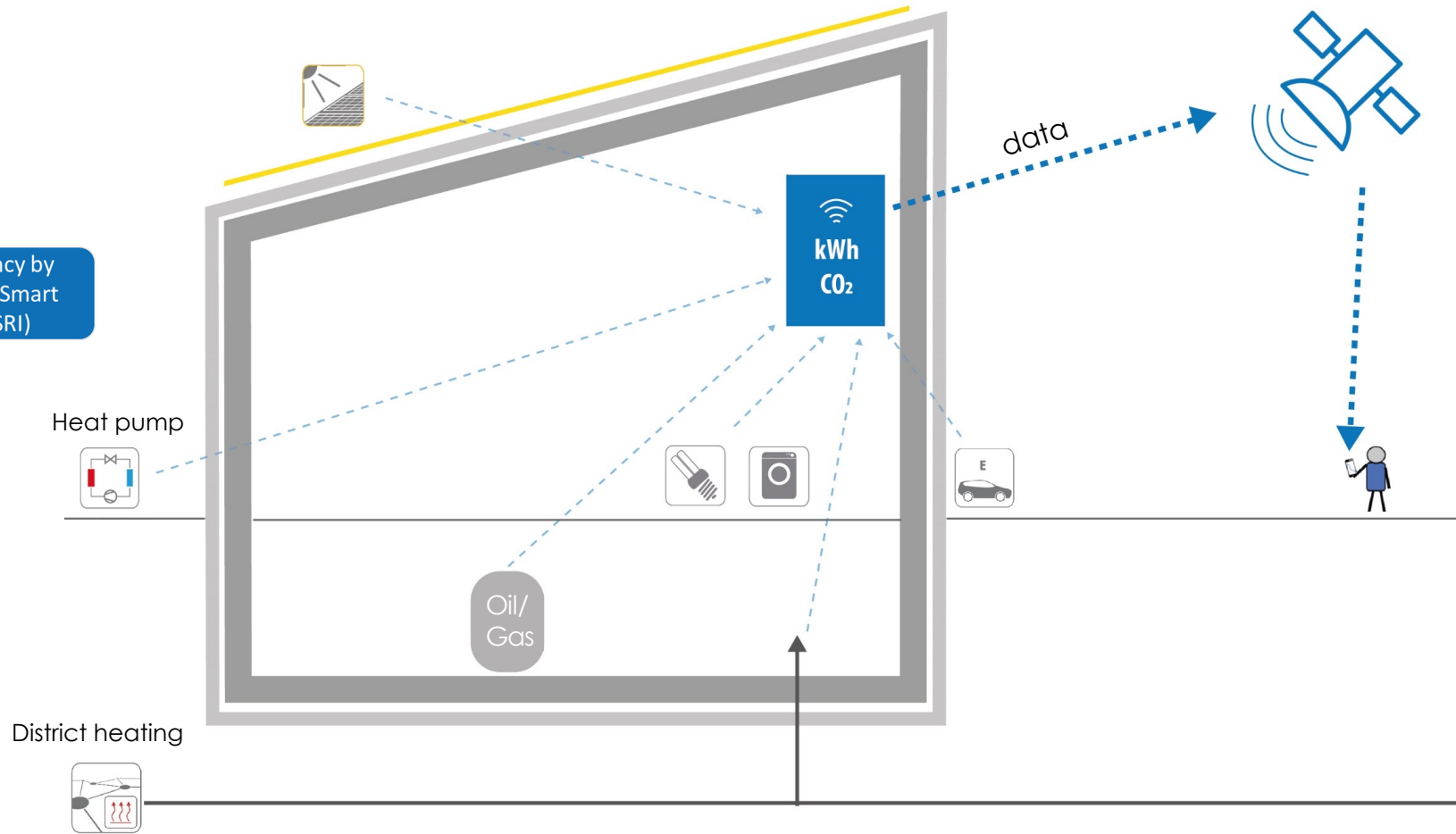
- Cost-effective GHG measures for emissions optimisation, with low costs per avoided metric tonne GHG emission, such as optimising operations and decarbonising the energy supply must be promoted and implemented.
- Urban mining or the cradle-to-cradle principle can help to put durable building materials back into the circular economy.
- Towards personnel resources:
  - Vocational training and further education initiatives
  - Qualified immigration
  - Creation and use of innovative construction methods (such as serial renovation)
  - Increase in building technology efficiency through standardisation and system solutions.
  - Development of additional resources

Source: see [Appendix A](#)

# Solution Proposal

10

10. Achieve transparency by digitalisation using the Smart Rediness Indicator (SRI)



Transparency through digitalisation of operational data

Source: see [Appendix A](#)

# Smart Readiness Indicator

## An Overview



A single score classifies the smart readiness of the building



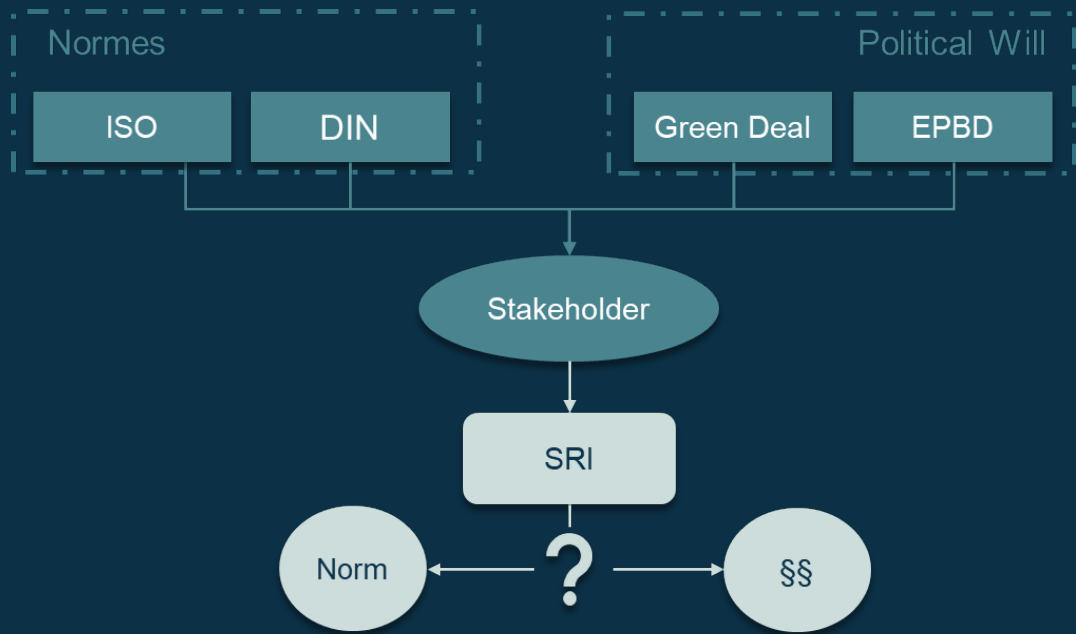
**Domains**



- Heating
- Domestic Hot Water
- Cooling
- Ventilation
- Lighting
- Energy
- Electric Vehicle Charging
- Dynamic Building Envelope
- Monitoring and Control

Domain	Energy efficiency	Maintenance and fault prediction	Comfort	User-friendliness	Well-being and health	Information to the user	Adaptation to the power grid
Heating							
Domestic Hot Water							
Cooling							
Ventilation							
Lighting							
Energy							
Electric Vehicle Charging							
Dynamic Building Envelope							
Monitoring and Control							

## Implementation?



Project at KIT: <https://smartreadinessindicator.com/>

Official Test Phase

# National building database

11

11. Set up a transparent national database of buildings

	building data	energy data	recommendations	qualified expert details	calculation input	comment
Germany	✓	✗	✗	✓	✗	only registration number of the energy certificate, building type, equipment or operation rating, region in which the building is located
Romania	✓	✓	✓	✓	✗	electronic copy of the energy certificate, all data are provided in the energy certificate
Slovakia	✓	✓	✓	✓	✗	all data are provided in the energy certificate
Lithuania	✓	✓	✓	✓	✓	All documents are used as inputs for calculation software, all data are provided in the Energy certificate
Greece	✓	✓	✓	✓	✓	all data are provided in the energy certificate .xlm und .pdf version of the ID card are stored in the database
Portugal	✓	✓	✓	✓	✓	The system requires 250 inputs, all data are provided in the energy certificate. provided. Qualitative / Quantitative information for benchmark
Hungary	✓	✓	✓	✓	✓	The system requires 80 input data, all data are provided in the energy certificate
France	✓	✓	✓	✓	✓	The system requires 105 input data, all data are provided in the energy certificate
Ireland	✓	✓	✓	✓	✓	The system requires 105 input data, all data are provided in the energy certificate

The German Federal Government's long-term renovation strategy is based on data from random checking of the EPC data containing less than 200,000 datasets taken between 2014 and 2018. This reflects less than 1% of the building stock in Germany.

[[https://www.bmwk.de/Redaktion/DE/Downloads/Studien/vorbereitende-untersuchungen-zur-langfristigen-renovierungsstrategie-ergaenzung.pdf?\\_\\_blob=publicationFile&v=6](https://www.bmwk.de/Redaktion/DE/Downloads/Studien/vorbereitende-untersuchungen-zur-langfristigen-renovierungsstrategie-ergaenzung.pdf?__blob=publicationFile&v=6)]

Buildings Performance Institute Europe (BPIE), Energy Performance Certificates across the EU: A mapping of national approaches, 2014. [Online]. Available: <https://www.bpie.eu/wp-content/uploads/2015/10/Energy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf> (accessed: Aug. 6 2021).

Source: see [Appendix A](#)

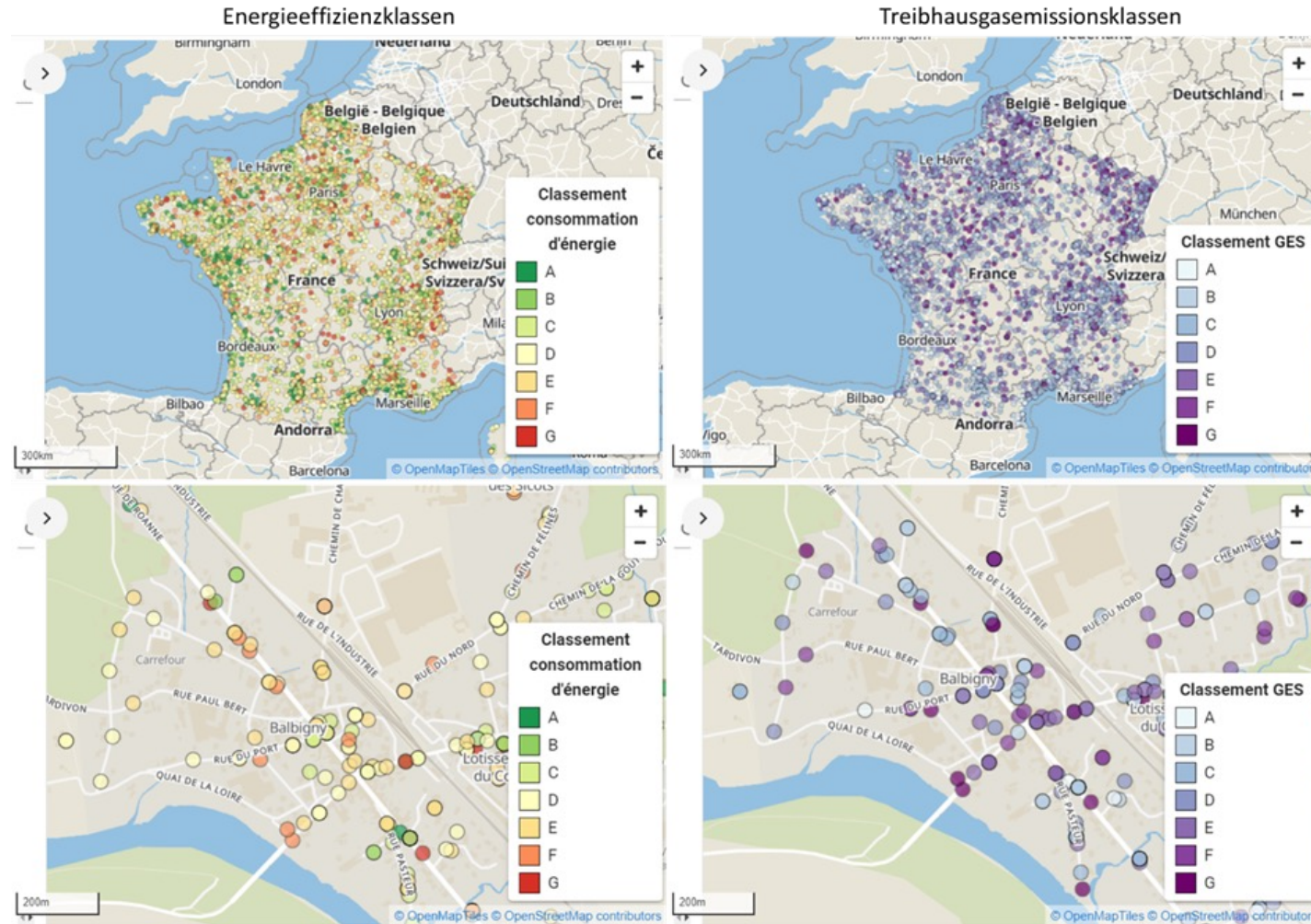
# Solution Proposal

## National building database

### Energy efficiency and GHG emissions (France)

11

11. Set up a transparent national database of buildings



Source: see [Appendix A](#)

# Building sector transformation recommendations for action sorted by their main addressed subjects

1. Simplify and adjust regulations	2. Introduce GHG emissions budgets	3. Do not enforce stricter requirements on building envelopes	<b>Basic Framework</b>
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10. Achieve transparency by digitalisation using the Smart Rediness Indicator (SRI)	11. Set up a transparent national database of buildings		<b>Digital Transformation</b>

Source: see [Appendix A](#)

- Scientific Paper: Carbon Management Volume 13 Issue 1 – Taylor & Francis

<https://www.tandfonline.com/doi/full/10.1080/17583004.2022.2133015>

## **Underlying work:**

- Study (long version – German)

<https://zia-deutschland.de/wp-content/uploads/2021/12/Verantwortung-uebernehmen-Gutachten.pdf>

- Study (extended executive summary – German)

<https://zia-deutschland.de/wp-content/uploads/2021/12/Verantwortung-uebernehmen-Extended-Executive-Summary.pdf>

A study in cooperation with Steinbeis Innovation Center siz energieplus and the German Property Federation (ZIA).

# Appendix B - Literature on building stock information

## ■ statistics on the german building stock:

Deutsche Energie-Agentur (Hrsg.) (dena, 2022) „DENA-GEBÄUDEREPORT 2023. Zahlen, Daten, Fakten zum Klimaschutz im Gebäudebestand.“ [https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2022/dena\\_Gebaeudereport\\_2023.pdf](https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2022/dena_Gebaeudereport_2023.pdf)

IWU (2021): ENOB:dataNWG dataNWG-Projektinfo 8.3: Forschungsdatenbank Nichtwohngebäude. Der Bestand der Nichtwohngebäude in Deutschland ist vermessen. Darmstadt: Institut Wohnen und Umwelt GmbH.  
[https://www.datanwg.de/fileadmin/user/iwu/210412\\_IWU\\_Projektinfo-8.3\\_BE\\_Strukturdaten\\_final.pdf](https://www.datanwg.de/fileadmin/user/iwu/210412_IWU_Projektinfo-8.3_BE_Strukturdaten_final.pdf)

## ■ statistics on the EU-28 building stock:

Gevorgian A., Pezzutto S., Zambotti S., Croce S., Filippi Oberegger U., Lollini R., Kranzl L., Müller A., European Building Stock Analysis, Bolzano, Italy: Eurac Research, 2021, ISBN 978-88-98857-68-5,  
[https://builthub.eu/fileadmin/user\\_upload/EBSA\\_WEB\\_2.pdf](https://builthub.eu/fileadmin/user_upload/EBSA_WEB_2.pdf)

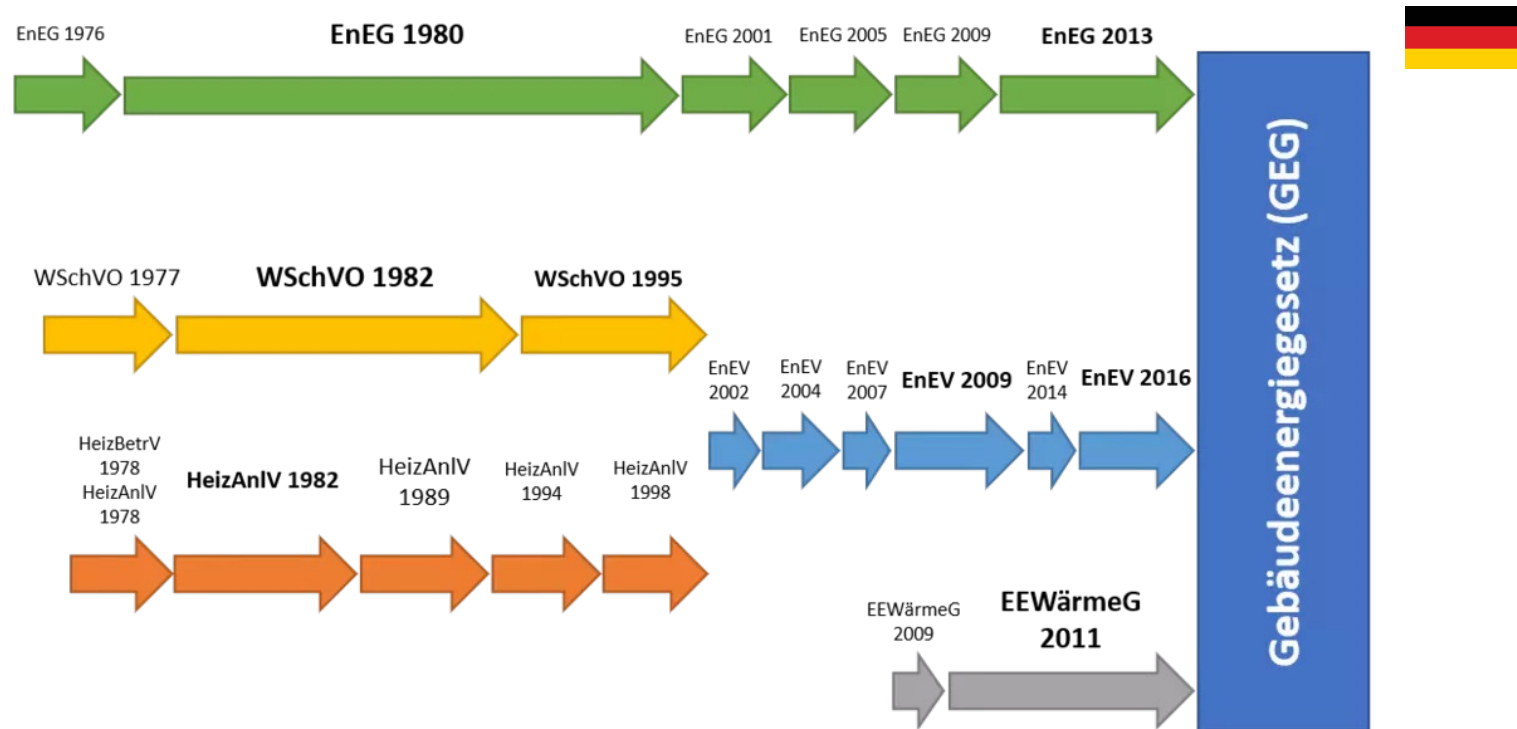
Pezzutto, S., Zambotti, S., Croce, S., Zambelli, P. Building stock analysis - Methodology. [Online] 2019.  
<https://gitlab.com/hotmaps/building-stock>.

## ■ International and national procedures - German perspective:

German Property Federation ZIA (2021). Bilanzierungsgrenzen und Key Performance Indicators (KPIs) für Sanierungsfahrpläne.  
<https://zia-deutschland.de/wp-content/uploads/2021/09/2021-07-23-ZIA-Positionspapier-Bilanzierungsgrenzen-und-Key-Performance-Indicators-KPIs-fuer-Sanierungsfahrplaene.pdf>



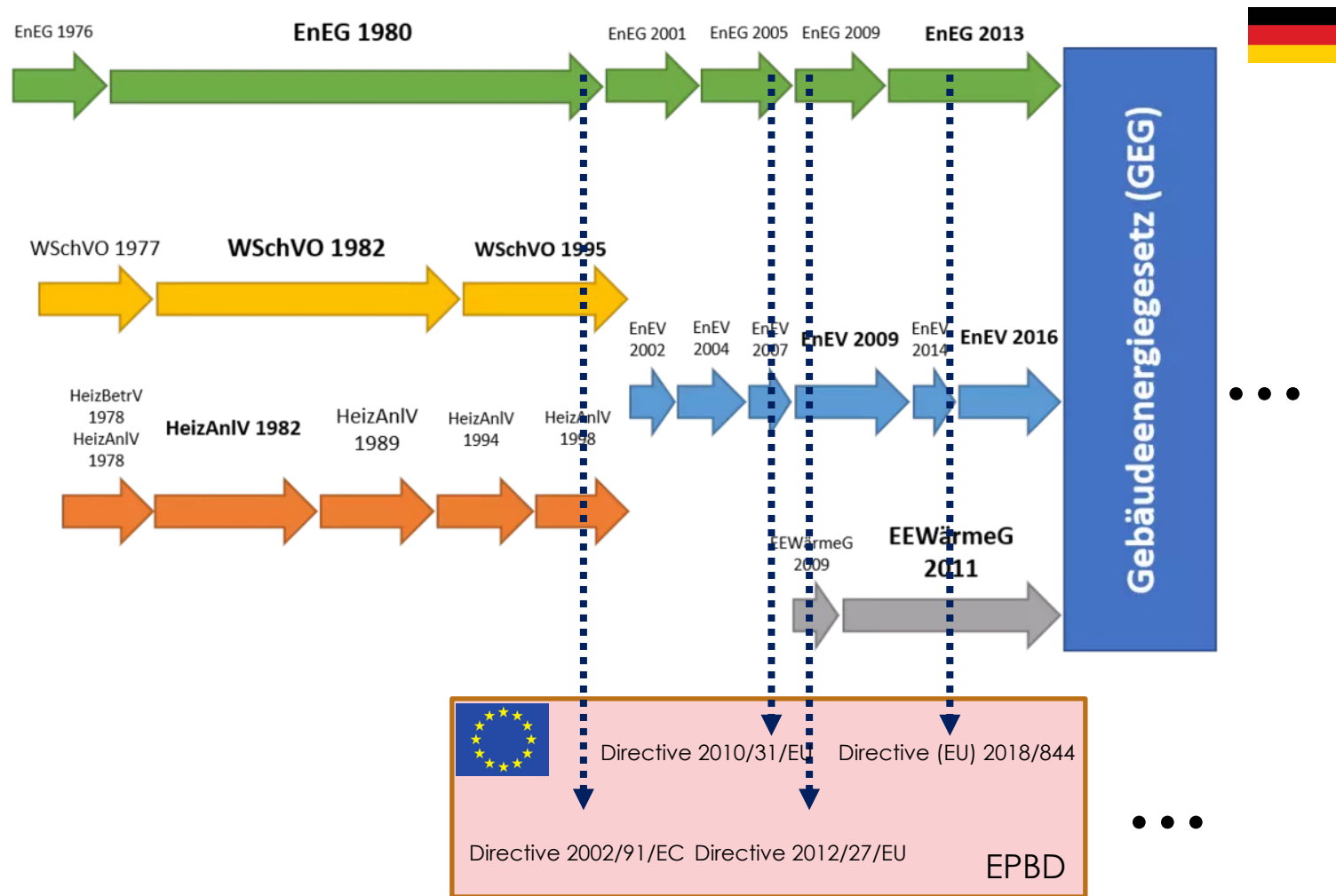
# History of the German Buildings Energy Act (GEG)



EnEG	Regulation for energy-efficient use of buildings
WSchVo	Establishes energy efficiency standards for buildings
HeizBetrV	Regulations for operation and maintenance of heating systems
HeizAnIV	Technical requirements for heating systems
EnEV	Energy efficiency standards for buildings and components
EEWärmeG	Promotes renewable energy use for heating and cooling
GEG	Consolidates various energy-related regulations for buildings

Source:  
<https://www.energie-experten.org/energie-sparen/energieberatung/gebäudeenergiegesetz/waermeschutzverordnung>

# History of the German Buildings Energy Act (GEG)



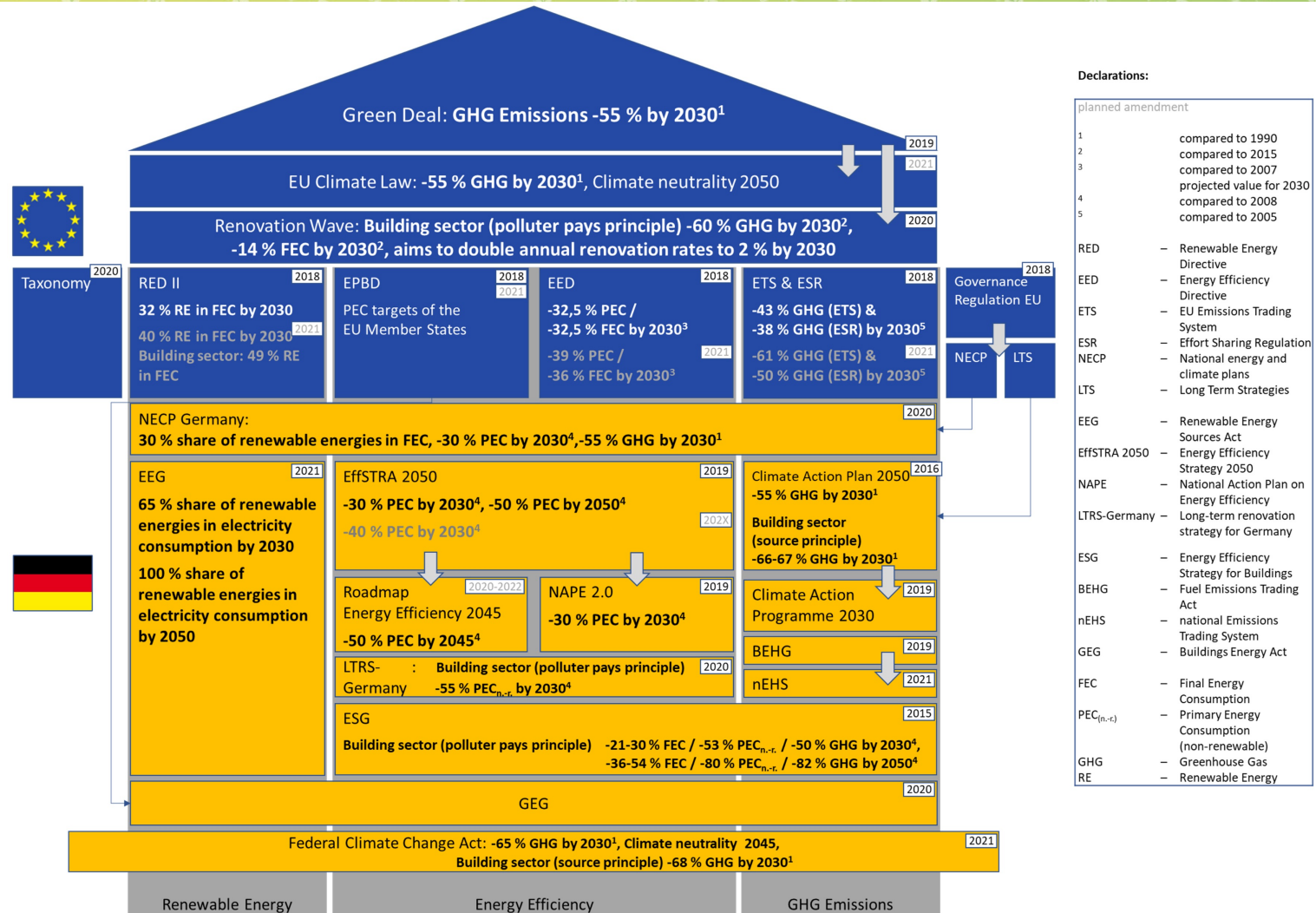
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Source:  
<https://www.energie-experten.org/energie-sparen/energieberatung/gebäudeenergiegesetz/waermeschutzverordnung>

# Political house of climate protection with applicable regulations and strategies of importance in Germany with their main targets and requirements

1

1. Simplify and adjust regulations



Source: see [Appendix A](#)

## 1

### 1. Simplify and adjust regulations

- Stakeholders need clear criteria to align their actions with. For this purpose, the existing regulations must be simplified and aligned with the main KPI GHG emissions.
- The overall national GHG emissions targets must be transferred to the building sector and further to individual buildings.
- The targets for GHG emissions must be aligned according to the polluter-pays principle in terms of embodied emissions on specific square meters (usable floor space according to the Building Energy Act) and take into account the available Budget (see 2<sup>nd</sup> recommendation for action)

Source: see [Appendix A](#)

# GHG emissions paths to comply with Paris climate protection targets in Germany (budget background information)

2

2. Introduce GHG emissions budgets

	Germany			EU 28 (2020) / EU 27 (2022)		
Climate Target [°C]	1,75	1,5	1,5	1,75	1,5	1,5
Probability of reaching the target	67%	50%	67%	67%	50%	67%
Calculation from 2020 based on <a href="#">IPCC SR151</a>						
Global CO <sub>2</sub> budget from 2018 in Gt	800	580	-	800	580	-
Maximum CO <sub>2</sub> budget from 2020 in Gt	6.7	4.2	-	47.0	31.6	-

	Germany			EU 28 (2020) / EU 27 (2022)		
Calculation from 2022 based on <a href="#">IPCC AR6</a>						
Global CO <sub>2</sub> budget from 2020 in Gt	775	500	400	775	500	400
Maximum CO <sub>2</sub> budget from 2022 in Gt	6.1	3.1	2.0	39.5	23.1	17.1

Determination of the distribution according to the share of the world population in the base year (2016):

i.e. for Germany 1.1%, for the EU-27 5.9%

(Population: Global, see [UN DESA 2019](#); Germany, see [Federal Statistical Office 2022](#); EU-27, see [Eurostat 2022](#))

Source:  
[https://www.umweltrat.de/SharedDocs/Downloads/DE/04\\_Stellungnahmen/2020\\_2024/2022\\_06\\_fragen\\_und\\_antworten\\_n\\_zum\\_co2\\_budget.pdf?\\_\\_blob=publicationFile&v=13](https://www.umweltrat.de/SharedDocs/Downloads/DE/04_Stellungnahmen/2020_2024/2022_06_fragen_und_antworten_n_zum_co2_budget.pdf?__blob=publicationFile&v=13)

# Solution Proposal

2020 values

$$\underbrace{(1.68 \text{ billion t CO}_2 * 1000 \text{ kg/t})}_{\text{CO}_2 \text{ budget for building sector from 2020 according to polluter-pays principle (40\% of THG emissions)}} / \underbrace{(6.9 \text{ billion m}^2)}_{\text{3.9 billion m}^2 \text{ floor space in residential buildings + 3.1 billion m}^2 \text{ net floor space in non-residential buildings}} = \underbrace{243 \text{ kg CO}_2 / \text{m}^2}_{\text{this is how much an average building (residential and non-residential) is allowed to emit in its life cycle from 2020 onwards}}$$

1

1. Simplify and adjust regulations

2

2. Introduce GHG emissions budgets

↓

e.g.	
220 kg CO <sub>2</sub> / m <sup>2</sup> floor space	residential
265 kg CO <sub>2</sub> / m <sup>2</sup> net floor space	non-residential

Must be split in such a way that total budget of 1.68 billion t CO<sub>2</sub> is complied with.

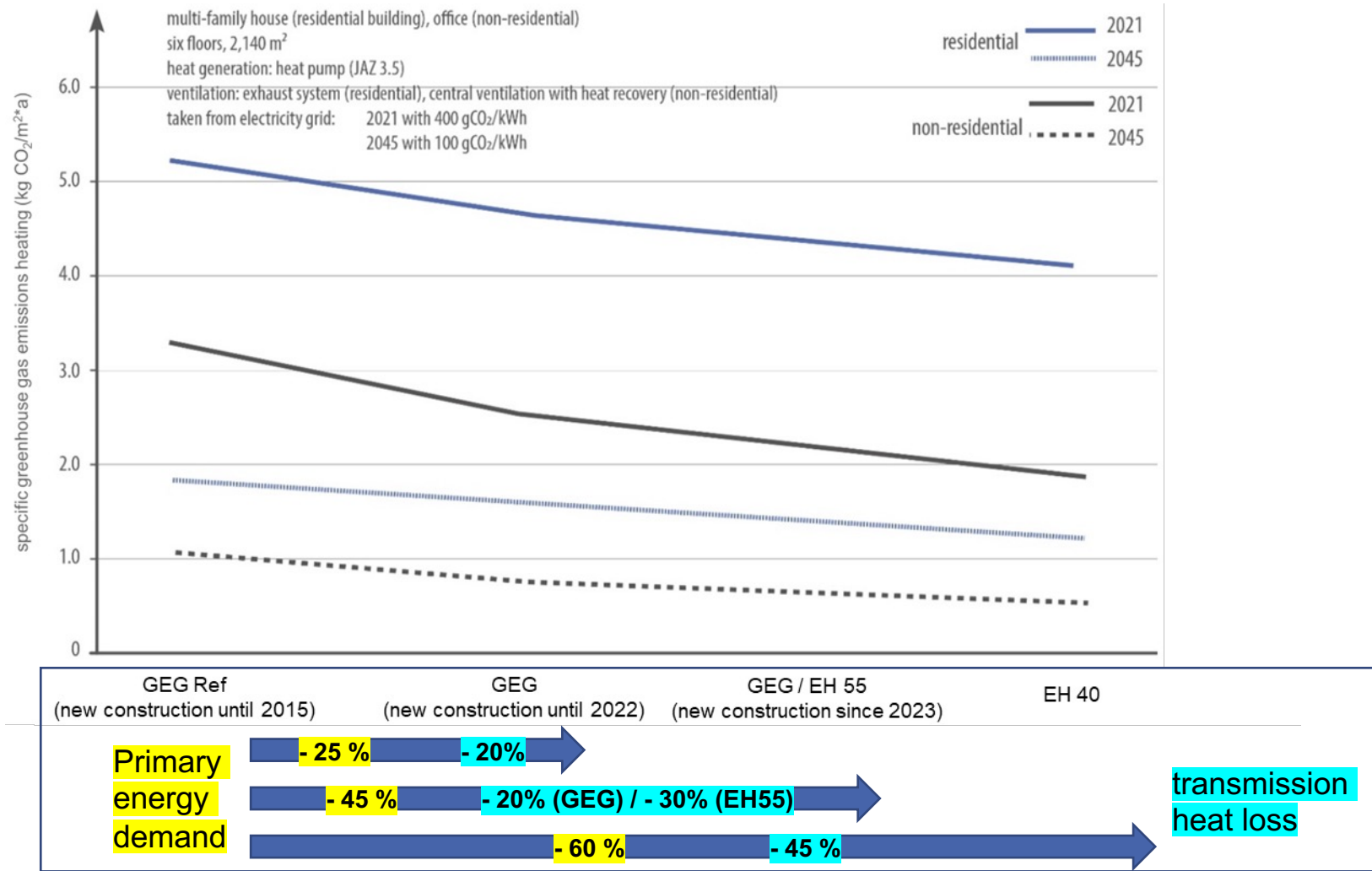
If possible, non-residential buildings must be further subdivided according to different building clusters

Source: see [Appendix A](#)

# Usable floor area-related GHG reductions for new buildings with different energy levels

## 3

3. Do not enforce stricter requirements on building envelopes



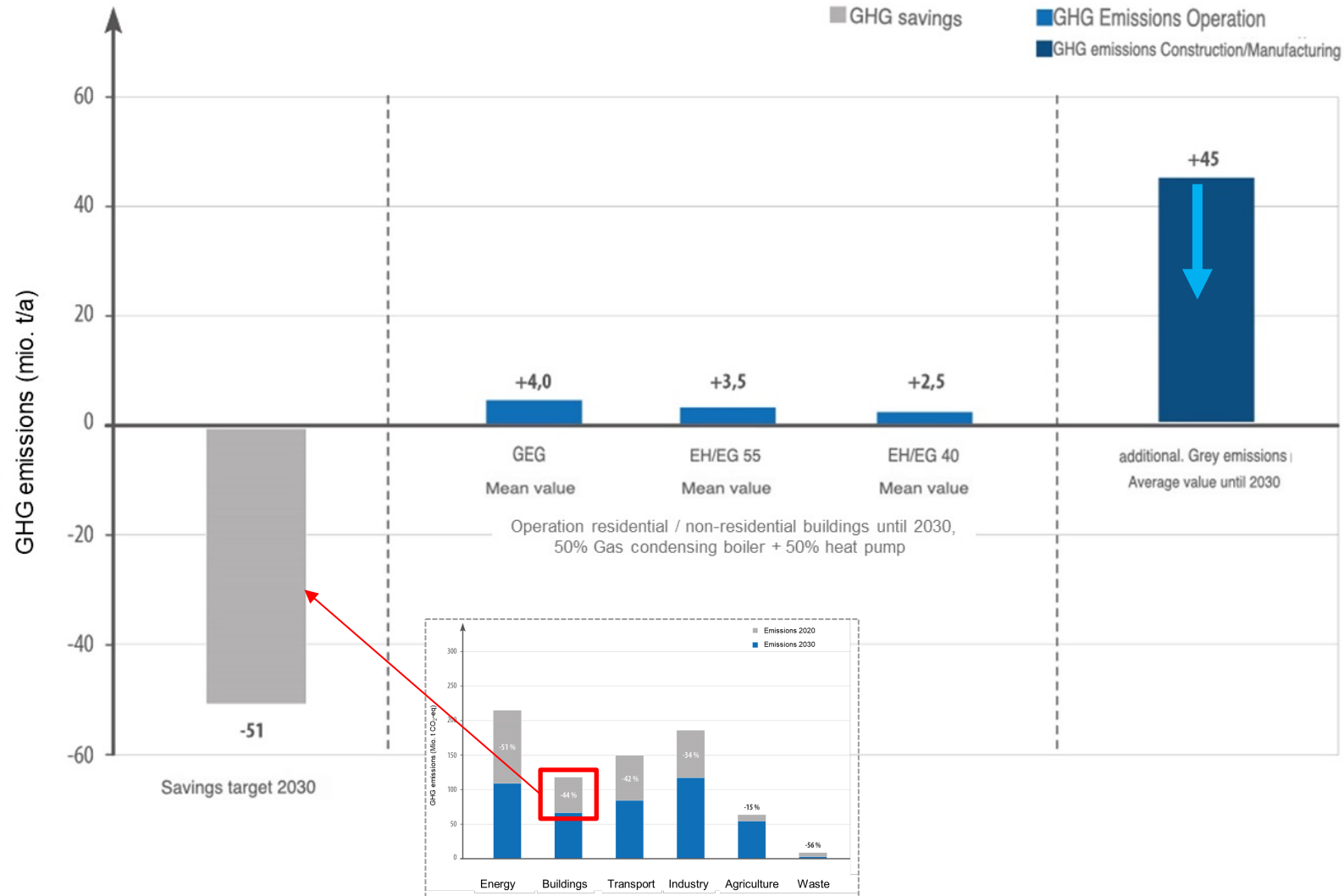
Source: see [Appendix A](#)

# GHG emissions in the building sector

## New construction and grey emissions in 2030

3

3. Do not enforce stricter requirements on building envelopes



**New construction no relevance to Achievement of reduction targets, GEG >> EH 40 max. - 1.5 mio. t CO<sub>2</sub> /a**

New construction + refurbishment cause annually approx. **40 to 50 mio. t CO<sub>2</sub> /a** in the industry + energy sector

Source: see [Appendix A](#)



3

3. Do not enforce stricter requirements on building envelopes

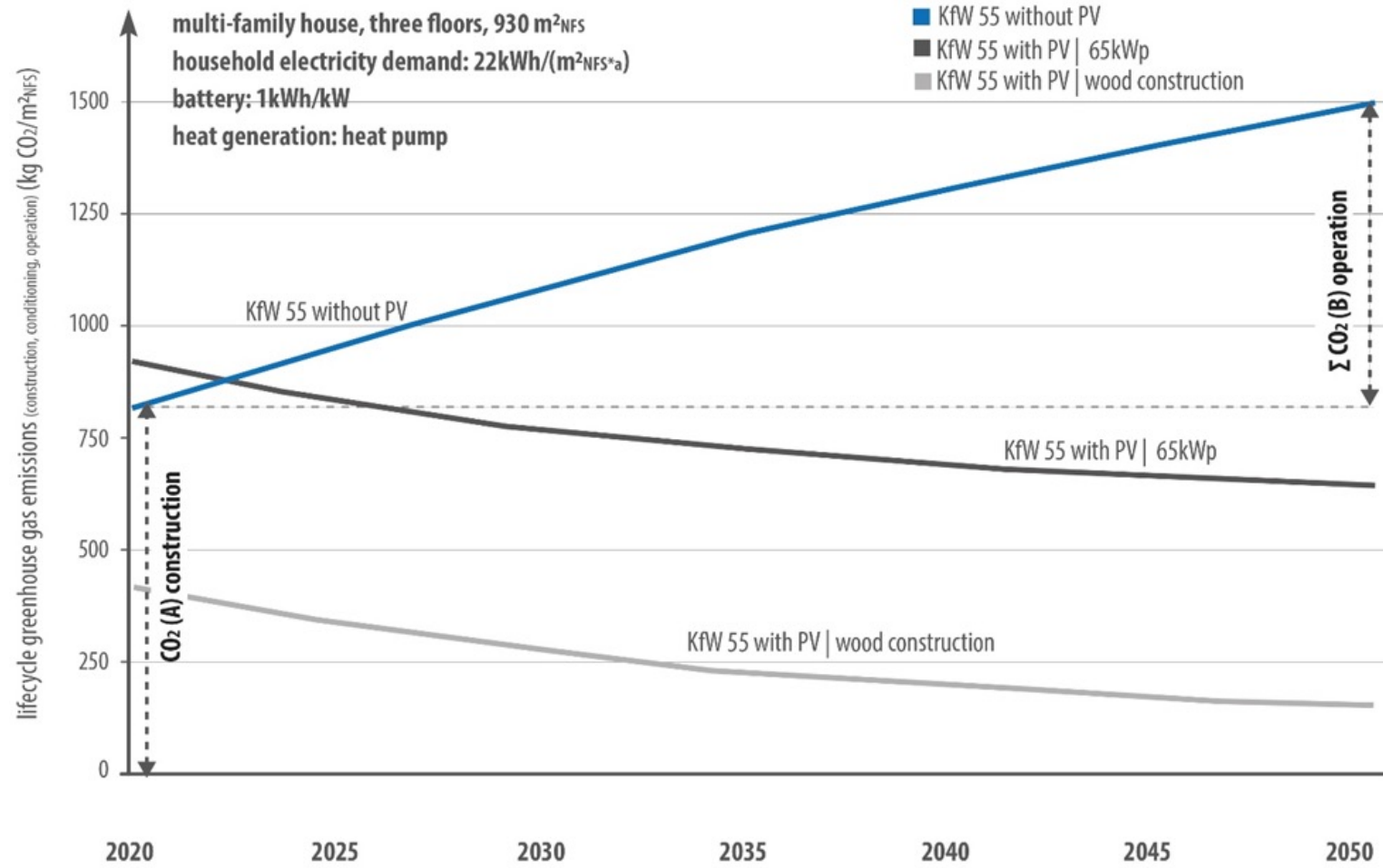
- **Decarbonising power** and **not the tightening of thermal insulation requirements** will be the decisive factor in achieving the climate protection targets.
- The building envelope will have less influence due to decreasing GHG emission factors.
- This also applies to heat supply via district heating, whose GHG emission factor decreases over time, too.

Source: see [Appendix A](#)

# GHG emissions in the life cycle - Multi-family house according to the polluter-pays principle

## 4

### 4. Focus on renovation



Source: see [Appendix A](#)

# Bring renovation roadmaps into broad application

5

5. Bring renovation roadmaps  
into broad application

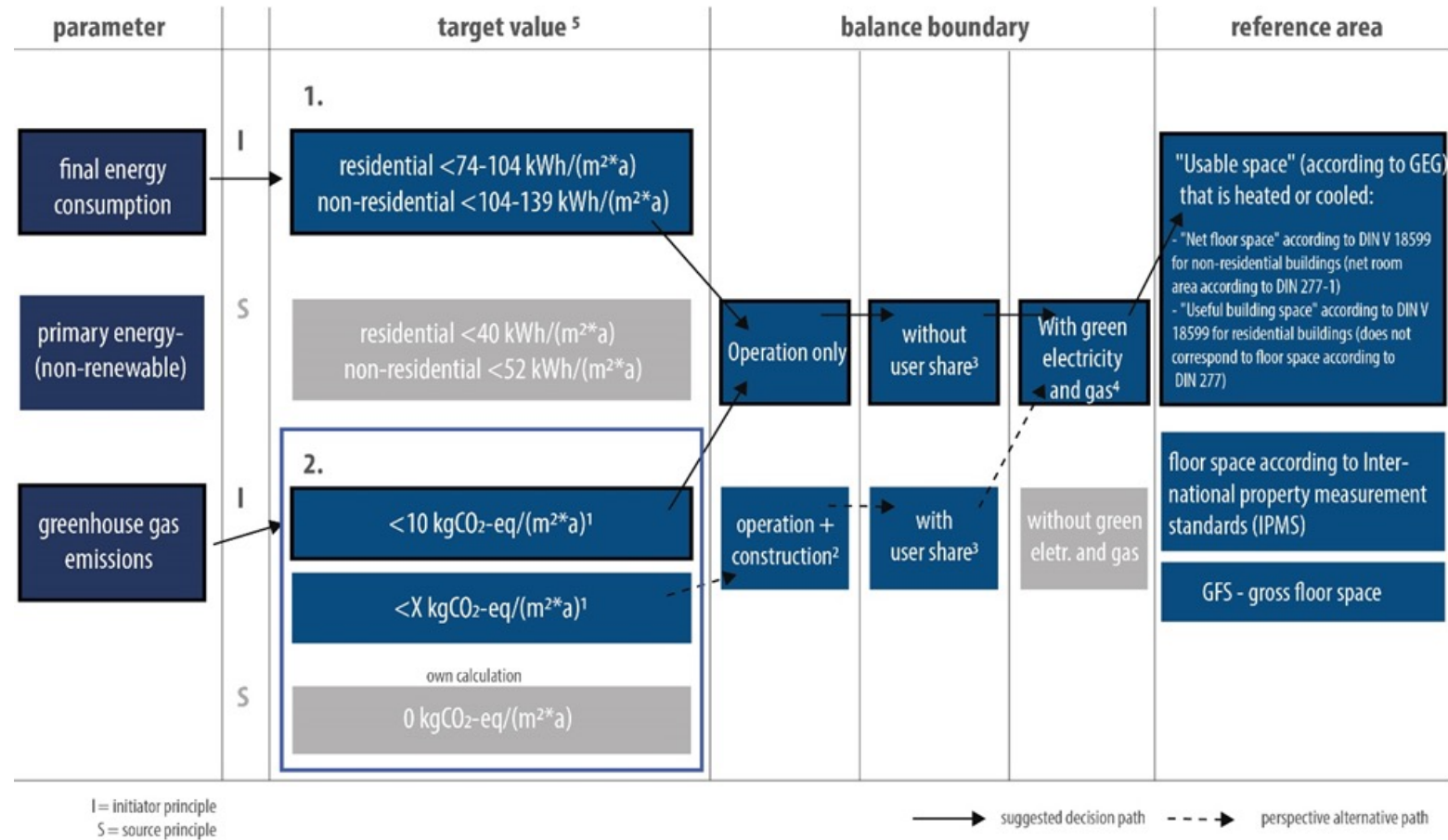
- To date, no uniform legal requirements have been imposed on the framework for drawing up renovation roadmaps in Germany.
- To be able to compare renovation roadmaps in the future a clear structure and definition of the assessment limit and the key performance indicators for residential and non-residential buildings is needed.
- Orientation to the remaining GHG emissions budget is needed (see recommendation for action 2).

Source: see [Appendix A](#)

# Solution Proposal

5

5. Bring renovation roadmaps into broad application



Source: see [Appendix A](#)

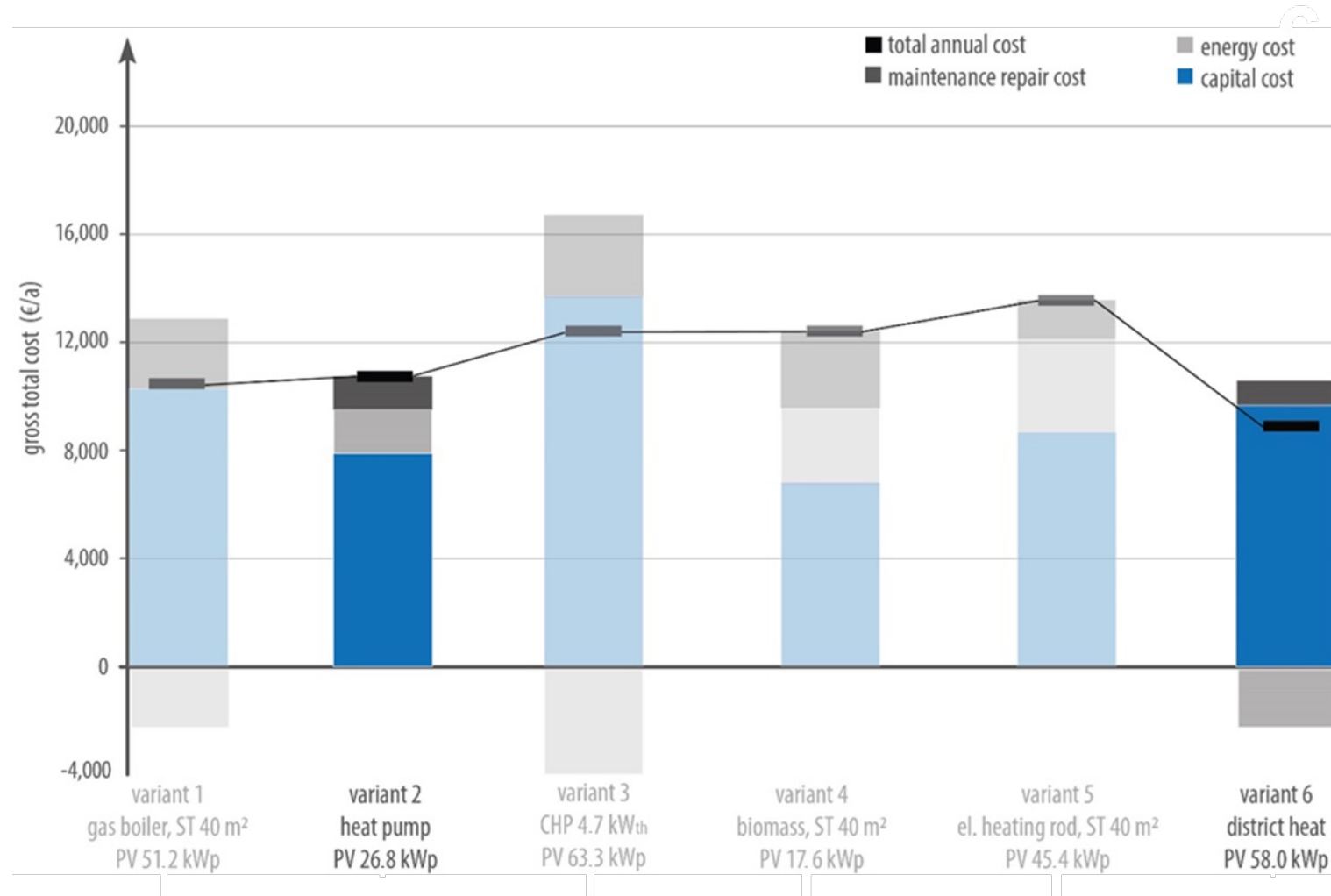
<sup>1</sup> if necessary, graded according to asset classes | <sup>2</sup> only newly installed components are considered | <sup>3</sup> energy or emission of user appliances | <sup>4</sup> according to ZfA position paper | reference space = "usable space" (from energy efficient building) | <sup>5</sup> Target values for the current changes to the requirements of the First Act to Amend the Federal Climate Protection Act still need to be legally transferred to the building sector in the initiator principle after the finalization.

# Climate-neutral renovation

## Total annual costs for multi-family houses

6

6. Decarbonise heating



Source: see [Appendix A](#)

## 6

### 6. Decarbonise heating

- Switch to electricity-based generators (electric heat pumps)
- Expansion of district or local heating networks
- Increased consideration of district approaches in renovation and energy supply measures
- Utilization of decentralized heat potentials e.g. from H<sub>2</sub> generation
- Use of surplus electricity from renewable sources (PtH, linking of sectors)

Source: see [Appendix A](#)

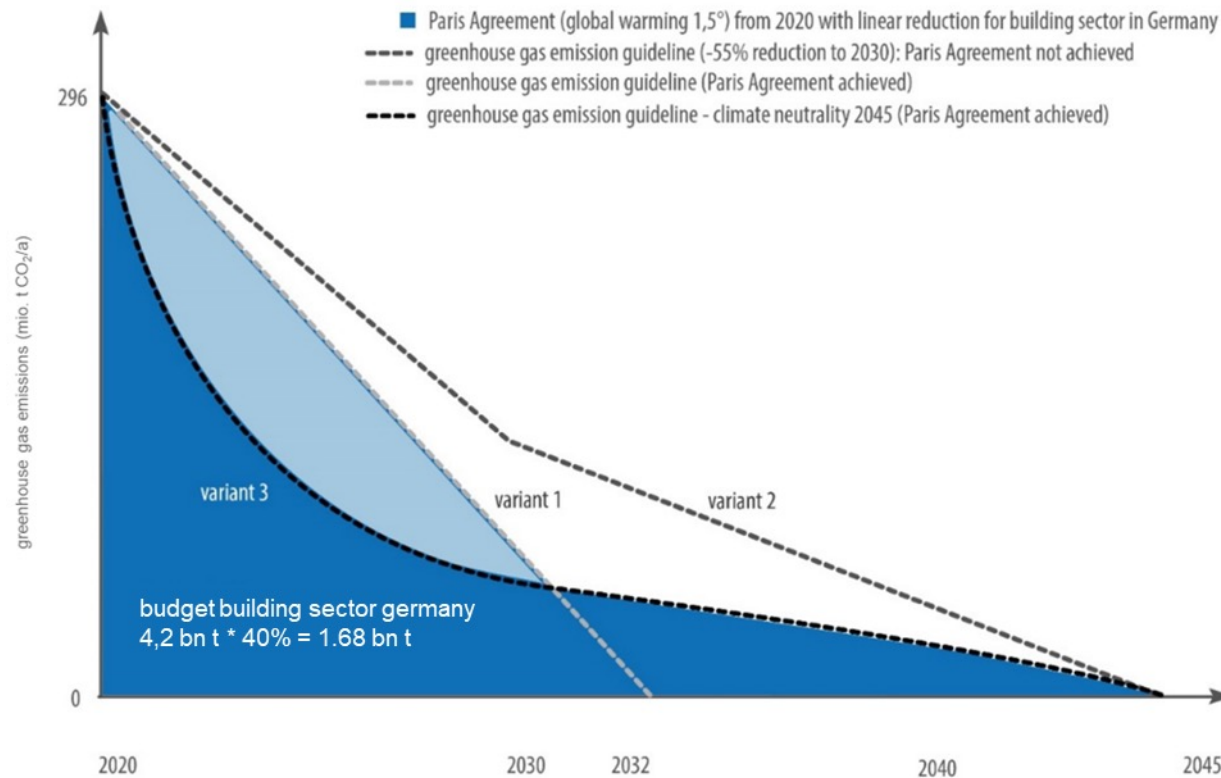
# GHG emissions paths to comply with Paris climate protection targets in Germany (schematic)

7

7. Fund fast-acting measures

2

2. Introduce GHG emissions budgets



Source: see [Appendix A](#)

## 7

### 7. Fund fast-acting measures

- Focus on measures with rapid implementation successes:  
Optimization of building operation and solarization of roof surfaces, installation of heat pumps
- Establish a long-term feed-in compensation for solar power
- Eliminate regulatory hurdles to solarization of buildings
- The installed photovoltaics capacity in Germany must increase annually by approx. 12.7 to 25 GW<sub>el</sub> (electric power) between 2020 and 2045 [[Fraunhofer ISE 2021](#)].
- In Germany, overall, there were around 59 GW<sub>el</sub> installed photovoltaics (approx. 2/3 on roofs and 1/3 on open spaces; [German Environment Agency 2021](#)) up until 2021 [[German Solar Association \(BSW\) 2022, Fraunhofer ISE from 12<sup>th</sup> of August 2022](#)]. Since about 5,3 GW<sub>el</sub> (approx. 240,000 plants) were being installed in 2021 alone [[German Solar Association \(BSW\) 2022](#)], at least a threefold increase in annual installations on roofs and open spaces is required to meet the budget-oriented target.

Source: see [Appendix A](#)



8

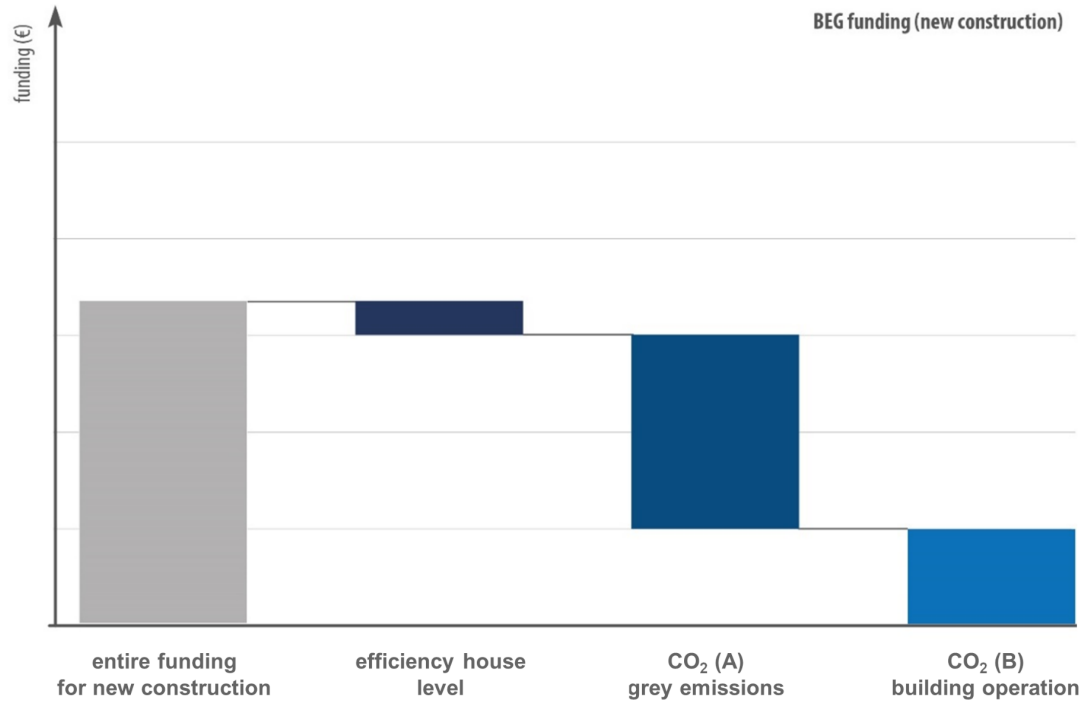
8. Offer a special bonus for emission reductions actually achieved

- The current Efficient Buildings Funding (BEG) grant in Germany supports the theoretical achievement of the targeted efficiency house level, which is assessed based on pre-calculated primary energy demand and transmission heat loss in operation.
- Yet, there can be significant differences between the theoretically calculated and in practice measured values.
- The real savings or GHG reductions of the building operation are not taken into account by the national funding framework.
- This also applies to the construction of buildings and the respective share of grey emissions. (since 2022 also necessity of sustainability certificate)

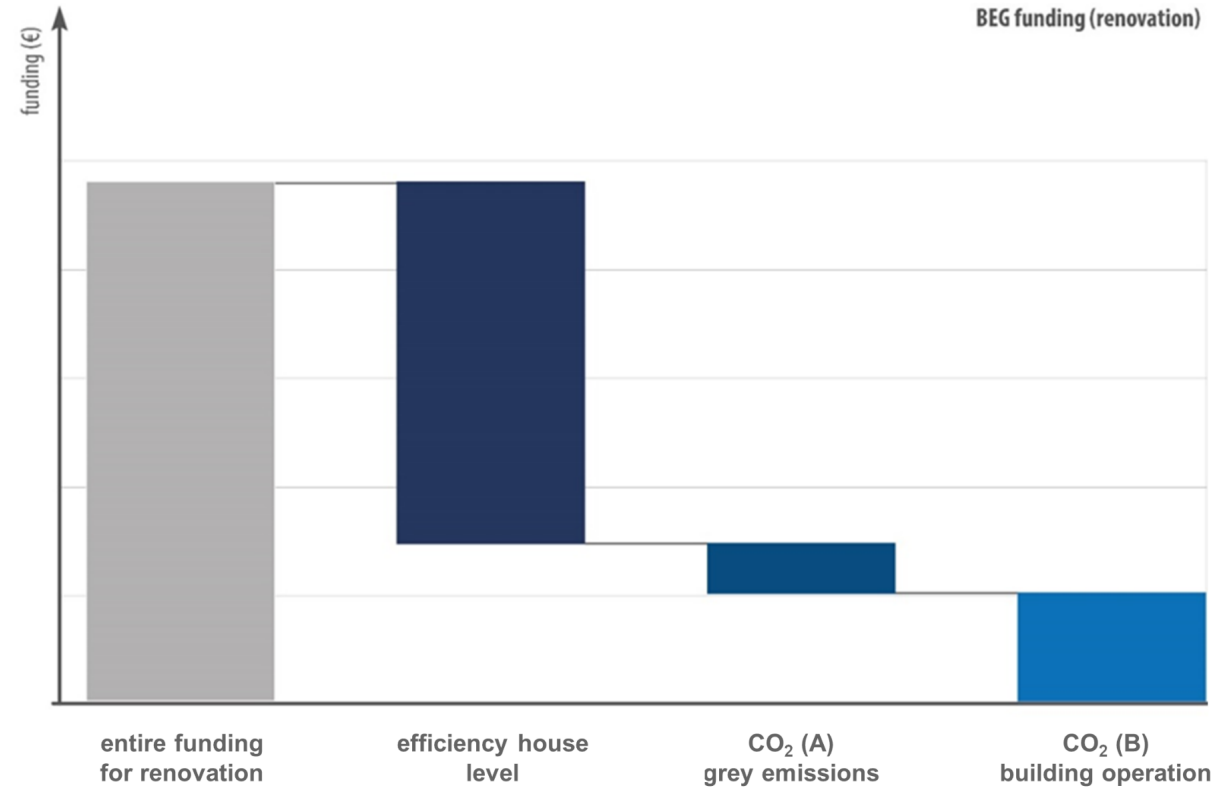
Source: see [Appendix A](#)

# Solution Proposal

## 4. Focus on renovation



## 8. Offer a special bonus for emission reductions actually achieved



Source: see [Appendix A](#)

10

10. Achieve transparency by digitalisation using the Smart Readiness Indicator (SRI)

- The European Energy Efficiency Directive (EED) prescribes remotely readable metering systems (smart meters) for buildings' heat supply.
- For electricity meters, the German Metering Point Operation Act (MsbG) goes hand in hand with an obligation to convert to digital meters (according to the MsbG: "meters which reflect the actual electricity consumption and actual utilisation period and can be integrated into a communication network via a smart meter gateway).
- But: there is no awareness if this data is not provided to the building user in a prompt manner.

Source: see [Appendix A](#)

11

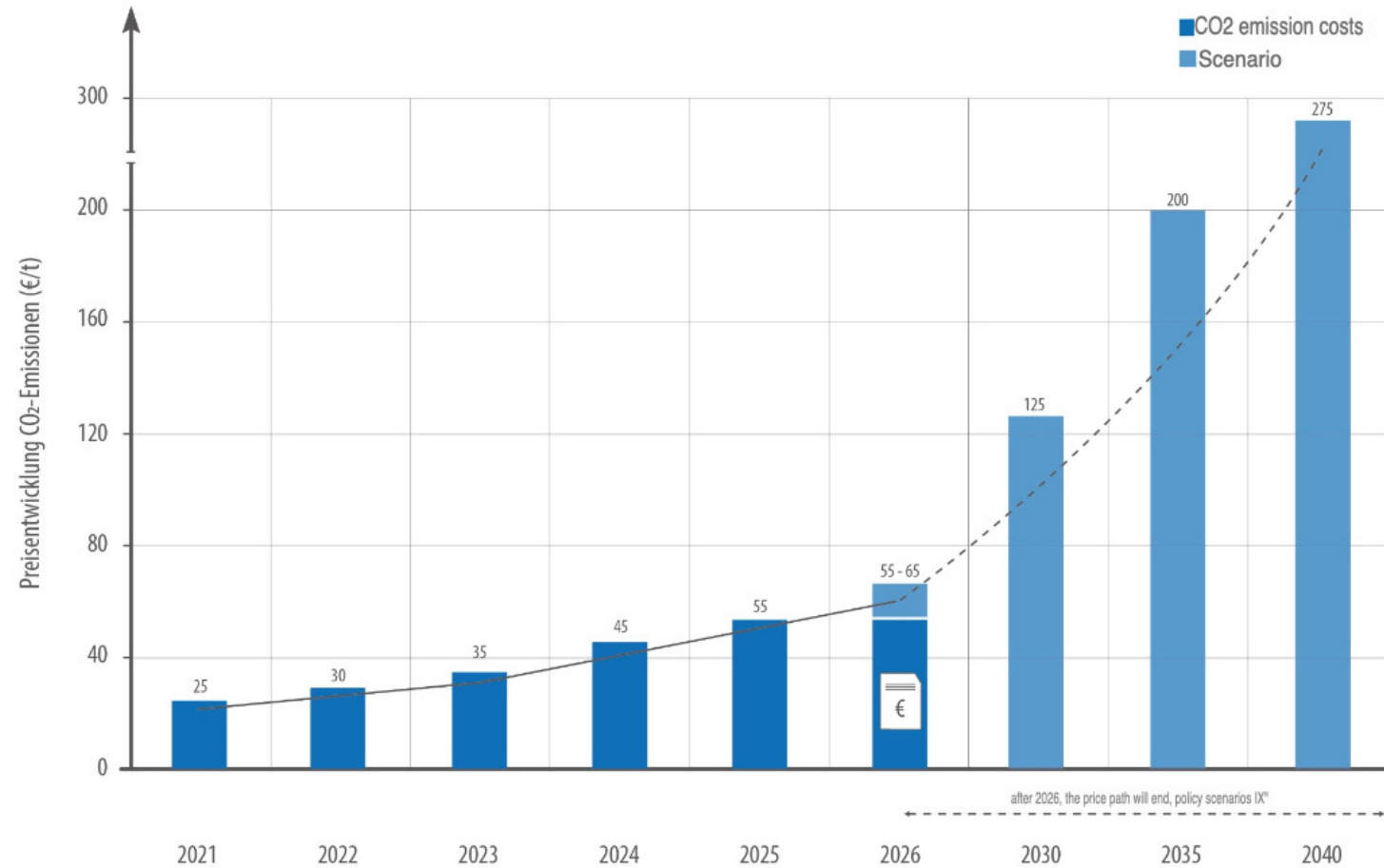
11. Set up a transparent national database of buildings

- Setting up such a comprehensive national database of buildings would enable stakeholders not only to reliably evaluate the existing building stock, but also monitor the effects of achieved climate protection measures in the building sector
- Tailored renovation roadmaps could be integrated in the database to create a transparent view on to expected developments of GHG emissions in the building sector.
- It is conceivable in the future to include building materials in this national database of buildings as a reliable data source for urban mining.
- Enormous stocks of materials are accumulated in buildings over decades, which hold great potential as a future source of secondary raw materials.

Source: see [Appendix A](#)

# Solution Proposal

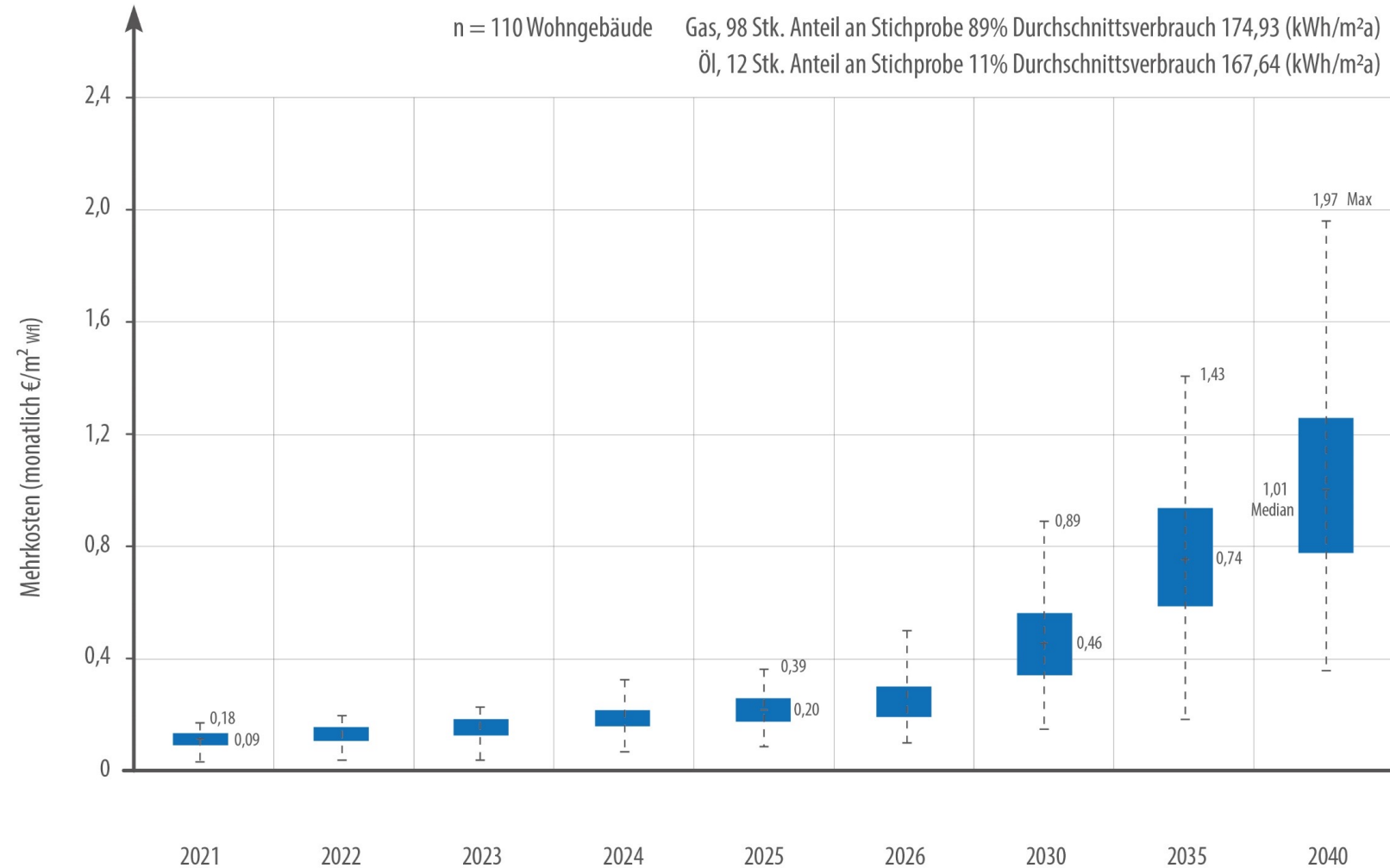
Price development of CO<sub>2</sub>-emissions per tonne in Germany according to the nEHS



Source: see [Appendix A](#)

# National emissions trading system (nEHS)

## Effects on residents



Source: see [Appendix A](#)