

**EPISCOPE Case Study:
Future Climate Protection Scenarios
for the National Housing Stock
in Germany**

"EPI Tables"

**Documentation of
Energy Performance Indicators**

Prepared in the framework
of the European project EPISCOPE
www.episcope.eu

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Institut Wohnen und Umwelt
(Institute for Housing and Environment)
Darmstadt / Germany



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The template for documentation of energy performance indicators has been prepared in the framework of the project EPISCOPE which was mainly funded by the programme Intelligent Energy Europe. The purpose is to report in a concerted way on input and output data of the building stock models and scenario calculations.

The usage of the EPI concept as well of this workbook by third parties is intended and desirable.



**Energy Performance Indicator Tracking Schemes
for the Continuous Optimisation of Refurbishment Processes
in European Housing Stocks**



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Programme of the European Union

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Project duration: April 2013 - March 2016

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General Information

General Information about the monitoring and scenario data documented in this workbook

Country	DE	Germany
Building stock	National residential building stock	
Person in charge	Nikolaus Diefenbach	
Organisation	IWU - Institut Wohnen und Umwelt / Institute for Housing and Environment	
Address	Rheinstraße 65 - 64295 Darmstadt	
Country	GERMANY	
URL	www.iwu.de	
Date	2016-03-18	
Documented study		
Reference	N. Diefenbach, T. Loga, B. Stein: Szenarienanalysen und Monitoringkonzepte im Hinblick auf die langfristigen Klimaschutzziele im deutschen Wohngebäudebestand – Bericht im Rahmen des europäischen Projekts EPISCOPE, Institut Wohnen und Umwelt, Darmstadt, September 2015.	

Explanations

Energy performance indicators of residential building stocks can either describe existing empirical data of a building stock or the input and outcome of building stock modelling. In EPISCOPE both types of quantities are clearly separated by distinguishing monitoring and scenario indicators (see [1] and [2]):

- ▶ *"Monitoring Indicators" are empirically justified. They are always based on reliable primary data on the observed building stocks. Due to a lack of empirical information they may draw an incomplete picture of the building stocks.*
- ▶ *"Scenario Indicators" describe the input data as well as the results of scenario analysis. Based on the monitoring indicators and additional assumptions they provide a complete picture of model analysis.*

Monitoring Indicators

The monitoring indicators are widely based on a representative survey of more than 7,300 German residential buildings, which reflects the state of the German residential building stock at the end of 2009. The project report provides a more detailed documentation of the results including statistical standard errors [6].

For that reason, on the one hand, data has to be seen as very reliable, on the other hand it is by now fairly out-of-date. However, because no other comparable data source was available, the starting point of scenario calculations ("basic case") was chosen as the year 2009, widely based on the monitoring data mentioned above.

A detailed description of the data situation in Germany can be found in the EPISCOPE Synthesis Report SR4 [3].

Scenario Indicators

Scenario <1> "Trend"

The trend scenario is widely based on the building stock modernisation trends observed 2009 by a survey. This trend was extrapolated until 2050 assuming only a small increase of refurbishment rates. No changes were assumed concerning the current structure of district heating and new buildings' standards (NZEB standards are not achieved), but the structural change of electric power generation was also applied to the trend approach.

Scenario <2> "Target-oriented / basic"

This scenario is designed to attain the climate protection targets of the national government. The target range for the year 2050 is between 80 % to 95 % CO₂ emission reduction compared to 1990.

Linear step-by-step development:

- Doubling of annual rate of thermal modernisation (area weighted mean of all building elements)
- New structure of newly installed heating systems (gas/oil boilers -> CHP, heat pumps, biomass)
- Structural changes of district heating and electricity generation: > 50 % renewables in 2050
- Transition period duration: 10 years

Further scenarios not documented in this workbook

- "Target-oriented / slow": same targets as "basic", but transition period duration: 15 years
- "Target-oriented / fast": same targets as "basic", but transition period duration: 5 years

Further Explanations

The scenario indicators documented here are those of the existing building stock of the year 2009 (buildings constructed until 2009).

For example: bs...2009|2050 is the subset of the residential building stock of the year 2050 which includes the buildings, which were constructed until 2009.

The number of buildings and dwellings and the living space decline because of demolition.

Insulation levels: Level 1 represents mean values of the past (from a 2009 point of view) and at the same the lowest level of future measures.

Solar thermal systems also represent photovoltaics + heat pumps. Because the photovoltaic systems do not need to be installed directly on the buildings (of which many might not have suitable roofs) high fractions of solar energy systems are achievable.

New buildings (erected from 2010) are not included in the EPI tables. In the target oriented scenario "basic" it is assumed that until 2020 a nearly zero energy building (NZEB) standard will be stepwise be introduced in the new building sector (here oriented towards the "KfW-Effizienzhaus 40" – a German standard promoted by a KfW promotional programme), and that until 2050 there is a continuous change of the structure of district heating (towards efficient CHP, mainly biomass-driven) and electric power generation "for the building sector" (towards 55 % renewables, 45 % efficient natural gas power plants).

More detailed data tables are documented in the appendix of the German case study report [5].

Energy Balance Indicators

"Energy Balance Indicators" are used to display the main results of the building stock models in terms of energyware demand (delivered energy / final energy) [1]. The EPISCOPE convention is to express the energy demand related to the gross calorific value in case of fuels. Total values as well as values relate to the EPISCOPE reference area are being displayed.

The numbers are related to the complete building stock of the respective year (including new buildings constructed from 2010). The total heat demand Q_{total} includes the energy need for heating and hot water supply as well as the losses of heat distribution and storage in the buildings. It also includes heat recovered by ventilation systems.

Auxiliary electric energy for control, pumps, fans of heat supply and ventilation systems is included in the numbers of electric energy demand.

Electric energy demand does not include electricity produced by CHP systems in residential buildings (which is assumed to be completely consumed for heat supply in the residential building stock). But the complete fuel demand of those CHP systems (for heat and electricity generation) is included in "natural gas" and "biomass".

Basic Case Details - Scenario and Energy Balance Indicators by Building Type

The basic cases of all EPISCOPE scenario calculations are documented in form of "average buildings" in the TABULA Webtool (<http://webtool.building-typology.eu>) area "Building Stocks". The most important input data are identical to the scenario indicators. [2]

6 building types are used for the definition of the TABULA "average buildings", referring to 2 building size classes (single-unit housing; multi-unit housing) and 3 construction year classes (... 1978; 1979 ... 1994; 1995 ...).

Summary Indicators

The summary indicators are designed to give a first and basic overview of the results of scenario analysis of residential building stocks. The format is binding - in contrast to the other indicators. [2]

Detailed comments on the summary indicators can be found in the description of the German case study of EPISCOPE Synthesis Report SR3 [4].

References

- [1] Diefenbach, N., Loga, T., Stein, B. (ed.) (2014): Energy Performance Indicators for Building Stocks. First version / starting point of the EPISCOPE indicator scheme, March 2014
http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_Indicators_FirstConcept.pdf
- [2] Diefenbach, N., Loga, T., Stein, B. (ed.) (2016): Application of Energy Performance Indicators for Residential Building Stocks. Experiences of the EPISCOPE project, March 2016
www.episcope.eu/communication/download/
- [3] Stein, B., Loga, T., Diefenbach, N. (ed.): Tracking of Energy Performance Indicators in Residential Building Stocks – Different Approaches and Common Results. EPISCOPE Synthesis Report No. 4, Institut Wohnen und Umwelt, Darmstadt, 2016
www.episcope.eu/communication/download/
- [4] Stein, B., Loga, T., Diefenbach, N. (ed.): Scenario Analyses Concerning Energy Efficiency and Climate Protection in Regional and National Residential Building Stocks. Examples from Nine European Countries – EPISCOPE Synthesis Report No. 3", Institut Wohnen und Umwelt, Darmstadt, 2016
www.episcope.eu/communication/download/
- [5] N. Diefenbach, T. Loga, B. Stein: Szenarienanalysen und Monitoringkonzepte im Hinblick auf die langfristigen Klimaschutzziele im deutschen Wohngebäudebestand – Bericht im Rahmen des europäischen Projekts EPISCOPE, Institut Wohnen und Umwelt, Darmstadt, September 2015; Download link [2015-01-25]:
www.episcope.eu/fileadmin/episcope/public/docs/pilot_actions/DE_EPISCOPE_NationalCase_Study_IWU.pdf
- [6] N. Diefenbach, H. Cischinsky, M. Rodenfels, K.-D. Clausnitzer: Datenbasis Gebäudebestand – Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohngebäudebestand, Institut Wohnen und Umwelt, Darmstadt, 2010. Download link [2016-01-25]:
www.iwu.de/fileadmin/user_upload/dateien/energie/klima_altbau/Endbericht_Datenbasis.pdf

Monitoring Indicators

General Remarks:

Data of the German Residential Building Stock
old building stock: buildings constructed until 1978

M.2.1 Building insulation: Basic information state and trends of modernisation

	Complete building stock	Old building stock constructed until 1978	percentages related to....
walls			
insulation improved (from original state)	20,8%	27,6%	building number
insulation improved (area-weighted)	16,1%	21,1%	element area
average thickness of improved insulation		9,1 cm	
annual rate of insulation improvement	0,82 %/a	1,06 %/a	building number
annual rate of insulation improvement (area-weighted)	0,65 %/a	0,83 %/a	element area
average thickness of insulation (recent modernisation)		11,1 cm	
roofs / upper floor ceilings			
insulation improved (from original state)	40,5%	52,2%	building number
insulation improved (area-weighted)	36,6%	47,0%	element area
average thickness of improved insulation		12,8 cm	
annual rate of insulation improvement	1,32 %/a	1,65 %/a	building number
annual rate of insulation improvement (area-weighted)	1,20 %/a	1,50 %/a	element area
average thickness of insulation (recent modernisation)		16,2 cm	
ground floors / cellar ceilings			
insulation improved (from original state)	9,5%	12,5%	building number
insulation improved (area-weighted)	7,6%	10,0%	element area
average thickness of improved insulation		7,5 cm	
annual rate of insulation improvement	0,34 %/a	0,42 %/a	building number
annual rate of insulation improvement (area-weighted)	0,25 %/a	0,31 %/a	element area
average thickness of insulation (recent modernisation)		8,5 cm	
windows			
annual rate of insulation improvement (area-weighted)	1,34%/a	1,8 %/a	element area
average quality of improved windows (recent modernisation)	100 % thermal protection glazing (75 % double, 25 % triple glazing)		

source: N. Diefenbach et al., Datenbasis Gebäudebestand, IWU, Darmstadt, 2010

situation in the residential building stock at the end of 2009, results of a survey (statistical errors see project report)

annual modernisation rates: mean values 2005-2008, thickness of recent insulation: mean values 2005-

M.2.2 Building insulation: Detailed information of the actual state

	Complete building stock	Old building stock constructed until 1978	percentages related to....
windows			
level 0a: Single glazing ($U > 3,0 \text{ W/m}^2\text{K}$)	3,1%	4,3%	
level 0b: double glazing ($3 \text{ W/m}^2\text{K} \geq U > 2 \text{ W/m}^2\text{K}$)	52,5%	56,8%	
level ≥ 1 : double thermal protection / triple glas. ($U \leq 2$)	44,4%	38,9%	100%
sources / remarks			
source: N. Diefenbach et al., Datenbasis Gebäudebestand, IWU, Darmstadt, 2010			
situation in the residential building stock at the end of 2009. Percentages related to building number and main type of windows in the buildings			

M.3.1 Main Heat Supply Systems for Space Heating	state of the building stock			modernisation trends		for comparison
	Complete building stock	Old building stock	New buildings	Complete building stock	Old building stock	state of the building stock
	percentages are related to buildings					Complete building stock
						percentages: apartments
M.3.1.1 Centralisation of space heating system				net modernisation rates (mean annual rates)		
district heating	3,9%	3,9%	3,7%	0,05%	0,07%	12,0%
building / apartment heating	88,8%	86,2%	93,8%	0,21%	0,24%	81,9%
room heating	7,3%	9,9%	2,5%	-0,26%	-0,31%	6,1%
M.3.1.2 Main energy carrier for space heating				net modernisation rates (mean annual rates)		
district heating	3,9%	3,9%	3,7%	0,05%	0,07%	12,0%
gas (natural / liquid gas)	51,9%	47,9%	58,8%	0,13%	0,24%	53,6%
oil	33,7%	37,2%	5,7%	-0,28%	-0,39%	26,5%
coal	0,7%	1,0%	0,0%	-0,05%	-0,06%	0,7%
wood/biomass	5,5%	6,5%	9,5%	0,17%	0,19%	3,6%
electricity	4,3%	3,5%	22,3%	-0,02%	-0,04%	3,6%
M.3.1.3. Main heat generation system for space heating				gross modernisation rates (mean annual rates)		
district heating	3,9%	3,9%	3,7%	0,07%	0,08%	12,0%
combustion of fossil fuels: stoves	2,6%	3,9%	0,0%	0,01%	0,02%	2,7%
combustion of fossil fuels: constant temperature boilers	14,5%	16,1%	0,7%	0,08%	0,09%	13,6%
combustion of fossil fuels: gas/oil low temperature boilers	46,0%	48,2%	8,0%	0,68%	0,83%	45,6%
combustion of fossil fuels: gas/oil condensing boilers	23,0%	17,8%	55,8%	1,52%	1,65%	18,7%
combustion of fossil fuels: gas/oil driven heat pumps / chp systems	0,1%	0,1%	0,0%	0,01%	0,00%	0,1%
combustion of wood/biomass: stoves (no pellets)	2,4%	3,4%	0,8%	0,03%	0,05%	1,3%
combustion of wood/biomass: boilers (no pellets)	2,2%	2,5%	4,3%	0,12%	0,14%	1,6%
combustion of wood/biomass: pellets (stoves or boilers)	0,8%	0,7%	4,5%	0,11%	0,13%	0,7%
direct electric heating	2,6%	2,7%	1,7%	0,02%	0,03%	2,3%
electric heat pumps	1,7%	0,8%	20,6%	0,09%	0,07%	1,3%
	total gross rate:			2,74%	3,09%	
Sources / remarks						
<p>*) explanation of gross/net rates: gross rates: e.g. all new heating generation systems are considered (e.g. also if the same type is installed again), net rates: only the net growth/decline of system types and energy carriers is considered. Accordingly the gross rates of all heat generation systems sum up to the complete modernisation rate of heat generation systems in the observed building stock, whereas net modernisation rates always add up to zero.</p> <p>All numbers are derived from the data base "Datenbasis Gebäudebestand", see project report: N. Diefenbach et al., Datenbasis Gebäudebestand, Institut Wohnen und Umwelt, Darmstadt 2010</p> <p>The data describe the German residential building stock at the end of 2009. Modernisation rates and new buildings' values are usually mean values of the period 2005-2009.</p> <p>The data base includes more than 7.000 data sets but there are considerable statistical errors, especially if small percentages are concerned (details see project report, e.g. percentages of about 1-2 % (or 5 % in the new building stock) and annual modernisation rates of less than circa 0.5 % must be considered as extremely rough.</p> <p>The percentages are related to the number of buildings. Because of structural differences of single and multi-family houses the percentages related to the apartment numbers may be quite different. For that reason a column was added describing the state of the complete building stock related to apartment numbers (to be compared with the first column).</p> <p>The building and apartment numbers are both related to building properties, that means the correct interpretation is for example: 3,9% of the residential buildings are mainly heated by district heating and: 12 % of the apartments are situated in buildings which are mainly supplied by district heating.</p>						

M.3.2 Special Systems (additional systems of special interest for space heating, hot water supply, ventilation, including photovoltaics)					
	state of the building stock			modernisation trends (annual gross rates)	
	Complete building stock	Old building stock constructed until 1978	New buildings	Complete building stock	Old building stock
solar thermal systems	8,9%	6,3%	28,2%	0,93%	
...for hot water supply only	5,8%	3,9%	18,1%	0,52%	
...for heating and hot water supply	3,2%	2,4%	10,1%	0,41%	
photovoltaic systems	2,4%	1,7%	3,4%		
ventilation systems (for buildings/apartments, not only kitchen/WC ventilation)	1,5%	0,4%	9,1%	0,03%	
....without heat recovery	0,7%	0,3%	1,6%	0,01%	
...with heat recovery	0,7%	0,1%	7,5%	0,02%	
sources / remarks					
source: "Datenbasis Gebäudebestand". The German residential building stock at the end of 2009 is described. Mean annual rates and new buildings' values are related to the period 2005-2009. Percentages are related to building numbers. Numbers are results of a survey, statistical errors see project report. N. Diefenbach et al., Datenbasis Gebäudebestand, Institut Wohnen und Umwelt, Darmstadt 2010					

M.3.3 Main System of Hot Water Supply apart from additional solar thermal systems (see above)			
	Complete building stock	Old building stock constructed until 1978	New buildings
M.3.3.1 Main Energy carrier for hot water supply			
district heating	2,7%	2,4%	3,3%
gas	46,1%	41,1%	55,8%
oil	29,1%	31,1%	5,0%
coal	0,3%	0,4%	0,0%
wood/biomass	3,0%	3,2%	8,5%
electricity	18,9%	21,9%	27,4%
M.3.3.2 Main heat generation system for hot water supply			
hot water generation combined with heating system	77,0%	71,8%	90,0%
separate system of hot water generation:	23,0%	28,2%	10,0%
- direct electric heat generation	16,9%	21,3%	6,1%
- electric heat pump	0,4%	0,3%	2,3%
- combustion of fossil fuels	5,4%	6,2%	1,6%
- combustion of wood/biomass	0,3%	0,4%	0,0%
sources / remarks			
source: "Datenbasis Gebäudebestand". The German residential building stock at the end of 2009 is described. Mean annual rates and new buildings' values are related to the period 2005-2009. Percentages are related to building numbers. Numbers are results of a survey. Statistical errors see project report. N. Diefenbach et al., Datenbasis Gebäudebestand, Institut Wohnen und Umwelt, Darmstadt 2010			

Scenario Indicators <1>

State Indicators

Scenario "Trend"		Subset of the building stock which was constructed until 2009: situation 2009-2050					
	2009 (basic case)	2015	2020	2030	2040	2050	
	bs...2009 2009	bs...2009 2015	bs...2009 2020	bs...2009 2030	bs...2009 2040	bs...2009 2050	
number of buildings	18.113.407	17.890.804	17.704.722	17.332.558	16.960.394	16.588.230	
number of apartments	38.584.956	38.000.657	37.510.054	36.528.850	35.547.646	34.566.442	
national reference area [m ²]	3.521.971.190	3.473.712.028	3.433.245.271	3.352.311.757	3.271.378.243	3.190.444.729	
TABULA/EPISCOPE reference area [m ²]	3.874.168.309	3.821.083.231	3.776.569.798	3.687.542.933	3.598.516.067	3.509.489.202	
Building insulation: state of modernisation : insulation improved from original state							
walls							percentages related to ...
insulation improved (area-weighted)	16%	20%	24%	31%	39%	48%	element area
roofs / upper floor ceilings							
insulation improved (area-weighted)	35%	42%	48%	59%	67%	75%	
ground floors / cellar ceilings							
insulation improved (area-weighted)	7%	9%	10%	12%	15%	18%	
windows							
insulation improved (area-weighted)	29%	37%	44%	58%	73%	79%	
Building insulation: Detailed information							
levels of wall insulation (area-weighted):							percentages related to...
level 0 (U > 0,7 W/m ² K)	51%	47%	44%	37%	29%	22%	element area
level 1 (0,7 W/m ² K >= U > 0,3 W/m ² K)	49%	50%	50%	51%	51%	50%	
level 2 (0,3 W/m ² K >= U > 0,20 W/m ² K)	0%	3%	6%	11%	18%	25%	
level 3 (U <= 0,20 W/m ² K)	0%	0%	0%	1%	2%	3%	
levels of roof/upper floor ceiling insulation (area-weighted):							percentages related to...
level 0 (U > 0,7 W/m ² K)	33%	26%	21%	12%	7%	3%	element area
level 1 (0,7 W/m ² K >= U > 0,3 W/m ² K)	67%	67%	66%	62%	51%	40%	
level 2 (0,3 W/m ² K >= U > 0,20 W/m ² K)	0%	7%	12%	24%	38%	53%	
level 3 (U <= 0,20 W/m ² K)	0%	0%	1%	2%	3%	5%	
levels of ground floor / cellar ceiling insulation (area-weighted):							percentages related to...
level 0 (U > 0,7 W/m ² K)	57%	56%	54%	51%	49%	45%	element area
level 1 (0,7 W/m ² K >= U > 0,3 W/m ² K)	43%	44%	46%	48%	51%	54%	
level 2 (0,3 W/m ² K >= U > 0,26 W/m ² K)	0%	0%	0%	0%	0%	0%	
level 3 (U <= 0,26 W/m ² K)	0%	0%	0%	0%	1%	1%	
levels of window insulation (area-weighted):							percentages related to...
level 0 (U > 1,7 W/m ² K)	55%	47%	40%	26%	13%	9%	element area
level 1 (1,7 W/m ² K >= U > 1,3 W/m ² K)	45%	45%	45%	44%	40%	24%	
level 2 (1,3 W/m ² K >= U > 1,0 W/m ² K)	0%	8%	14%	27%	43%	61%	
level 3 (U <= 1,0 W/m ² K)	0%	0%	1%	2%	4%	6%	
Main Heat Supply Systems for Space Heating							
Centralisation of space heating system							percentages related to...
district heating	7%	7%	8%	9%	10%	11%	living space
building / apartment heating	87%	88%	90%	90%	90%	89%	
room heating	6%	4%	3%	1%	0%	0%	
Main energy carrier for space heating							percentages related to...
district heating	7%	7%	8%	9%	10%	11%	living space
gas (natural / liquid gas)	53%	53%	53%	52%	50%	48%	
oil	30%	29%	28%	26%	23%	20%	
coal	1%	0%	0%	0%	0%	0%	
wood/biomass	5%	6%	7%	10%	13%	16%	
electricity	4%	4%	3%	4%	5%	6%	
Main heat generation system for space heating							percentages related to...
district heating	7%	7%	8%	9%	10%	11%	living space
combustion of fossil fuels: stoves	2%	1%	1%	0%	0%	0%	
combustion of fossil fuels: constant temperature boilers	14%	9%	6%	2%	1%	0%	
combustion of fossil fuels: gas/oil low temperature boilers	47%	40%	35%	24%	18%	14%	
combustion of fossil fuels: gas/oil condensing boilers	21%	32%	40%	51%	54%	53%	
combustion of wood/biomass	5%	6%	7%	10%	13%	16%	
direct electric heating	2%	1%	1%	0%	0%	0%	
electric heat pumps	2%	2%	3%	4%	5%	6%	
Special Systems							percentages related to...
solar thermal systems	6,2%	11,1%	15,3%	24,0%	33,0%	42,6%	living space
...for hot water supply only	3,7%	6,2%	8,3%	12,6%	17,1%	21,9%	
...for heating and hot water supply	2,5%	5,0%	7,0%	11,4%	15,9%	20,6%	
photovoltaic systems							
ventilation systems (for buildings/apartments, not only kitchen/WC ventilation)	2,4%	3,0%	3,5%	4,6%	5,7%	6,9%	
....without heat recovery	1,8%	2,1%	2,4%	2,9%	3,4%	4,0%	
....with heat recovery	0,6%	0,9%	1,2%	1,7%	2,3%	2,9%	

Scenario Indicators <2>

State Indicators

Scenario "Target-oriented / basic"		Subset of the building stock which was constructed until 2009: situation 2009-2050					
	2009 (basic case)	2015	2020	2030	2040	2050	
	bs...2009 2009	bs...2009 2015	bs...2009 2020	bs...2009 2030	bs...2009 2040	bs...2009 2050	
number of buildings	18.113.407	17.890.804	17.704.722	17.332.558	16.960.394	16.588.230	
number of apartments	38.584.956	38.000.657	37.510.054	36.528.850	35.547.646	34.566.442	
national reference area [m ²]	3.521.971.190	3.473.712.028	3.433.245.271	3.352.311.757	3.271.378.243	3.190.444.729	
TABULA/EPISCOPE reference area [m ²]	3.874.168.309	3.821.083.231	3.776.569.798	3.687.542.933	3.598.516.067	3.509.489.202	
Building insulation: state of modernisation : insulation improved from original state							
walls							percentages related to
insulation improved (area-weighted)	16%	20%	25%	39%	54%	70%	element area
roofs / upper floor ceilings							
insulation improved (area-weighted)	35%	42%	49%	67%	76%	81%	
ground floors / cellar ceilings							
insulation improved (area-weighted)	7%	9%	13%	36%	63%	81%	
windows							
insulation improved (area-weighted)	29%	37%	44%	61%	77%	84%	
Building insulation: Detailed information							
levels of wall insulation (area-weighted):							percentages related to....
level 0 (U > 0,7 W/m ² K)	51%	47%	43%	30%	17%	3%	element area
level 1 (0,7 W/m ² K >= U > 0,3 W/m ² K)	49%	50%	51%	52%	53%	53%	
level 2 (0,3 W/m ² K >= U > 0,20 W/m ² K)	0%	3%	5%	10%	15%	20%	
level 3 (U <= 0,20 W/m ² K)	0%	0%	2%	7%	15%	23%	
levels of roof/upper floor ceiling insulation (area-weighted):							percentages related to....
level 0 (U > 0,7 W/m ² K)	33%	26%	20%	6%	0%	0%	element area
level 1 (0,7 W/m ² K >= U > 0,3 W/m ² K)	67%	67%	67%	63%	48%	28%	
level 2 (0,3 W/m ² K >= U > 0,20 W/m ² K)	0%	7%	11%	19%	25%	30%	
level 3 (U <= 0,20 W/m ² K)	0%	0%	3%	12%	27%	42%	
levels of ground floor / cellar ceiling insulation (area-weighted):							percentages related to....
level 0 (U > 0,7 W/m ² K)	57%	56%	52%	33%	11%	0%	element area
level 1 (0,7 W/m ² K >= U > 0,3 W/m ² K)	43%	44%	47%	54%	58%	50%	
level 2 (0,3 W/m ² K >= U > 0,26 W/m ² K)	0%	0%	0%	0%	0%	0%	
level 3 (U <= 0,26 W/m ² K)	0%	0%	2%	13%	31%	50%	
levels of window insulation (area-weighted):							percentages related to....
level 0 (U > 1,7 W/m ² K)	55%	47%	47%	23%	10%	6%	element area
level 1 (1,7 W/m ² K >= U > 1,3 W/m ² K)	45%	45%	45%	44%	39%	22%	
level 2 (1,3 W/m ² K >= U > 1,0 W/m ² K)	0%	8%	8%	21%	27%	34%	
level 3 (U <= 1,0 W/m ² K)	0%	0%	0%	11%	24%	39%	
Main Heat Supply Systems for Space Heating							
Centralisation of space heating system							percentages related to....
district heating	7%	7%	8%	10%	12%	13%	living space
building / apartment heating	87%	88%	89%	89%	88%	87%	
room heating	6%	4%	3%	1%	0%	0%	
Main energy carrier for space heating							percentages related to....
district heating	7%	7%	8%	10%	12%	13%	living space
gas (natural / liquid gas)	53%	53%	52%	40%	25%	16%	
oil	30%	29%	27%	16%	5%	1%	
coal	1%	0%	0%	0%	0%	0%	
wood/biomass	5%	6%	7%	10%	11%	12%	
electricity	4%	4%	6%	25%	47%	59%	
Main heat generation system for space heating							percentages related to....
district heating	7%	7%	8%	10%	12%	13%	living space
combustion of fossil fuels: stoves	2%	1%	1%	0%	0%	0%	
combustion of fossil fuels: constant temperature boilers	14%	9%	6%	2%	0%	0%	
combustion of fossil fuels: gas/oil low temperature boilers	47%	40%	34%	18%	6%	1%	
combustion of fossil fuels: gas/oil condensing boilers	21%	32%	38%	34%	21%	12%	
combustion of wood/biomass	5%	6%	7%	10%	11%	12%	
direct electric heating	2%	1%	1%	0%	0%	0%	
electric heat pumps	2%	2%	5%	25%	47%	59%	
Special Systems							percentages related to....
solar thermal systems	6,2%	11,1%	17,7%	40,9%	67,2%	95,2%	living space
...for hot water supply only	3,7%	6,2%	7,3%	11,6%	16,8%	22,4%	
...for heating and hot water supply	2,5%	5,0%	10,4%	29,3%	50,5%	72,7%	
photovoltaic systems							
ventilation systems (for buildings/apartments, not only kitchen/WC ventilation)	2,4%	3,0%	4,8%	14,0%	26,2%	41,0%	
....without heat recovery	1,8%	2,1%	2,5%	4,3%	6,3%	8,6%	
....with heat recovery	0,6%	0,9%	2,2%	9,7%	19,9%	32,4%	

Energy Balance Indicators <1>

Scenario "Trend"	2009:	2015	2020	2030	2040	2050
	Basic Case					
all values in TWh/a (10 ⁹ kWh/a)	bs ₂₀₁₂	bs ₂₀₁₅	bs ₂₀₂₀	bs ₂₀₃₀	bs ₂₀₄₀	bs ₂₀₅₀
TABULA/EPISCOPE reference area [10⁹ m²]	3,87	3,95	4,03	4,10	4,16	4,23
Required heat amounts						
Q _{total} Supplied heat (space heating and DHW)	567,2	548,7	533,5	495,7	463,3	432,2
Q _{total} of the buildings constructed until 2009	567,2	539,1	514,7	465,6	421,7	379,2
Q _{total} of the new buildings constructed from 2010	0,0	9,5	18,8	30,2	41,6	53,0
Final energy demand by fuel (gross calorific value)						
1 natural gas (incl. liquid gas)	323,2	304,6	290,0	256,9	227,9	199,8
3 oil	201,0	181,8	166,4	134,2	106,0	79,9
4 coal	3,2	1,4	0,1	0,0	0,0	0,0
5 wood / biomass	60,1	69,0	75,9	86,1	95,5	103,6
6 district heating	34,0	36,2	37,8	39,3	39,9	40,1
7 electric energy (used for heat supply)	31,2	27,6	24,9	22,7	22,7	24,7
Sum of fuels / energy carriers (1-7)	652,9	620,6	595,2	539,2	492,1	448,3
8 environmental heat (used by heat pumps)	5,2	8,5	11,3	15,4	19,2	22,7
9 heat from solar thermal systems	3,9	7,7	10,7	15,8	20,5	24,6
10 ventilation heat recovery	0,3	1,0	1,7	2,6	3,5	4,5
sum of final energy demand (1-10)	662,0	770,7	617,2	570,4	531,8	495,6
CO₂ emissions (in million tons / year)	135,0	125,1	117,6	102,2	89,6	77,9

Scenario "Trend"	2009:	2015	2020	2030	2040	2050
	Basic Case					
Reference area related values in kWh/(m ² a)	bs ₂₀₁₂	bs ₂₀₁₅	bs ₂₀₂₀	bs ₂₀₃₀		bs ₂₀₅₀
TABULA/EPISCOPE reference area [10⁹m²]	3,87	3,95	4,03	4,10	4,16	4,23
Required heat amounts						
Q _{total} Supplied heat (space heating and DHW)	146,4	138,9	132,4	121,0	111,4	102,3
Q _{total} of the buildings constructed until 2009	146,4	136,5	127,7	113,7	101,4	89,7
Q _{total} of the new buildings constructed from 2010	0,0	2,4	4,7	7,4	10,0	12,5
Final energy demand by fuel (gross calorific value)						
1 natural gas	83,4	77,1	72,0	62,7	54,8	47,3
3 oil	51,9	46,0	41,3	32,8	25,5	18,9
4 coal	0,8	0,3	0,0	0,0	0,0	0,0
5 wood / biomass	15,5	17,5	18,8	21,0	23,0	24,5
6 district heating	8,8	9,2	9,4	9,6	9,6	9,5
7 electric energy (used for heat supply)	8,1	7,0	6,2	5,5	5,5	5,8
Sum of fuels / energy carriers (1-7)	168,5	157,1	147,7	131,7	118,3	106,1
8 environmental heat (used by heat pumps)	1,3	2,2	2,8	3,8	4,6	5,4
9 heat from solar thermal systems	1,0	1,9	2,7	3,9	4,9	5,8
10 ventilation heat recovery	0,1	0,3	0,4	0,6	0,9	1,1
sum of final energy demand (1-9)	170,9	195,1	153,1	139,3	127,8	117,3
CO₂ emissions	34,8	31,7	29,2	24,9	21,5	18,4

Energy Balance Indicators <2>

Scenario "Target-oriented / basic"	2009: Basic Case	2015	2020	2030	2040	2050
all values in TWh/a (10 ⁹ kWh/a)	bs ₂₀₁₂	bs ₂₀₁₅	bs ₂₀₂₀	bs ₂₀₃₀	bs ₂₀₄₀	bs ₂₀₅₀
TABULA/EPISCOPE reference area [10 ⁹ m ²]	3,87	3,95	4,03	4,10	4,16	4,23
Required heat amounts						
Q _{total} Supplied heat (space heating and DHW)	567,2	547,8	528,1	461,5	398,1	344,7
Q _{total} of the buildings constructed until 2009	567,2	539,1	511,8	436,8	365,1	303,3
Q _{total} of the new buildings constructed from 2010	0,0	8,7	16,3	24,7	33,0	41,3
Final energy demand by fuel (gross calorific value)						
1 natural gas (incl. liquid gas)	323,2	304,1	278,8	181,1	94,0	54,1
3 oil	201,0	181,8	155,1	71,6	19,0	2,9
4 coal	3,2	1,4	0,1	0,0	0,0	0,0
5 wood / biomass	60,1	68,8	71,6	71,0	64,0	51,9
6 district heating	34,0	36,2	39,4	40,3	38,1	32,4
7 electric energy (used for heat supply)	31,2	27,5	28,8	48,1	61,6	60,0
Sum of fuels / energy carriers (1-7)	652,9	619,7	573,9	412,0	276,7	201,2
8 environmental heat (used by heat pumps)	5,2	8,3	20,0	71,2	104,7	98,9
9 heat from solar thermal systems	3,9	7,8	13,6	30,1	44,8	56,6
10 ventilation heat recovery	0,3	1,1	2,7	8,0	14,7	22,4
sum of final energy demand (1-10)	662,0	769,4	607,6	513,3	426,1	356,7
CO₂ emissions (in million tons / year)	135,0	125,0	115,1	78,5	45,3	24,3

Scenario "Target-oriented / basic"	2009: Basic Case	2015	2020	2030	2040	2050
Reference area related values in kWh/(m ² a)	bs ₂₀₁₂	bs ₂₀₁₅	bs ₂₀₂₀	bs ₂₀₃₀		bs ₂₀₅₀
TABULA/EPISCOPE reference area [10 ⁹ m ²]	3,87	3,95	4,03	4,10	4,16	4,23
Required heat amounts						
Q _{total} Supplied heat (space heating and DHW)	146,4	138,7	131,0	112,7	95,7	81,6
Q _{total} of the buildings constructed until 2009	146,4	136,5	127,0	106,7	87,7	71,8
Q _{total} of the new buildings constructed from 2010	0,0	2,2	4,1	6,0	7,9	9,8
Final energy demand by fuel (gross calorific value)						
1 natural gas	83,4	77,0	69,2	44,2	22,6	12,8
3 oil	51,9	46,0	38,5	17,5	4,6	0,7
4 coal	0,8	0,3	0,0	0,0	0,0	0,0
5 wood / biomass	15,5	17,4	17,8	17,3	15,4	12,3
6 district heating	8,8	9,2	9,8	9,8	9,2	7,7
7 electric energy (used for heat supply)	8,1	7,0	7,1	11,7	14,8	14,2
Sum of fuels / energy carriers (1-7)	168,5	156,9	142,4	100,6	66,5	47,6
8 environmental heat (used by heat pumps)	1,3	2,1	5,0	17,4	25,2	23,4
9 heat from solar thermal systems	1,0	2,0	3,4	7,4	10,8	13,4
10 ventilation heat recovery	0,1	0,3	0,7	2,0	3,5	5,3
sum of final energy demand (1-9)	170,9	194,8	150,7	125,3	102,4	84,4
CO₂ emissions in kg/(m²a)	34,8	31,6	28,6	19,2	10,9	5,8

Summary Indicators

Year			2009 "basic case"	2015	2020	2030	2050
Reference area	National reference area [m ²]			3.590.962.028	3.664.245.271	3.723.311.757	3.841.444.729
	EPISCOPE reference area [m ²]			3.950.058.231	4.030.669.798	4.095.642.933	4.225.589.202
CO₂ emissions	<1> Scenario "Trend" kg/m ² yr			31,7	29,2	24,9	18,4
	<2> Scenario "Target-oriented / basic" kg/m ² yr				28,6	19,2	5,8
	EPISCOPE benchmark kg/m ² yr				29,5	21,4	7,4
	National benchmark kg/m ² yr				25,3	18,7	5,0
Total heat demand	<1> Scenario "Trend" kWh/(m ² yr)			139	132	121	102
	<2> Scenario "Target-oriented / basic" kWh/(m ² yr)				131	113	82
CO₂ emission factor heat supply	<1> Scenario "Trend" kg/kWh			0,228	0,220	0,206	0,180
	<2> Scenario "Target-oriented / basic" kg/kWh				0,218	0,170	0,071

Values related to EPISCOPE Reference Area

Basic Case Details - Scenario and Energy Balance Indicators by Building Type

Building Stock	DE	National	German residential building stock	Year	2009
Details	IWU Model, representing the year 2009, elaborated in 2015 / Source: EPISCOPE national report (2015)				

Annotations to this sheet: Simplification: percentages of heat supply systems from national statistics are considered equal to fractions of produced heat

	1	2	3	4	5	6	7	8	9	10
Building type / label	SUH I	SUH II	SUH III	MUH I	MUH II	MUH III				
Building size category	single-unit housing	single-unit housing	single-unit housing	multi-unit housing	multi-unit housing	multi-unit housing				
Construction time band	... 1978	1979 ... 1994	1995 1978	1979 ... 1994	1995 ...				

General Data

	Total	1	2	3	4	5	6	7	8	9	10	
Number of buildings	18 659	9 490	3 041	2 992	2 432	407	296					10 ³
Number of dwellings	38 585	11 465	3 352	3 128	14 744	3 548	2 348					10 ³
Floor area national		1 269	418	409	1 003	248	176					10 ⁶ m ²
Floor area TABULA	3 874	1 396	459	450	1 103	273	193					10 ⁶ m ²

Building Insulation

Original state / not refurbished fraction of the envelope area

U-values of the original state

Roof	1,00	0,44	0,33	1,09	0,45	0,34						W/(m ² K)
Wall	1,40	0,60	0,28	1,35	0,68	0,39						W/(m ² K)
Window	2,70	2,70	1,60	2,70	2,70	1,60						W/(m ² K)
Floor	1,24	0,68	0,41	1,45	0,69	0,43						W/(m ² K)

Refurbishments (averages)

Refurbished fraction of envelope areas

Roof	47%	24%		48%	23%							
Wall	20%	7%		26%	15%							
Window	36%	12%		45%	24%							
Floor	10%	3%		11%	7%							
<i>Total (indicative)</i>	<i>27%</i>	<i>12%</i>		<i>30%</i>	<i>16%</i>							

U-values of the refurbished fraction (averages)

Roof	0,28	0,28		0,28	0,28							W/(m ² K)
Wall	0,37	0,37		0,37	0,37							W/(m ² K)
Window	1,60	1,60		1,60	1,60							W/(m ² K)
Floor	0,39	0,39		0,39	0,39							W/(m ² K)

Energy Balance

All energy quantities in **GWh/a** Heating + DHW

Output of IWU Model, close to official statistics of sector, but not calibrated

fuels related to **gross** calorific value

												Total	per m ²
Net heat need		228 377	54 577	33 101	133 544	27 588	13 349	0	0	0	0	490 536	127
Produced heat		258 630	64 055	39 497	155 243	32 752	17 030	0	0	0	0	567 206	146
Gas	1,09	128 534	33 175	27 122	94 551	22 752	14 719	0	0	0	0	320 853	83
Oil	1,05	111 651	27 173	7 573	44 509	4 604	958	0	0	0	0	196 467	51
Coal	1,05	2 334	0	0	884	0	0	0	0	0	0	3 219	1
Bio	1,05	35 538	7 792	4 151	8 800	459	817	0	0	0	0	57 556	15
DH		3 563	1 438	1 491	18 472	7 115	1 948	0	0	0	0	34 028	9
EI		13 145	3 402	2 433	9 249	2 222	899	0	0	0	0	31 350	8
Other / not specified		0	0	0	0	0	0	0	0	0	0	0	0
<i>Sum final energy</i>		<i>294 766</i>	<i>72 980</i>	<i>42 770</i>	<i>176 465</i>	<i>37 152</i>	<i>19 342</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>643 474</i>	<i>166</i>
<i>per m²</i>		<i>211</i>	<i>159</i>	<i>95</i>	<i>160</i>	<i>136</i>	<i>100</i>						
CHP electr. producti		0	0	0	0	0	0	0	0	0	0	0	0

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