Case Study Berlin

Summary

WP 4 Energy Efficiency and CO_2 Emission Reduction

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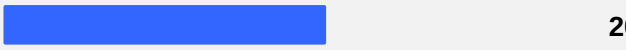
Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument).

Situation 1991/1992 – Kaskelkiez (KAS)

- Total living / usable area: 187.450 m²
- Industry / business in the west of the area (Knorr Co.)
- Buildings mainly masonry structure – construction period 1875 - 1920
- Block development with war-related gaps
- Condition of the buildings:
  12 % poor /desolate, 59 % moderate damage, 29 % normally usable
- high individual renovation effort required
- primarily decentralised heat supply
  76 % stove heating
  14 % gas individual room heaters (GAMAT)
  2 % Gas storey heating
  8 % central heating (coal)
- Hot water: (estimated [1], no data available)
  45 % coal stoves
  30 % electrical storage heaters
  25 % gas instantaneous water heaters
- Natural gas network in good condition, no district heating service



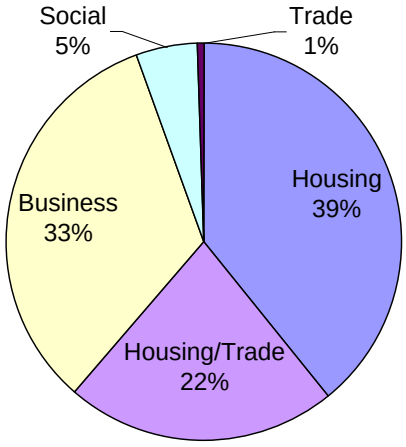
203 kWh/m²a
spec. heating energy demand

319 kWh/m²a
spec. final energy demand

383 kWh/m²a
spec. primary energy demand

108 kg/m²a
CO_2 - emission

Kaskelkiez, Türrschmidtstrasse
(Source: Archive BA Lichtenberg, Urban planning department)



Distribution of total area KAS

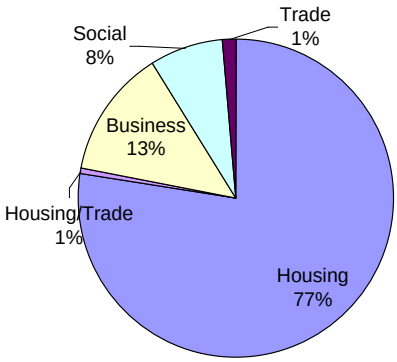
	effective energy dem.		input factor	final energy demand		primary energy dem.		CO2-emission	
	kWh/m²*a averaged	MWh/a	ep averaged	kWh/m²*a averaged	MWh/a	PE-Faktor averaged	MWh/a	E-factor averaged	t/a
housing, MW-GZ, approx. 115.100 m²									
heating	205	23.536	1,55	318	36.588	1,18	43.338	0,328	12.017
hot water	15	1.726	1,32	20	2.274	1,52	3.455	0,405	920
housing / trade, approx. 63.500 m²									
heating	192	12.226	1,36	262	16.644	1,20	19.949	0,348	5.792
hot water	9	573	1,30	12	747	1,26	938	0,360	268
social institutions, approx. 9.300 m²									
heating	251	2.329	1,39	348	3.229	1,20	3.859	0,343	1.108
hot water	30	279	1,31	39	364	1,33	483	0,372	135
total area, approx. 187.900 m ²									
heating / hw	216	40.670	1,47	319	59.846	1,20	72.021	0,338	20.241

[1] Estimated by the author, after consultation with STERN Gesellschaft der behutsamen Stadterneuerung GmbH

Situation 1991/1992 – Frankfurter Allee-Süd (FAS)

- Total residential /usable area: 418.500 m²
- Industry/Business on east side
- Good facilities with schools, day-care, retail
- Prefabricated buildings; construction period between 1970 and 1985
  56 % P2/10; P2/11 ; 17 % WHH GT 18/21 ; 4 % WBS 70
- 11 % Masonry structure (incl. business / commercial)
- 12 % remaining buildings (schools, day-care, businesses, etc.)
- Condition of the buildings:
  Facades in need of renovation, concrete damage
  Heating and central hot drinking water preparation inefficient
- Central district service for heating and hot drinking water
- Mainly single-pipe heating system

Frankfurter Allee Süd (FAS), P2/11



Distribution of total area FAS

spec. heating energy demand — **131 kWh/m²a**

spec. final energy demand — **175 kWh/m²a**

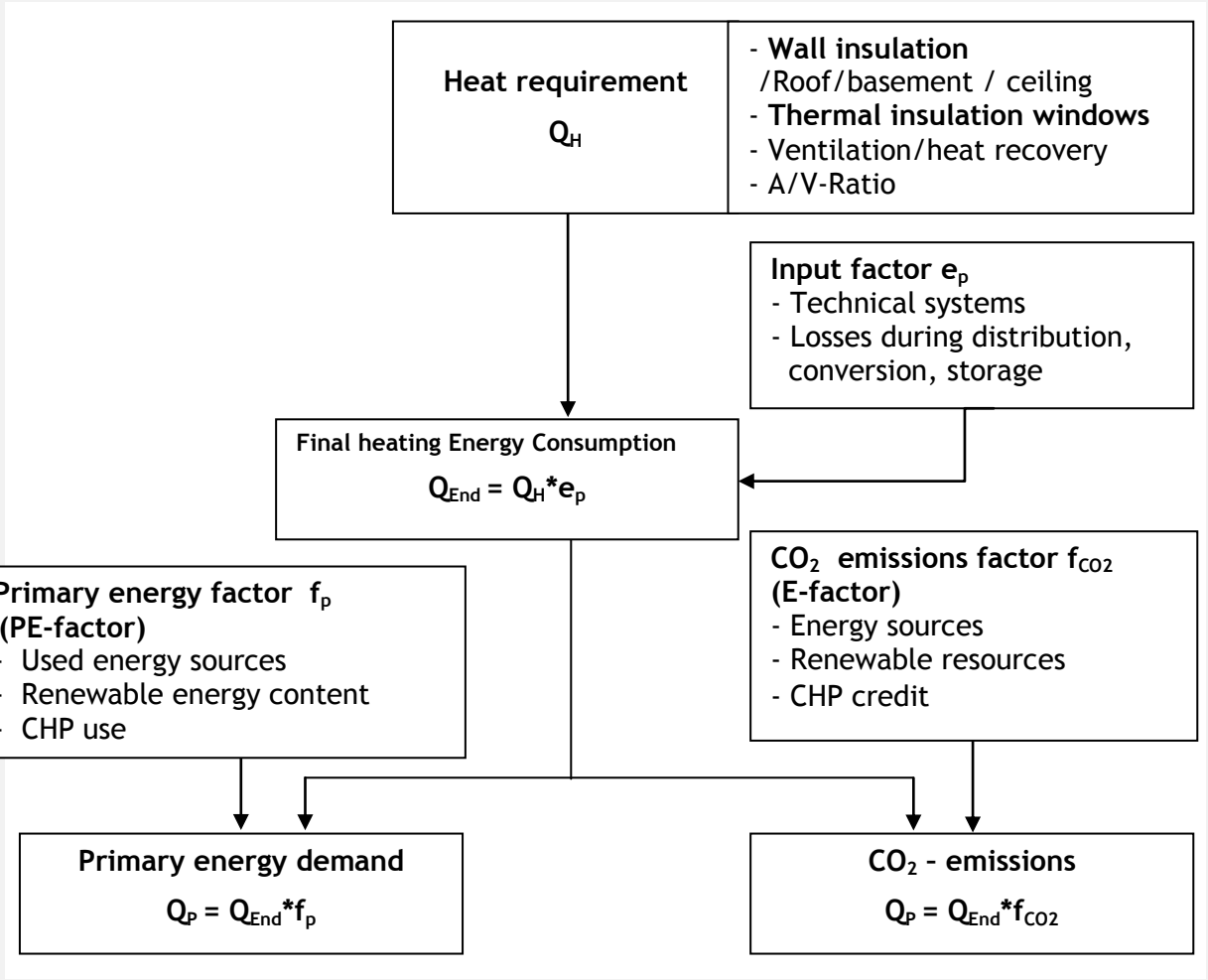
spec. primary energy demand — **125 kWh/m²a**

CO2 - emission — **53 kg/m²a**

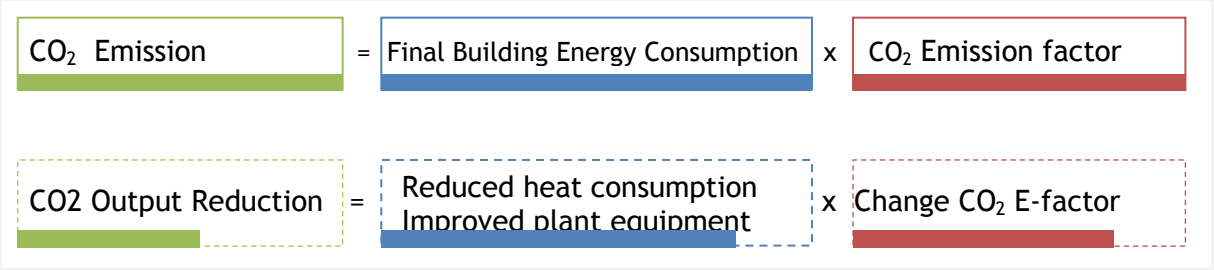
	effective energy dem.		input factor	final energy demand		primary energy dem.		CO2-emission	
	kWh/m²*a averaged	MWh/a	ep averaged	kWh/m²*a averaged	MWh/a	PE-Faktor averaged	MWh/a	E-factor averaged	t/a
housing, MW-GZ, approx. 4.600 m²									
heating	248	1.145	1,33	329	1.520	1,02	1.552	0,317	481
hot water	15,0	69	1,11	17	77	1,38	106	0,388	30
housing type WHH-GT 18/21, approx. 71.600 m²									
heating	137	9.800	1,02	140	9.996	0,70	6.997	0,300	2.999
hot water	47	3.353	1,14	53	3.822	0,70	2.675	0,300	1.147
housing type P2/11, approx. 234.300 m²									
heating	114	26.712	1,02	116	27.246	0,70	19.072	0,300	8.174
hot water	39	9.138	1,14	44	10.418	0,70	7.292	0,300	3.125
housing type WBS 70, approx. 16.400 m²									
heating	118	1.929	1,02	120	1.968	0,70	1.377	0,300	590
hot water	40	659	1,14	46	752	0,70	526	0,300	226
business, trade, approx. 60.100 m²									
heating	157	9.460	1,02	161	9.650	0,70	6.755	0,300	2.895
hot water	8	455	1,14	9	518	0,70	363	0,300	156
social instutions, approx. 31.500 m²									
heating	187	5.877	1,07	200	6.309	0,77	4.853	0,304	1.915
hot water	29	920	1,14	33	1.047	0,75	784	0,306	321
total area, approx. 418.500 m²									
heating/ hw	166	69.519	1,05	175,2	73.323	0,71	52.354	0,301	22.058

Evaluation and Calculation Scheme

- Reference to usable floor space A_{NGF}, not to building floor space A_N according to the EnEV (EnergieEinsparVerordnung / German Energy Conservation Regulations)
- Thereby the named parameters (energy demand / consumption) are approximately 20% higher ($A_N \approx 1{,}2 * A_{NGF}$) than parameters calculated ones pursuant to EnEV.
- Area determination based upon built-up floor space and number of floors (gross floor space), as well as a conversion factor to determine A_{NGF} from gross floor space
- Energy parameters are determined on the basis of requirement calculations according to DIN 4108-6 / DIN 4701-10, including approximation approaches for simplification; Comparison to actual consumption data



Potential for CO_2 savings



Building Types and Average Energy Demand 1991/92

The various buildings in the case-study area were classified into the following building types:
(Heating and hot water related to the heated floor area of buildings)

Building type	Building characteristics		Final energy (kWh/m² a)	Primary energy (kWh/m² a)	CO_2 Emissions (kg/m² a)
MW-GZ	Masonry construction, 3-5 floors, block development, decentralised heat supply Year of construction. 1870 -1920		314	378	108
P2/11	Prefabricated building standardized construction Central heat supply Year of construction. 1970 - 1985	Residential bldg 11 floors	161	113	48
WHH-GT		Residential bldg 18/21 floors	193	135	58
WBS 70		Residential bldg 5/6 floors	166	116	50
Day-care		1-2 floors	197	138	59
Schools		5 floors	187	131	56
Shopping centres		1 floor	261	182	78
Production facilities		1-2 floors	128	90	38

Energy networks

Kaskelkiez

- Completely developed with natural gas
- The network was upgraded to the greatest possible extent in the 1980's and steel piping was laid
- Dimensioning was sufficient to supply the area
- No district heating supply, although lines were adjacent

FAS

- District heating network completely developed
- Natural gas supply existing, only partially used for heating

District heating supply (yellow): Kaskelkiez 0 %, FAS completely

Energy-related renovation actions at Kaskelkiez

Initial situation

- Partially desolated structural condition, as well as poor energy condition
- Unsettled ownership situations complicate restoration activity (restitution claims)
- Fragmented ownership structure, approximately 20 % owner-occupied
- Historical monument protection, or restoration and conservation statutes limit energy-related renovation

Kaskelkiez Actions

- Replace decentralised heat generators (stove heating / gas outer wall heating),
  Installed central heating equipment with modern low-temperature / condensation boilers, almost completely based on natural gas
- Occasional installation of storey-level gas heating per housing unit (via residents renovation programme in the 1990s)
- Installation of central hot water equipment during total renovation
- Renovation of leaky roofs, to some extent with insulation of the top ceiling
- Insulation of the roof during loft conversions to extend residential use
- Insulation of the lowest ceiling / basement ceiling
- Replacement/Refurbishing of old wood windows
- Renovation of the facades (stucco facades) without insulation in the case of historical monument protection
- Insulation of only rear facade surfaces (courtyard or side wing) in the case of buildings protected as historical monuments or with restoration/conservation statutes
- Application of renewable energy sources for particular properties:
  4 properties with solar thermal energy
  1 property with photovoltaic technology
  1 property with a biomass furnace (pellets)

Energy-related renovation actions at Frankfurter-Allee-Süd

Initial Situation

- Buildings constructed from prefabricated components show defects in the facade (outer walls/windows), as well as in the technical equipment (defective condition / dimensioning / adjustment)
- Initial situation in terms of energy parameters clearly better than at Kaskelkiez
- Ownership situations for the most part clarified (restitution claims excluded for prefabricated residential buildings))
- Buildings are the property of a few larger owners (housing associations/cooperatives), by whom mainly complex renovations were implemented

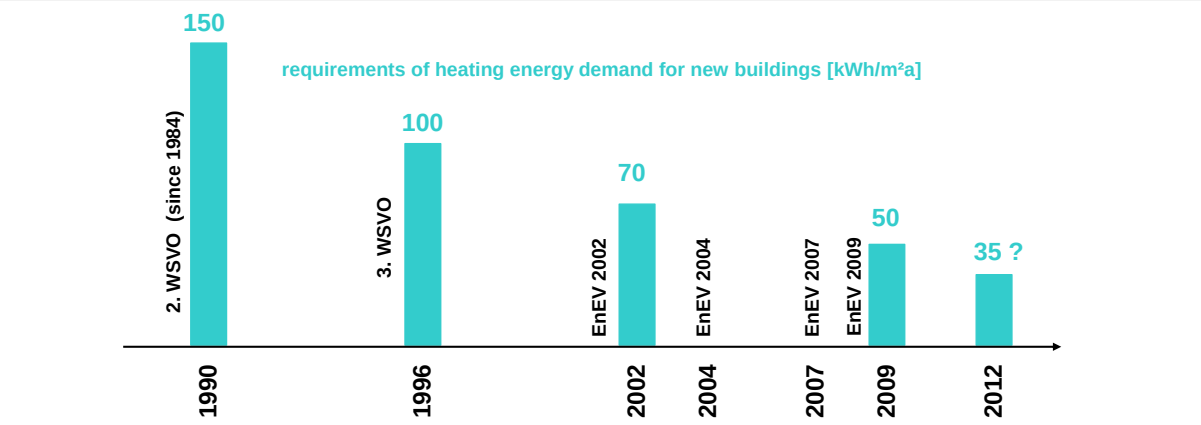
Energy-related Actions Frankfurter Allee Süd

- Renovation of the district heating feed point stations, including hot water preparation
- Installation of thermostatic valves as well as consumption-based billing
- Replacement of the single-pipe heating equipment by twin-pipe equipment in the process of complex renovation
- Renovation of the supply equipment (ventilation, cold/hot water distribution, electric distribution) in the process of complex renovation projects
- Insulation of the hot water / circulation lines to reduce distribution losses
- Complex renovation of building types:
  P2/11 (mainly 1995-98)
  WBS 70
  WHH GT (1998-2000 and 2005/2006)
  including
  - heat insulation of the facades
  - heat insulation of the lowest / top ceilings
  - window replacement
  - renovation of the building supply equipment
- Maintaining district heating supply
- Partial renovation of a school and day-care
- Renovation of a sports hall in 2010 within the framework of a stimulus programme
- One combined heat and power unit by heating station in the low-energy building WHH GT 18/21

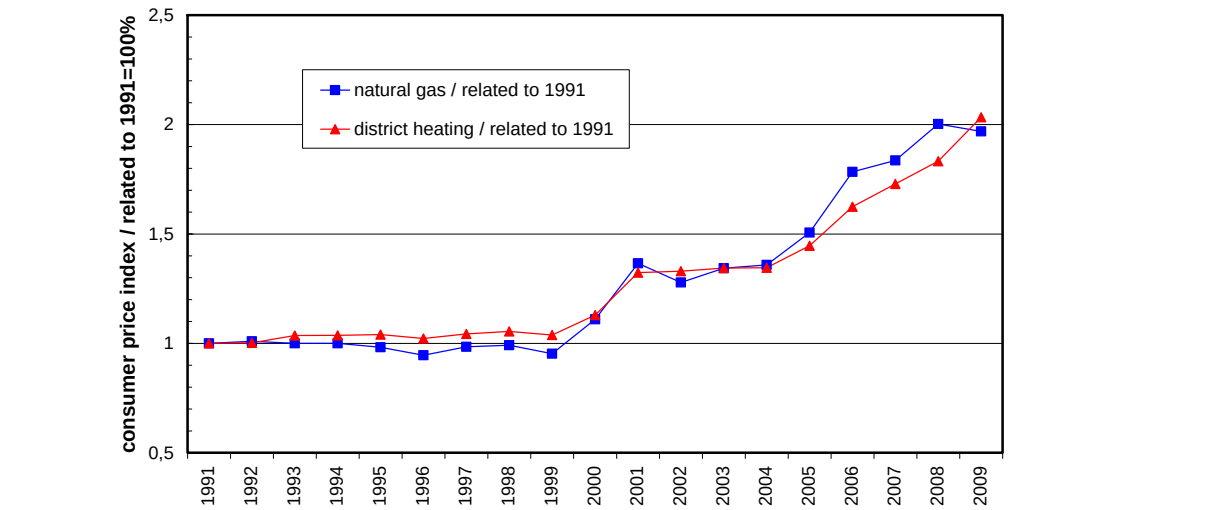
Energy Concepts 1991/92 to 2010

- Energy-saving measures in existing buildings are voluntary; if renovated, however, the modified or replaced components are subject to requirements oriented to new buildings (EnEV)
- Short-term economic measures (replacement of heating boilers from before 1978, insulation of the top ceilings, insulation of lines, consumption-based billing) are prescribed by law.

Inception of the Heat Insulation Ordinance (WSVO) or Energy-Saving Regulations (EnEV)
(Following: Development of heat requirements for new construction, W. Ornth, BMVBS)



- The development of energy prices since 2000 provides stimulus for energy-savings (source BMWI)

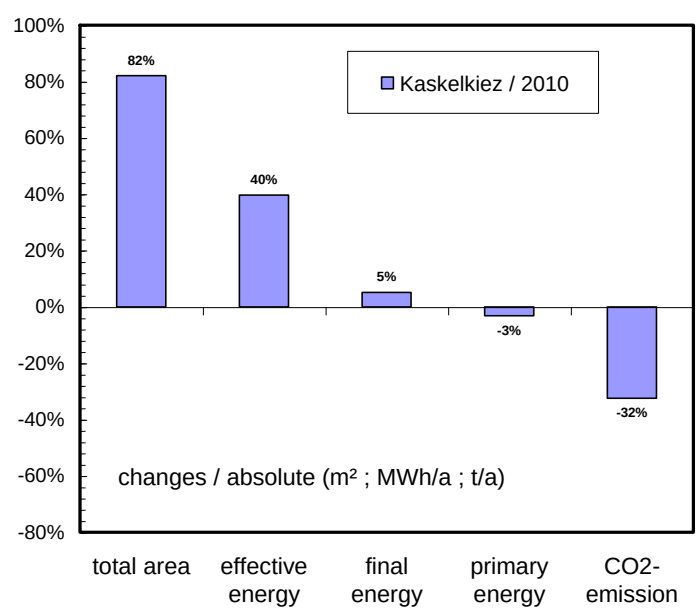


- Since renovation is voluntary, government programmes provide incentives for energy-saving actions: the KfW Programme with interest subsidy (by partial repayment waiver for low energy standard), government programme for the launch of renewable energy sources (BAFA)
- Outstanding examples for energy efficiency:
  - Existing low-energy building, WHH GT 18/21 high-rise, renovation 2005/06
  - Renovation on new construction level with solar thermal technology: Kaskelstrasse 49 (2005/06)
  - New low-energy building with solar thermal technology: Spittastrasse 36 (2009/10)
- In case of historic buildings and facades, historic monument protection has priority over energy saving.

Energy Efficinecy Kaskelkiez 2010

Achieved level of energy-related renovation

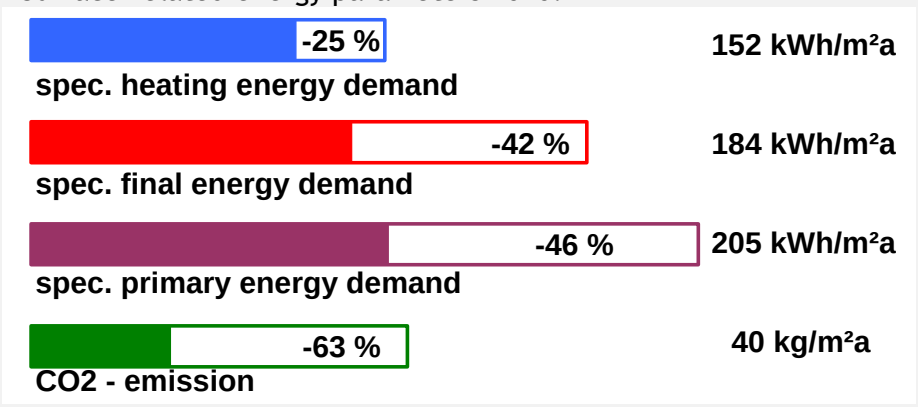
- large part of houses renovated :
  approx. 60 % completely / partially
  approx. 15 % basically
- New construction for living buildings, businesses (offices) and trade
- Total area increase approx. 82% through new buildings and extensions
- Absolute reduction of CO_2 emissions by approx. 6.500 t/a



Energy consumption und CO_2 emissions

- Residential buildings:
  80 % central heating / natural gas
  15 % storey-level gas heating
  5 % stove heating / other
- Businesses: 100 % central heating natural gas
- Hot water: 85 % centralised / natural gas; 15 % decentralised (electric)

Surface-related energy parameters 2010:

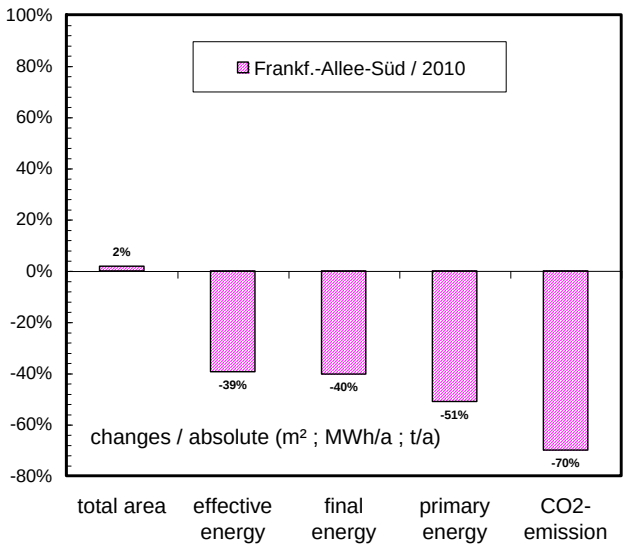


	effective energy dem.		input factor	final energy demand		primary energy dem.		CO2-emission	
	kWh/m²*a averaged	MWh/a	ep averaged	kWh/m²*a averaged	MWh/a	PE-Faktor averaged	MWh/a	E-factor averaged	t/a
housing, MW-GZ + new + extensions of roofs, approx. 162.900 m²									
heating	163	26.599	1,12	182	29.663	1,11	32.815	0,220	6.516
hot water	19	3.054	1,11	21	3.377	1,26	4.262	0,250	845
buisness, trade, including new buildings, approx. 168.300 m²									
heating	136	22.957	1,10	149	25.150	1,10	27.671	0,211	5.315
hot water	9	1.494	1,11	10	1.664	1,17	1.944	0,227	379
social institutions, approx. 11.000 m²									
heating	225	2.465	1,12	250	2.749	1,11	3.043	0,221	607
hot water	23	247	1,10	25	272	1,29	351	0,257	70
total area, approx. 342.100 m ²									
heating / hw	166	56.817	1,11	184	62.877	1,11	70.086	0,218	13.732
Δ to 1991/92	-23%	40%		-42%	5%		-3%		-32%

Energy Efficiency Frankfurter-Allee-Süd 2010

Achieved level of energy-related renovation

- Nearly 100% renovation of residential buildings
- Schools and day-cares only partially until now, currently renovation of day-care and gymnasiums
- No energy-related renovation of commercial halls
- Partial energy-related renovation of office buildings
- Decentralised heat and power unit in the low-energy building of Howoge
  175 MWh heat, 85 MWh power annually
- Clear reduction of CO_2 emissions of district heating
  (decrease of emission factor from 300 to149 kg/MWh)



-40 % — **78 kWh/m²a**
spec. heating energy demand

-41 % — **103 kWh/m²a**
spec. final energy demand

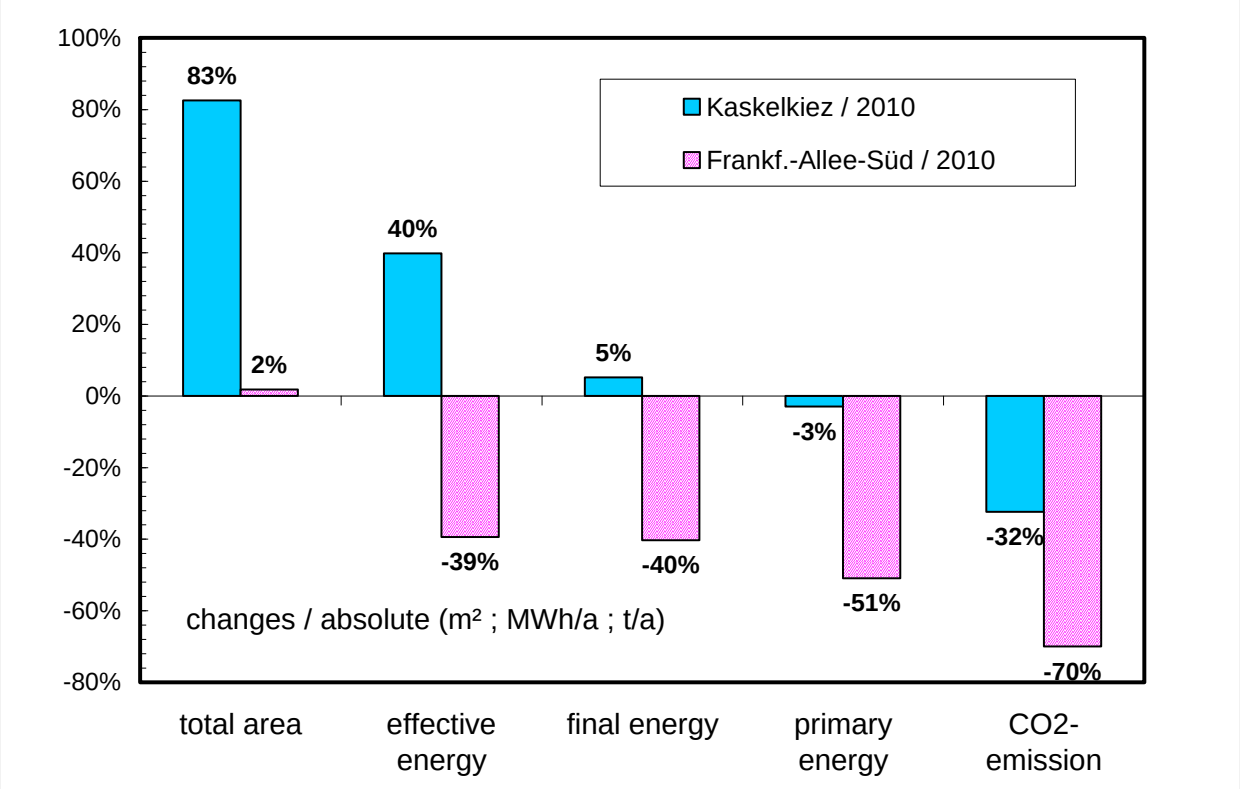
-52 % — **60 kWh/m²a**
spec. primary energy demand

-70 % — **16 kg/m²a**
CO2 - emission

	effective energy dem.		input factor	final energy demand		primary energy dem.		CO2-emission	
	kWh/m²*a averaged	MWh/a	ep averaged	kWh/m²*a averaged	MWh/a	PE-Faktor averaged	MWh/a	E-factor averaged	t/a
housing, MW-GZ + extensions of roofs, approx. 5.000 m² (increase in 400 m²)									
heating	188	946	1,06	200	1.002	0,88	885	0,191	192
hot water	19	94	1,13	21	106	0,90	95	0,187	20
housing type WHH-GT 18/21, approx. 72.300 m²									
heating	61	4.427	1,01	62	4.471	0,57	2.535	0,149	666
hot water	23	1.684	1,14	27	1.920	0,57	1.088	0,149	286
housing type P2/11, approx. 234.400 m²									
heating	56	13.221	1,01	57	13.353	0,57	7.571	0,149	1.990
hot water	24	5.598	1,14	27	6.382	0,57	3.618	0,149	951
housing type WBS 70, approx. 16.400 m²									
heating	72	1.181	1,01	73	1.193	0,57	676	0,149	178
hot water	24	388	1,14	27	442	0,57	251	0,149	66
business, trade, include new buildings/extensions, approx. 67.900 m²									
heating	130	8.844	1,01	132	8.933	0,57	5.065	0,149	1.331
hot water	8	517	1,14	9	589	0,57	334	0,149	88
social instutions, approx. 29.900 m²									
heating	153	4.566	1,02	156	4.661	0,64	2.980	0,159	740
hot water	22	661	1,14	25	753	0,59	446	0,152	114
total area approx. 426.000 m ² (increase in 7.500 m²)									
heating / hw	99	42.127	1,04	103	43.805	0,58	25.546	0,151	6.621
Δ to1991/92	-40%	-39%		-41%	-40%		-51%		-70%

Summary

Changes in the areas (absolute values)



Parameters of Energy Demand and CO_2 Emissions 2010 and achieved CO_2 Savings

		Kaskelkiez		Frankfurter Allee Süd				
		Residential	Business	P2/11	WBS 70	WHH GT 18	Day-care	School
Spec.heat demand	kWh/m²a	175	138	56	72	61	125	127
Final energy demand	kWh/m²a	207	160	84	100	88	145	145
Primary energy demand	kWh/m²a	231	177	48	57	50	82	82
CO_2 Emissions	(kg/m²a)	45,3	33,9	12,5	14,9	13,2	21,4	21,6
CO_2 Savings (by comparison 1990)	(kg/m²a)	62,7	60,6	35,7	34,9	44,7	37,9	34,6
	(kg/m²a)	(-58 %)	(-64 %)	(-74 %)	(-70 %)	(-77 %)	(-63 %)	(-61 %)
through heat protection	(kg/m²a)	9,4	18,5	17,3	13,7	22,7	10,5	7,0
through equipment tech.	(kg/m²a)	27,3	19,9	5,7	6,2	8,7	5,7	5,7
through energy sources	(kg/m²a)	25,9	22,2	12,7	15,1	13,3	21,6	21,9

Potential for Energy Savings / Energy Efficiency

Kaskelkiez

- Small-scale ownership structure leads to differentiated planning and renovation
- Partial renovation in steps according to urgency and financial possibilities
- Energy-related renovation of building shell still holds great potential.
- Renovation of the heating / hot water equipment prevailingly implemented
- Until now very few investments in renewable energy sources, since investments in heat insulation and heating system modernisation were more economic
- Connection of the area to district heating had only been investigated in 2006 – majority of the renovation and new construction actions were already completed and supplied for example with natural gas, district heating supply still assessed as uneconomical.

Frankfurter-Allee-Süd

- 5 owners (housing associations/cooperatives) possess 99% of housing → best conditions for large-scale implementation of renovation and energy-efficient measures
- All residential buildings were renovated using state-of-the-art technology while respecting legal energy demand guidelines
- Until now only a few investments in renewable energy sources: not more energy-efficient compared to district heating from combined power and heat technology available in the area.
- Intensive use of government incentive programmes (KfW Programme, Berlin Prefabricated construction incentive progr. 1993 to 2001, Urban development progr.)
- Definite effects via energy source change and efficiency improvement of district heating applications (network operator) without individual investments of the building owners

Conclusions

1. Large owners or organised ownership structures more successful in energy-related renovation
2. Planning / decisions as to energy sources / supply networks to be considered from outset
3. Partial renovation possible, but coordinated total concept needed; otherwise: risk of structural damages/ inefficiency/ higher efforts of user involvement.
4. Targets for energy-related area development should be defined individually, subsequently renovation concepts with information as to the approach, renovation sequence or data on savings potential should be developed.
5. Energy-related renovation of building shell should be implemented on the highest possible level, since energy saving measures have long usage duration (20 -40 years).
6. Stepwise energy-related improvement of building components recently renovated at present uneconomical.
7. Involvement of the tenants / occupants in process very important, since user behaviour bears considerable influence on the actual energy consumption.

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