REPORT
PUBLIC

CS 36: Multifamily Housing Renovation Erlangen / Construction phase 3

RENOVATION APPROACH DOCUMENT

outPHit
Deep retrofits made faster, cheaper and more reliable

Deliverable D5.2

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OUTPHIT – DEEP RETROFITS MADE FASTER, CHEAPER AND MORE RELIABLE
outPHit pairs such approaches with the rigour of Passive House principles to make deep retrofits cost-effective, faster and more reliable. On the basis of case studies across Europe and in collaboration with a wide variety of stakeholders, outPHit is addressing barriers to the uptake of high quality deep retrofits while facilitating the development of high performance renovation systems,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957175. The presented contents are the author's sole responsibility and do not necessarily reflect the views of the European Union. Neither the CINEA nor the European Commission are responsible for any use that may be made of the information contained therein.

CS36_MULTI FAMILY BUILDINGS ERLANGEN PHASE III

Renovation Approach Description

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1. Executive Summary

The housing association GEWOBAU Erlangen has set itself the goal of a climate-neutral housing stock by 2030. For this reason, all upcoming renovations will be carried out to the kfw40 or EnerPHit standard. The third construction area comprises 7 apartment blocks. The buildings each have 12, 16, 18 or 22 residential units and between two and four floors.

The buildings were built in the 1950s and were retrofitted in the 1990s with 8cm ETICS and insulation of the top floor ceiling. Currently, the facades and windows are being renovated with serially prefabricated highly insulating elements. In the area of the balconies, the insulation measures are traditionally carried out as a doubling on the existing ETICS. While the windows of the prefabricated facade are located in the insulation level, the balcony doors remain in their original position in the masonry. In addition, the basement ceiling will be fitted with additional 8cm of thermal insulation from below. In addition, gas heating will be replaced by heat pumps. To fulfill the EH40 funding standard, each residential unit has to install a ventilation system with heat recovery. The heat transfer station and the ventilation system are installed in a kind of backpack from the outside to the outer wall in the area of the bathroom. This backpack is thus attached from the outside as a prefabricated element like the facade elements, so that no space is required for it within the existing apartment.

The 3rd construction area consists of 7multifamily buildings with 4 storeys, with 157 residential units in total on 10.959 m² residential floor area. In this block, 6 of the buildings are orientated to East and West, thereby being considerably shaded by the neighbor buildings. For the evaluation purposes, building 135 was chosen to be representative for the other buildings within this district.



Site plan, Source: GEWOBAU

2. Description of the existing building

The building is typical of the multi-story residential buildings of the 1950s and 1960s in Germany. Masonry walls and reinforced concrete floors form the supporting structure. The buildings have gable roofs with cold stores. The staircases are slightly set back. The original windows have been replaced in the meantime by plastic windows and partly by wooden windows with 2-pane thermal insulation glazing.



2.1. Building data

Year of construction:	1957
Treated Floor Area:	1071 m²
Number of floors:	4
Number of apartments:	16
Building typology (residential / other):	residential
Main construction type (e.g. massive)	massive

2.2. Owner data

Name:	GEWOBAU Erlangen
City:	Erlangen
Type (private / housing association):	Housing Association

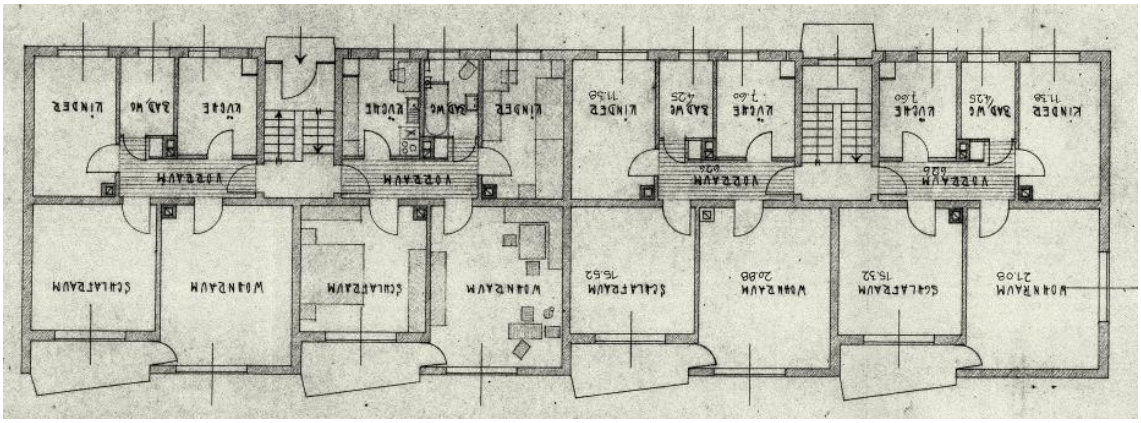
2.3. Location description

The city of Erlangen in the Middle of Franconia in the Free State of Bavaria. Due to its location in Central Europe, it is in the cool temperate climate zone. The town can neither be clearly assigned to the continental climate nor to the maritime climate. Typical of the continental influence is the low annual precipitation of 645 mm. Source: Wikipedia

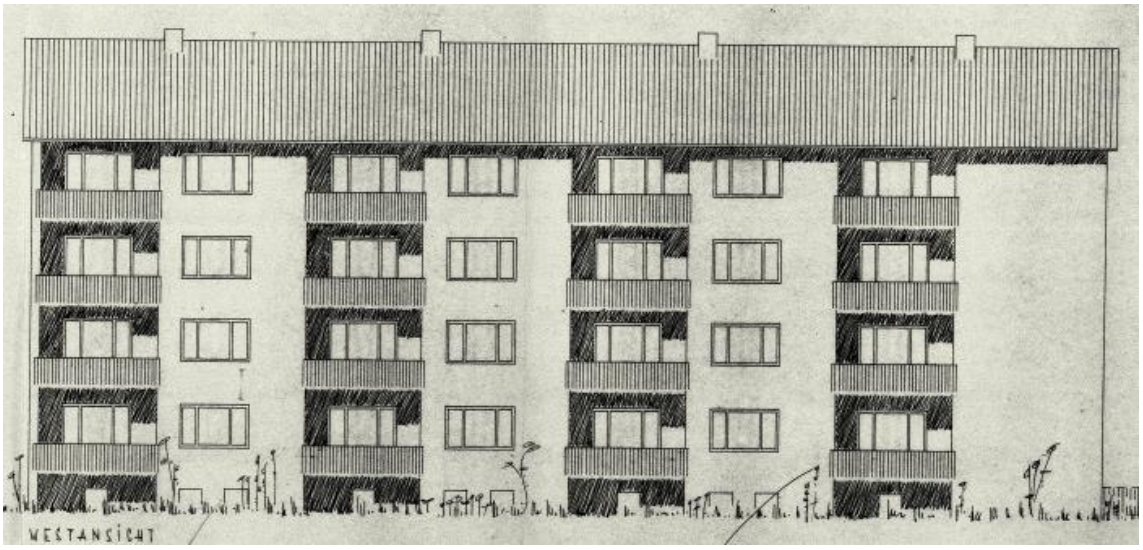
2.4. Original situation

The building fabric consists of 30cm of masonry walls and reinforced concrete ceilings as well as a gable roof and a massive basement. The windows and façade have been renewed once so far in 1990, also roof attic and basement ceiling had been implemented.

2.5. Plans and pictures of the existing building



Ground Floor, Source: GEWOBAU



West Elevation, Source: GEWOBAU

2.6. Envelope of the existing building

External walls

Material:	Brick with 80mm ETICS
Thickness:	42 [cm]
Surface (Render / Brick / Cladding):	Render surface
U-Value:	0,35 [W/(m²K)]

Floor slab / Basement ceiling

Material:	Concrete
Thickness:	35 [cm]
Surface (Render / Brick / Cladding):	Concrete
U-Value:	0,3 [W/(m²K)]

Roof / Top floor ceiling

Material:	Concrete
Thickness:	31 [cm]
Surface (Render / Brick / Cladding):	OSB Board
U-Value:	0,30 [W/(m²K)]

Windows

Material:	PVC
Thickness:	8 [cm]
Material (Wood / Plastic / Aluminium):	Plastic
U-Value (Uw, installed):	1,85 [W/(m²K)]

2.7. Technical equipment of the existing building

Ventilation

Ventilation concept:	window ventilation only

Heating, Cooling and DHW

Heating:	central gas heating
Cooling:	Roller shutters at all windows, no active cooling
Domestic hot water:	central gas heating

2.8. Energy efficiency of the existing building

Passive House Planning Package (PHPP)

PHPP calculation:	PHPP_10.5
Space heating demand:	99 [kWh/(m²a)]
Heating Load:	48 [W/m²]
Overheating frequency:	0,3 %
Cooling demand:	0 [kWh/(m²a)]
Cooling Load:	0 [W/m²]
Primary Energy Demand:	193 [kWh/(m²a)] including household applications
PER Demand:	265 [kWh/(m²a)]

Final Energy demand

Final energy demand gas:	141 [kWh/(m²a)]
Final energy demand electricity:	21 [kWh/(m²a)] for auxiliary + household electricity
Final energy demand other:	0 [kWh/(m²a)]

Available consumption before renovation

Annual energy consumption gas:	not available
Annual energy consumption electricity:	not available
Annual energy consumption other:	not available

Available energy costs before renovation

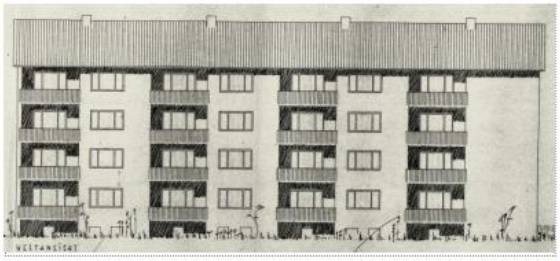
Annual energy costs gas:	not available
Annual energy costs electricity:	not available

PHPP verification sheet before retrofit

EnerPHit-Nachweis

10.5 DE

PHPP



Objekt:	CS36_Erlangen_PGStr 85-87		
Straße:	Paul-Gossen-Strasse 85-87		
PLZ/Ort:	91502	Erlangen	
Provinz/Land:	Bayern	DE-Deutschland	
Objekt-Typ:	5-Mehrfamilienhaus I Geschosswohnungsbau		
Klimadatensatz:	ud---01-Nürnberg PHI, höhenkorrigiert		
Klimazone:	3: Kühl-gemäßigt	Standorthöhe:	285 m
Bauherrschaft:	GEWOBAU Erlangen		
Straße:	Nägelsbachstr. 55 a		
PLZ/Ort:	91052	Erlangen	
Provinz/Land:	Bayern	DE-Deutschland	

Architektur:		**Haustechnik:**	
Straße:		Straße:	
PLZ/Ort:		PLZ/Ort:	
Provinz/Land:		Provinz/Land:	
Energieberatung:	Passivhaus Institut GmbH	**Zertifizierung:**	
Straße:	Rheinstrasse 44/46	Straße:	
PLZ/Ort:	64283 Darmstadt	PLZ/Ort:	
Provinz/Land:	Hessen DE-Deutschland	Provinz/Land:	

Baujahr:	1957	Innentemperatur Winter [°C]:	20,0	Innentemp. Sommer [°C]:	25,0
Anzahl WE:	16	Interne Wärmequellen (IWQ) Winter [W/m²]:	2,8	IWQ Sommer [W/m²]:	3,2
Personenzahl:	28,4	spez. Kapazität [Wh/K pro m² EBF]:	204	Mechanische Kühlung:	

Gebäudekennwerte mit Bezug auf Energiebezugsfläche und Jahr — 1 Fehlermeldung(en) im Blatt 'Kontrolle'

				Kriterien	alternative Kriterien	Erfüllt?[2]
	Energiebezugsfläche m²	1071,1				
Heizen	Heizwärmebedarf kWh/(m²a)	99	≤	-	-	-
	Heizlast W/m²	48	≤	-	-	
Kühlen	Kühl- + Entfeuchtungsbedarf kWh/(m²a)	-	≤	-		-
	Übertemperaturhäufigkeit (> 25 °C) %	0	≤	10		ja
	Häufigkeit überhöhter Feuchte (> 12 g/kg) %	0	≤	20		ja
Luftdichtheit	Drucktest-Luftwechsel n_{50} 1/h	3,0	≤	1,0		nein
Feuchteschutz						
	kleinster Temperaturfaktor $f_{Rsi=0,25\ m²K/W}$ -	-	≥	0,75	0,60	-
Behaglichkeit	Alle Anforderungen erfüllt? -					nein
	U-Wert W/(m²K)		≤	0,84		
	U-Wert W/(m²K)		≤	1,01		
	U-Wert W/(m²K)		≤	1,10		
	U-Wert W/(m²K)		≤	0,46		
Nicht erneuerbare Primärenergie (PE)	PE-Bedarf kWh/(m²a)	193	≤	-		-
Erneuerbare Primärenergie (PER)	PER-Bedarf kWh/(m²a)	265	≤	130	145	nein
	Erzeugung erneuerb. Energie (Bezug auf überbaute Fläche) kWh/(m²a)	0	≥	60	108	

PHPP results of the existing building [PHPP 10.5] / Source: PHI

3. Renovation approach description

The building will be equipped with a prefabricated facade of wood with cellulose fibre insulation. The windows are already installed to the elements in the factory. Some work will be carried out by a craftsman's company on site. This includes the connection of new windows to the existing reveal, the doubling of the existing ETICS in the area of the balconies as well as the replacement of the balcony doors, the insulation in the area of the basement as well as the insulation of the basement ceiling from below.

The buildings are intended to be extended by an extra floor with living space on top within the next two years, with adequate roof or top floor insulation and PV systems. However the extension has not yet been decided, therefore, even the attic is not currently being upgraded, the buildings are assumed to be renovated with adequate component qualities for the existing building geometry.

The prefabricated facade elements will be attached to the building within two days after delivery. Between the facade elements are located so-called backpackers. These are attached to the outside of the facade in the area of the bathrooms and contain a heat transfer station and a ventilation system with heat recovery for each residential unit.

Heating and hot water are supplied by an externally installed heat pump that serves 4 residential units on each side of the stair cases per building. The heat is transported to the appartments through the external backpacker concept as well and then connected through the bathrooms.



East façade (backside) of the renovated building, Source: PHI

Facade elements with ventilated facade made of wood lath. The black strips are the backpackers with the building services components: The heat transfer station from district heating grid and the ventilation system

3.1. EnerPHit standard approach

EnerPHit standard target (class):	classic (RES generation yet unclear)
Climate Zone	cool-temperate
EnerPHit verification method:	component quality method

3.2. Design / Consultancy teams

Name:	Passive House Institute
City:	Darmstadt
Type (private / housing association)	private

3.3. Design / Construction periods

Design period:	01.2023 – 09.2023
Construction period:	09.2023 – 06.2024

3.4. Plans and pictures of the renovation



West façade (front side) of the renovated building, Source: PHI

3.5. Envelope of the renovated building

External walls

Material:	EPS / Prefab timber panels with cellulose filling
Thickness:	8 [cm] / 28 [cm]
Surface (Render / Brick / Cladding):	Wood lamellas
U-Value:	0,12 [W/(m²K)]

Floor slab / Basement ceiling

Material:	EPS / EPS
Thickness:	8 [cm] / 5 [cm]
Surface (Render / Brick / Cladding):	EPS
U-Value:	0,21 [W/(m²K)]

Roof or top floor ceiling

Material:	EPS / PUR
Thickness:	10 [cm] / 15 [cm]
Surface (Render / Brick / Cladding):	OSB planking
U-Value:	0,10 [W/(m²K)]

Windows

Material:	PVC
Frame Thickness:	10 [cm]
Material (Wood / Plastic / Aluminium):	Plastic
U-Value (Uw, installed):	0,84 [W/(m²K)]

3.6. Technical equipment of the renovated building

Ventilation

Ventilation concept (central / decentral)	decentral
Ventilation heat recovery efficiency	85 %
Ventilation specific efficiency	0,30 [Wh/m³]
Ventilation standard air flow rate	923 [m³/h]

Heating, Cooling and DHW

Heating:	4 air-water heat pumps supplying 4 units each
Cooling:	Roller shutters at all windows, no active cooling
Domestic hot water:	4 air-water heat pumps supplying 4 units each

3.7. Summer comfort

The climate is moderate in summer, therefore active cooling is not required. Furthermore, due to the recessed loggias and the east-west orientation with neighbor buildings, the building is quite shaded. The windows of living rooms in the prefabricated facade receive a roller shutter. However, summer ventilation can be realized through the ventilation system.

3.8. Energy efficiency of the renovated building

Passive House Planning Package (PHPP)

PHPP calculation:	PHPP_10.5
Space heating demand:	31 [kWh/(m²a)]
Heating Load:	18 [W/m²]
Overheating frequency:	1 %
Cooling demand:	0 [kWh/(m²a)]
Cooling Load:	0 [W/m²]
Primary Energy Demand:	91 [kWh/(m²a)] including household applications
PER Demand:	67 [kWh/(m²a)]
Airtightness n_{50} target:	1,0 1/h (maximum assumed for design purposes)

Final Energy demand

Final energy demand gas:	0 [kWh/(m²a)]
Final energy demand electricity:	51 [kWh/(m²a)] for heating + auxiliary + household





Prefab renovation panels + “backpacker” for heating and ventilation ducts, Source: PHI

PHPP verification sheet after retrofit

EnerPHit-Nachweis

10.5 DE

PHPP



Objekt:	CS36_Erlangen_PGStr 85-87		
Straße:	Paul-Gossen-Strasse 85-87		
PLZ/Ort:	91502	Erlangen	
Provinz/Land:	Bayern		DE-Deutschland
Objekt-Typ:	5-Mehrfamilienhaus I Geschosswohnungsbau		
Klimadatensatz:	ud---01-Nürnberg PHI, höhenkorrigiert		
Klimazone:	3: Kühl-gemäßigt	Standorthöhe:	285 m
Bauherrschaft:	GEWOBAU Erlangen		
Straße:	Nägelsbachstr. 55 a		
PLZ/Ort:	91052	Erlangen	
Provinz/Land:	Bayern		DE-Deutschland

Architektur:		**Haustechnik:**	
Straße:		Straße:	
PLZ/Ort:		PLZ/Ort:	
Provinz/Land:		Provinz/Land:	
Energieberatung:	Passivhaus Institut GmbH	**Zertifizierung:**	
Straße:	Rheinstrasse 44/46	Straße:	
PLZ/Ort:	64283 Darmstadt	PLZ/Ort:	
Provinz/Land:	Hessen DE-Deutschland	Provinz/Land:	

Baujahr:	1957	Innentemperatur Winter [°C]:	20,0	Innentemp. Sommer [°C]:	25,0
Anzahl WE:	16	Interne Wärmequellen (IWQ) Winter [W/m²]:	2,8	IWQ Sommer [W/m²]:	3,2
Personenzahl:	28,4	spez. Kapazität [Wh/K pro m² EBF]:	204	Mechanische Kühlung:	

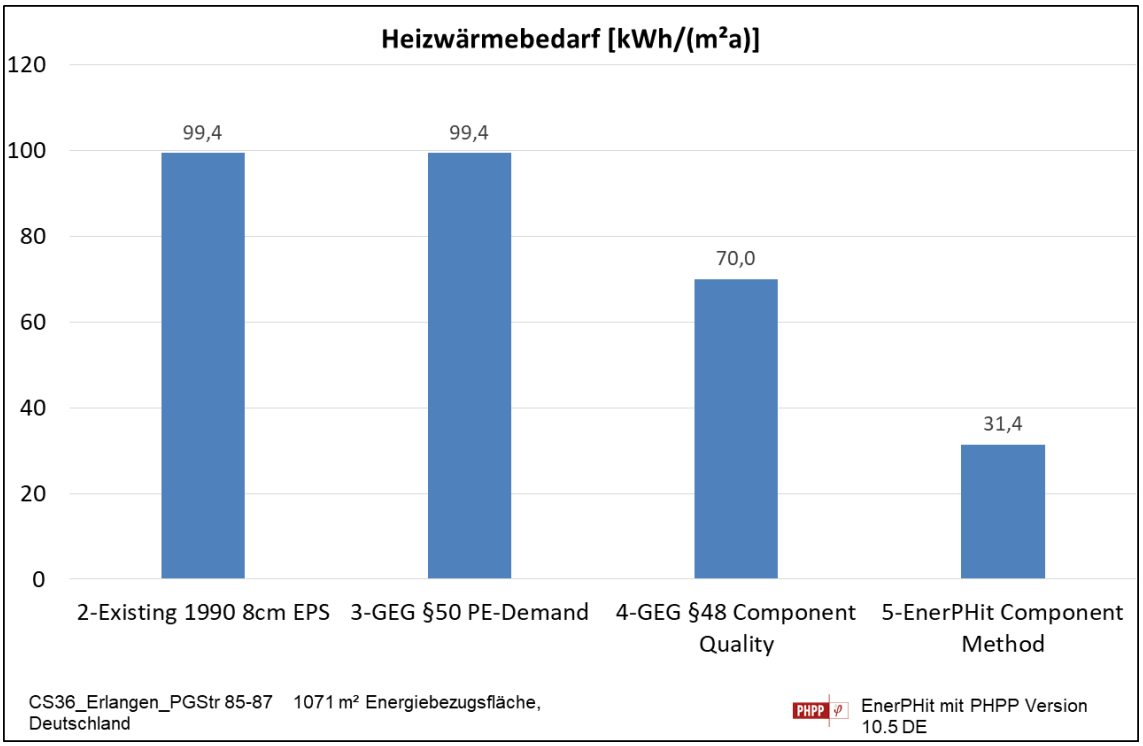
Gebäudekennwerte mit Bezug auf Energiebezugsfläche und Jahr

				Kriterien	alternative Kriterien	Erfüllt?²
	Energiebezugsfläche m²	1071,1				
Heizen	Heizwärmebedarf kWh/(m²a)	31	≤	-	-	-
	Heizlast W/m²	18	≤	-	-	
Kühlen	Kühl- + Entfeuchtungsbedarf kWh/(m²a)	-	≤	-		-
	Übertemperaturhäufigkeit (> 25 °C) %	1	≤	10		ja
	Häufigkeit überhöhter Feuchte (> 12 g/kg) %	0	≤	20		ja
Luftdichtheit	Drucktest-Luftwechsel n_{50} 1/h	1,0	≤	1,0		ja
Feuchteschutz						
	kleinster Temperaturfaktor $f_{Rsi>0,25\ m^2K/W}$ -	-	≥	0,51	0,38	-
Behaglichkeit	Alle Anforderungen erfüllt? -					ja
	U-Wert W/(m²K)		≤	0,84		
	U-Wert W/(m²K)		≤	1,01		
	U-Wert W/(m²K)		≤	1,10		
	U-Wert W/(m²K)		≤	0,46		
Nicht erneuerbare Primärenergie (PE)	PE-Bedarf kWh/(m²a)	91	≤	-		-
Erneuerbare Primärenergie (PER)	PER-Bedarf kWh/(m²a)	67	≤	62	67	ja
	Erzeugung erneuerb. Energie (Bezug auf überbaute Fläche) kWh/(m²a)	192	≥	60	76	

PHPP results of the existing building [PHPP 10.5] / Source: PHI

3.9. Predicted (calculated) energy savings

Savings In space heating demand: 68 [kWh/(m²a)]

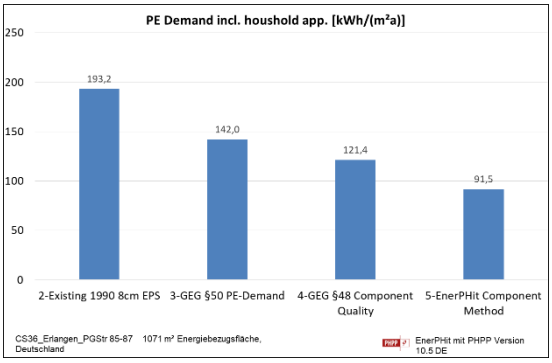


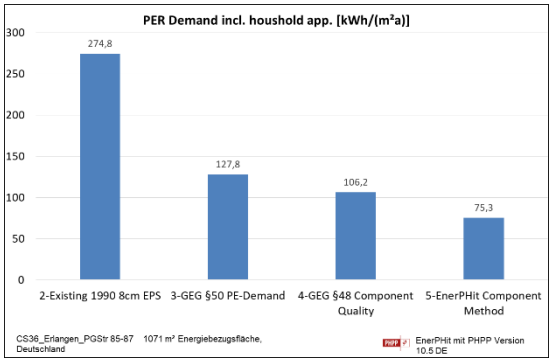
Heating demand before and after the renovation [PHPP 10.5] / Source: PHI

The two minimum requirement standards for Germany, fulfilling a minimum PE-demand approach according to GEG §50 or fulfilling a minimum component quality approach according to GEG §48 have also been modelled. Clearly visible is the considerable heating demand reduction enabled by the EnerPHit standard.

Savings Primary Energy Demand: 168 [kWh/(m²a)]

Savings PER Demand: 243 [kWh/(m²a)]





Primary Energy PE Demand and Primary Energy Renewable PER Demand of the building before and after the renovation [PHPP 10.5]: The PER demand simulates a future energy supply environment (for example 2050), when most of the energy generation will be renewable and considerable storage losses will have to be expected, especially for seasonal energy storages, that will be required for heating / Source: PHI

Savings of Final energy demand gas: 141 [kWh/(m²a)]

Savings of Final energy demand electricity: 0 [kWh/(m²a)] Household appliances not updated

Additional final energy demand electricity: 28 [kWh/(m²a)] Heat pumps for Heating and DHW



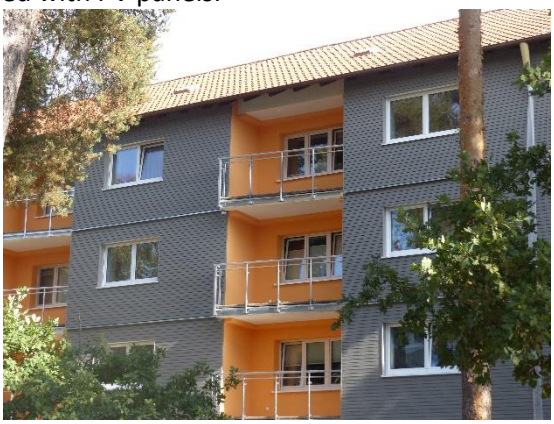


North and south façade (end sides) of the renovated building / Source: PHI

3.10. RES strategy

The buildings will receive solar PV elements on the rooftop after finalization. The detailed energy delivery is not yet clear as the form and the useful roof-area are not yet designed. Due to the East-West orientation of the buildings, however, a PV yield of 60 kWh/(m²a) would be possible, if most of the roof area would be covered with PV panels.





PV panels on some buildings in the 1st building phase area + roofs of not yet extended buildings in the 3rd construction phase area / Source: PHI

4. Project challenges and opportunities

An important goal is to ensure the least possible impact on tenants during the construction period. Intervention in the residential units should therefore be kept to a minimum. The construction processes must settle in with the first property. A challenge is therefore the high time pressure for the implementation and the work in the individual apartments: Removal of the old windows and sealing of the new windows to the existing reveal including reveal cladding is a crucial task. As far as the building services are concerned, the new prefabricated bathrooms have to be installed and the ducts of the ventilation system have to be installed and connected.

The digital geometric measurement of the building and the precisely fitting prefabrication of the elements worked very well. There were only very few touch-ups on site.

The air-tightness concept still has to be proved. Testing the element joints and the interfaces between the curtain wall and the ETICS is a major challenge, as it will not be possible to find leaks in the curtain wall elements.

5. Current project status

Currently (Summer 2024) the curtain wall is in place on all 7 buildings. The old windows have been removed and the new windows in the façade elements have been connected to the old reveal with suitable foils and bonding to ensure airtight connections between windows and the airtightness layer of the external walls. Basement wall insulation and basement ceiling insulation have been carried out and heat pumps to replace the gas heating are being installed

6. Lessons learnt and guidelines for replication

Very important for the successful process is the planning phase before the elements are produced in the factory. High time pressure leads to adjustments of details in the ongoing refurbishment process and increases the susceptibility to errors. By repeating the same steps several times and always using comparable details, the construction team can quickly practice and learn good implementations. Quality assurance during the design process (optimization of thermal bridge effects and air tightness concept) is very helpful. During the construction of the first buildings, appropriate supervision is absolutely necessary so that routine can be practiced by the team during execution.

7. Pre-Monitoring description (if applicable)

Pre-Monitoring in some buildings before renovation has been organized during Spring 2024, but until today, no results have been made available.