E2ReBuild

Industrial Energy Efficient Retrofitting of Resident Buildings in Cold Climates

SEVENTH FRAMEWORK PROGRAMME

D2.4
Demonstrator Augsburg

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- Trecodome — Trecodome BV, Netherlands
- NCCFI — NCC Rakennus Oy, Finland
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Executive Summary

The two buildings Grüntenstraße 30-36 in Augsburg, Germany, were built in 1966 and represent a typical example for a massive brick construction with concrete ceilings built in the late 60's, early 70's throughout Germany. The building was mostly in its original state by the beginning of the retrofit, fully rented and retrofitted in an inhabited status. Grüntenstraße 30-32 is a three story block with 12 apartments, Grüntenstraße 34-36 a six story block with 48 apartments is the E2ReBuild demo case.

The vision in the competition prior to the retrofit project was to transform the building into a contemporary piece of architecture. The wrap around solution of *TES EnergyFaçade* is cladded with rough sawn, white painted spruce boards. The new design supports the visibility of the building in the urban context at the east gate of the city. The existing balconies were converted into winter-gardens or living room extensions thus offering extra interior living space and additional balconies offer outdoor space.

Figure 1 - Situation before and after retrofit

The bathrooms including vertical installation shafts were completely renovated. Barrier freedom was achieved by adding new elevators as well as leveling the floors in the apartments thus making a significant change to living quality in the building.

With these measures, additional value was created, which led to higher acceptance of the whole modernization of the block.

Energy consumption figures have dropped nearly 80 %. This high value performance of the building is appreciated by tenants and the land lord equally.

Grüntenstraße has received numerous prestigious awards (e.g. Holzbau Plus Prize, Deutscher Holzbaupreis Anerkennung, Deutscher Bauherrenpreis 2013) and is attracting more and more public interest for a holistic refurbishment method as it is promoted by E2ReBuild.

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1 Introduction

1.1 E2ReBuild Demonstrations

The demonstration projects in E2ReBuild are the core of the project (work package 2). E2ReBuild is driven by demonstration projects, whereas research activities feed into the demonstrations, and results of the demos feed into the evaluation and lessons learned in other work packages. The results and conclusions from the demonstrations will be gathered to produce an industrial platform for energy efficient retrofitting (work package 6).

The objective of the work package 2 projects is to demonstrate seven high energy efficient innovative retrofitting concepts for low energy performing buildings which are representative building types for a large geographical area in Europe.

Each project establishes and demonstrates sustainable renovation solutions that will reduce the energy use to fulfill at least the national limit values for new buildings according to the applicable legislation based on the Energy Performance of Buildings Directives (for 2010) and to reduce the space heat use by about 75%.

Monitoring and follow-up: Based on recommendations given by Work Package 5, monitoring takes place during at least one year within this project, in some cases for a longer period (also continuing after the completion of this project).

One of the main issues in initial refurbishment discussions concerns costs. This has been treated in depth in deliverable D3.4 *Holistic Strategies for Retrofit* where costs from all demonstration projects are reported, analysed and discussed[1].

The demonstrators are supported by work carried out in work packages 1, 3, 4 and 5.

This deliverable is defined as a “demonstrator”. This document is the written record of the achievements of one of the demonstration projects.

1.2 Demonstration Augsburg

The two buildings at Grüntenstraße in Augsburg, Germany built in 1966 represent a typical example of a massive brick construction with concrete ceilings built in the late 60’s, early 70’s throughout Germany [Figure 2]. The buildings were mostly in their original state before the retrofit. They were fully rented and retrofitted in an inhabited status. Grüntenstraße 30-32 is a three story block with 12 apartments, Grüntenstraße 34-36 a six story block with 48 apartments. This building is documented as the E2ReBuild demo case. The vision in the competition prior to the retrofit project was to transform the building into a contemporary piece of architecture. The wrap around solution of the *TES EnergyFacade* is cladded with rough sawn, white painted spruce boards. The new design supports the visibility of the building in the urban context at the east gate of the city. The existing balconies were converted into winter-gardens or living room extensions thus offering extra interior living space and additional balconies offer outdoor space.

[1] As report D3.4 is restricted, public information can be found in GEIER, SONJA; EHRBAR, DORIS; SCHWEHR, PETER (2014); Holistic Strategies for the Retrofit to Achieve Energy-efficient Residential Buildings. In: Proceedings 9th International Masonry Conference 2014. Guimarães (P)

Figure 2 - Situation before retrofit

Figure 3 - Situation after retrofit

With these measures, additional value was created, which lead to higher acceptance of the whole modernization of the block.

Tenants were at the heart of the modernization process of the residential complex at the Grüntenstraße. Since the construction was conducted in an inhabited state, the interests of the inhabitants have been a central concern during the planning stage [Figure 4]. A high degree of prefabrication of construction elements for the building envelope reduced construction time and construction friction for all participants to a minimum.

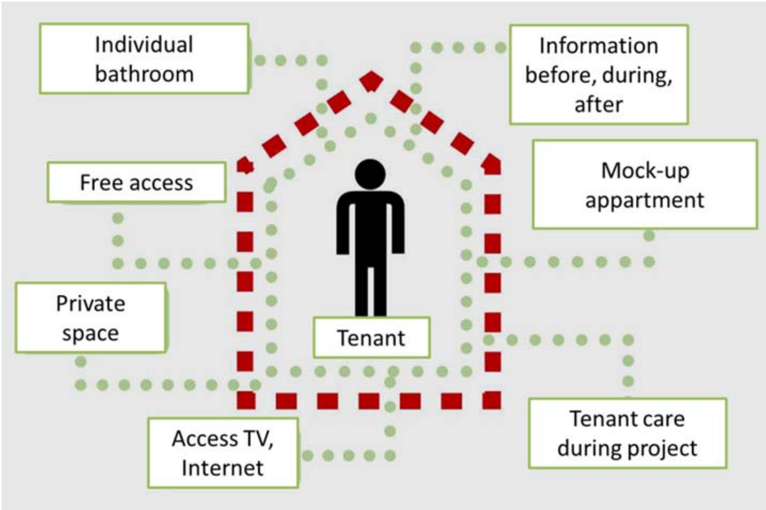


Figure 4 - Tenants perspective

The building in its original status had a calculated heat energy demand of 180 kWh/m²y due to its poor building envelope of brick walls, 30-36 cm with a U-value of 1.6 W/m²K (BEST sheet Appendix A) and leakages around the old windows and joints to the roof. The ceilings to the unheated basement have not been insulated. Furthermore the amount of thermal bridges was high; the weakest points have been the balconies, which have been constructed as cantilevered concrete slabs. There was no mechanical ventilation system, just exhaust air ducts. Electricity and plumbing have been basically original.

Main actions that have been planned and executed [Figure 5]:

- Improvement of the building envelope
- Barrier free access to all apartment levels
- Conversion of balconies to winter gardens
- Concrete renovation of exterior corridors

- New elevator with direct access to exterior corridor level
- Complete renovation of bathrooms

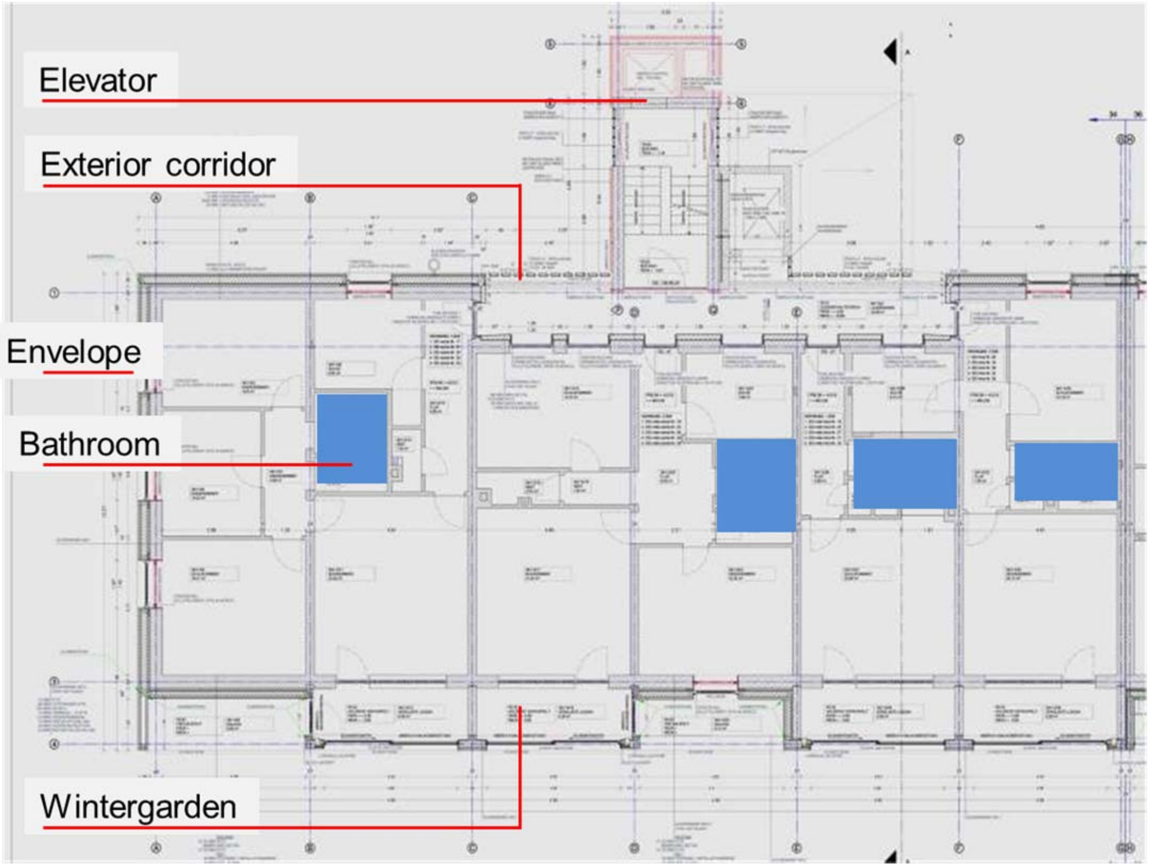


Figure 5 - Retrofit actions

Besides the measures, which lead to the improvement of the energy efficiency of the building, all building services including ductwork and installations of bathrooms and toilets were fully refurbished. Although there were no mayor damages of piping - only due to the fact that the technical devices were near their lifespan - the landlord decided to fully renovate bathrooms in a concentrated action. Bathroom furniture, tiles and duct work were fully dismantled. This was done as a vertical process, where always all bathrooms on one strand were retrofitted at the same time. For about three weeks, tenants had to use a neighboring bathroom or a container that was provided in the court yard. Due to the existing layout of ground floor plans with interior bathrooms, these works were an additional mayor impact for the tenants as workers had to cross private rooms [Figure 6].

The construction process on site started in June 2011 with the integration of a new pellet heating system including a storage room in the basement of block 34, replacing the old gas driven central and decentralized burners.

Parallel to the interior construction work, workshop planning and off-site production of the façade started at *Gumpp & Maier* timber manufacturers. Augsburg's main contribution to E2ReBuild is based on the implementation of prefabricated retrofit solutions based on *TES EnergyFacade*[2], a prefabricated timber element system. The preparation of the exterior works began in August with the excavation of the foundation walls as a basis for the new façade. Starting at the end of October, the prefabricated

[2] TES EnergyFaçade supported by ERA-NET "WoodWisdom-Net..Project partners: TU München, NTNU Trondheim, Norway, SINTEF Norway; Aalto University Helsinki, Finland. Praxispartner u.a. Gumpp & Maier, Amboros Huas GmbH

façade elements were mounted in only eight weeks to the 6 story block of Grüntenstraße 34-36. In spring 2012 the façade of the building 34-36 was finalized as well as the assembly of block 30-32.

Figure 6 - Bathroom renovation including new ductwork

1.2.1 Situation of Existing Construction

Exterior wall

- Brick, 36,5 cm, U_w=1,16 W/m²K
- Mineral plaster partly chipping
- Old paint

Windows

- Plastic windows, U_W=1,3 W/m²K

Roof

- Flat roof, U_r=0,38 W/m²K
- Concrete ceiling
- Bituminous vapor tight barrier
- Insulation, polyurethane 120 mm
- Bituminous waterproofing membrane, double layer

Balcony

- Cantilevering concrete slab with parapet
- Large thermal bridge, leaking construction

Access

- Stair case, concrete construction
- External corridor, concrete construction extensively corroded
- Elevator in need of repair

Landscape

- Partly decayed

Building services
- State of 1966

Heating
- Single gas stoves

Plumbing
- DHW partly from gas combination boiler or power boiler

Ventilation
- Ventilation of bathrooms through chimneys, air inlets in basement ceiling.
- No mechanical ventilation

1.2.2 Action Plan

Exterior wall
- *TES EnergyFaçade* added to existing wall, Uw=0,13 W/m²K

Windows
- New timber-aluminum windows, U_W=0,98 W/m²K

Roof
- Partly repair of bituminous waterproofing membrane

Balcony
- Conversion into winter garden
- Additional balcony between existing concrete structure

Access
- Stair case repaired
- External corridor: concrete repair, additional insulation and bituminous mastic floor
- New elevator

Landscape
- New tracks
- Gardening, lawn

Building services
- Total replacement

Heating
- Central pellet heating (2 boilers, 60 kW)

Plumbing
- Central DHW supply

Ventilation
- Mechanical ventilation as exhaust system
- Air inlets in façade and windows

2 Energy Efficient Retrofitting

2.1 Building Envelope

The main goal of the Augsburg case is the demonstration and evaluation of an innovative process of applying a prefabricated construction system from survey-off-site fabrication and on-site assembly with reduced disturbance for tenants.

Key façade technologies applied

- Fully retrofitted thermal envelope in an inhabited status
- Conversion of balconies into winter garden plus additional balconies
- *TES* modernization in building class 5 with combustible cladding
- Fire safety measures in building envelope
- Improvement of the architectural quality of the building and its surrounding
- Exhaust air supply with integration of air inlets into the prefabricated façade
- Site drainage around building combined with a new foundation wall for *TES EnergyFaçade*
- Integration of electric cables in tubes into *TES EnergyFaçade*

The south façade prior to construction works was structured by balconies of cantilevering concrete slabs and walls which performed as a large thermal bridge [Figure 7]. To avoid heat losses through construction parts, the balconies were converted into winter gardens by wrapping them with a *TES* element. A second effect of this strategy is the passive heat gain in winter. The extension adds extra space to the living room of the apartment and works as a buffer zone, were in cold times the air is heated by sunshine. To prevent from overheating, the windows are equipped with sun shading devices. Fresh air enters through inlets in the exterior wall of the winter garden.


Figure 7 - South façade – before and after refurbishment

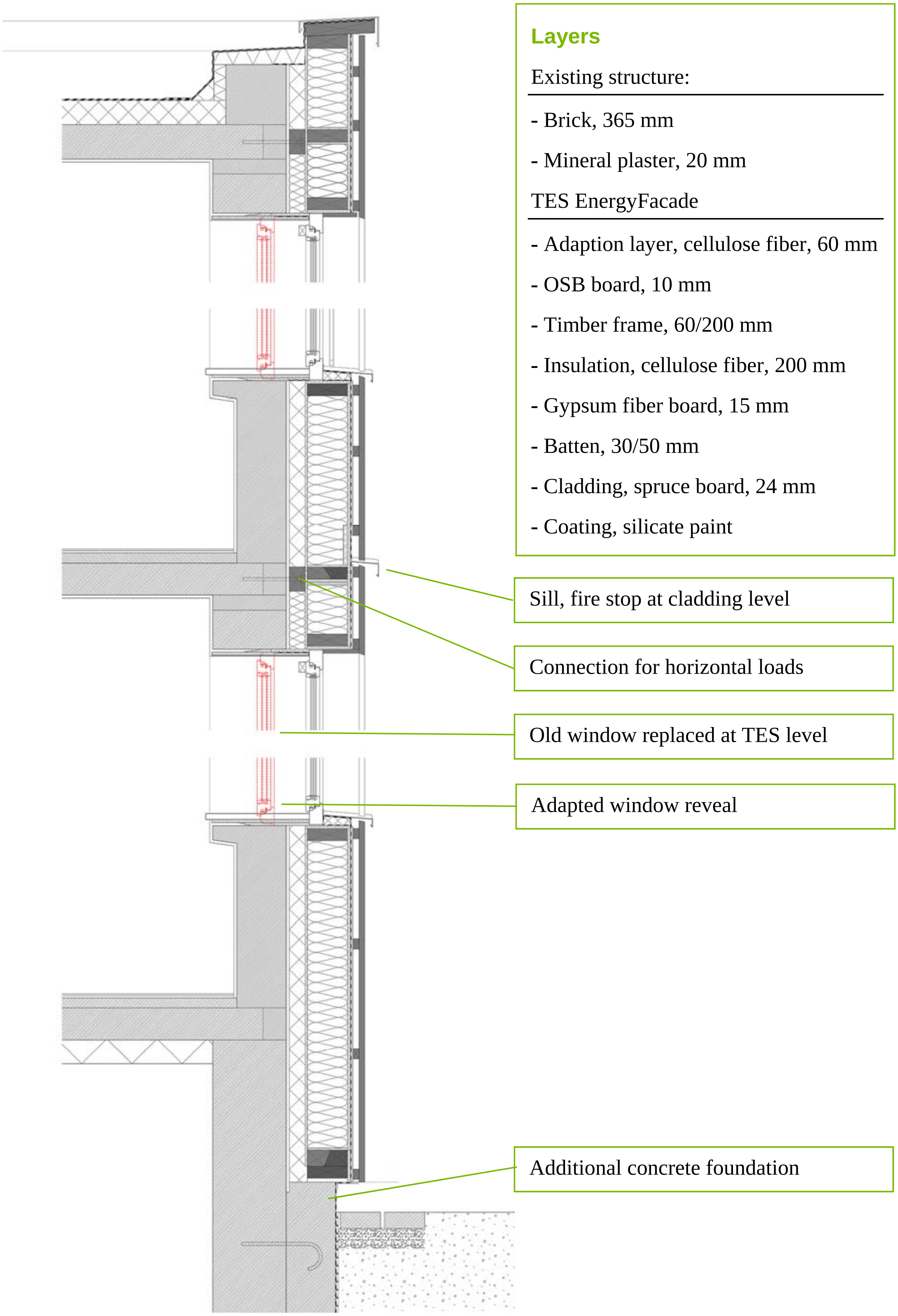


Figure 8 - Section of *TES EnergyFaçade*

E2ReBuild partner *Gumpp & Maier* manufactured single large sized façade elements (max. size 3,4 x 12,0 metres) according to the system of *TES EnergyFaçade* resulting in a U-value (wall) of 0,11 W/m²K and a thermal bridge free building envelope [Figure 9]. The *TES EnergyFaçade* system is based on the principles of a timber frame construction common throughout Europe[3].

The façade is designed as a multifunctional building envelope (compare D 4.4 Building Envelope) with integrated valves in window frames for fresh air in sleeping and living rooms and for exhaust air in kitchen and bathrooms.

Specification building envelope (*TES EnergyFaçade*) from inside to outside

- Adaption layer (40-80 mm blown-in cellulose fibre)
- Panel, OSB 10 mm
- Timber frame KVH 60/200 mm, e = 625 mm
- Insulation, cellulose fibre 200 mm, WLG 040
- Panel, gypsum fibre board 15 mm
- Building wrap (diffusion open)
- Counter batten, 100/12 mm
- Batten 30/50 mm
- Tongue and grove cladding, spruce 140/28 mm, silicate coating (*Keim Farben*)
- Wood aluminium window

Figure 9 - TES fabrication at Gumpp & Maier

Specification of façade appliances

- Window
  Wood aluminium frame, *UNILUX*, pine frame, triple glazed, U_g = 0,60 W/m²K; warm edge, U_W = 0,98 W/m²K
- Ventilation system
  The ventilation system consists of rooftop ventilation units [Figure 10] working as exhaust fans and air transfer devices in the façade (winter garden wall) *LUNOtherm* air inlet ALD-R

[3] J. Kolb, Holzbau mit System, Birkhäuser 2012

160[4] and in window frames *AERECO ZFHF 40*[5]. The main ventilation duct work connecting apartments and the roof top fan are situated in the abandoned chimney pipes.

- Sun shading device
  External venetian blinds, *WAREMA E80 A6 AS* are integrated in a lintel box behind the cladding of the TES element. They are operated with a cordless sensor from inside and connected to a central wind detection system to open in case of strong gusts.

Figure 10 - Exhaust fan on roof top

2.2 Heating

The existing gas stoves per unit were replaced by a central pellet heating (2 boilers, each 60 kW) with warm water treatment [Figure 11]. A cellar space in Grüntenstraße 34 was refurbished to take the technical devices as well as the pellets storage [Figure 12]. Ground pipes connect to houses 30-32.

Piping for hot water and heating was built in existing vertical shafts, the pipes to the radiators in the apartment were connected at the location of the former gas stove in the bathroom.

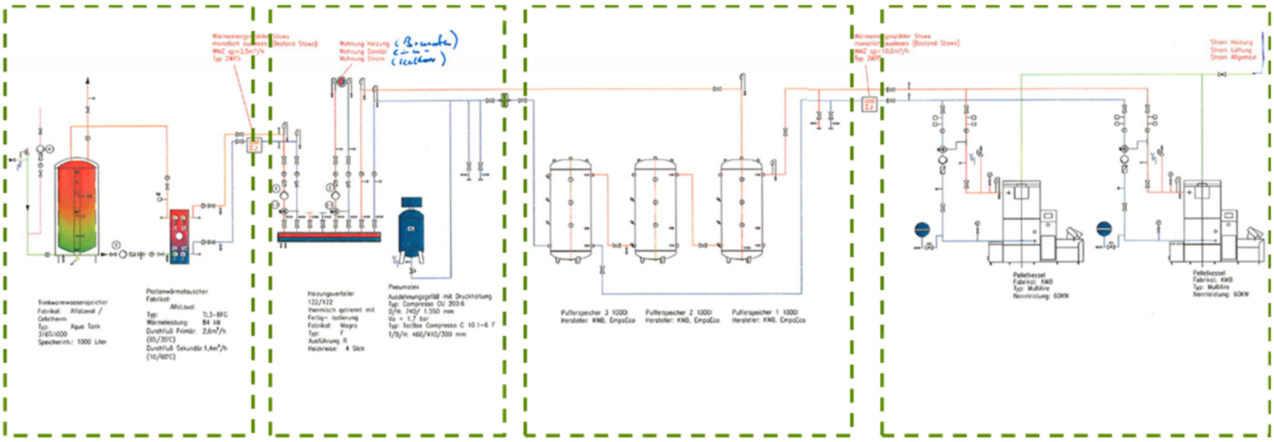


Figure 11 - Heating system, technical plan (IB Ulherr)

4 LUNOtherm: ALD-R 160 L mit LUNOtherm A, http://www.lunos.de/
5 AERECO: Zuluftelement ZFHF 40, Specification: Projektdatenblatt www.aereco.de

Domestic hot water treatment is centralized next to the heating room. A heat exchanger regulates the water temperature at 60°C.

Figure 12 - Pellet boiler and DHW system

3 Retrofitting Process

The retrofitting process in Augsburg is based on a frictionless workflow from design to production of prefabricated façade elements [Figure 13]. Following text documents the project planning phase and the renovation process.

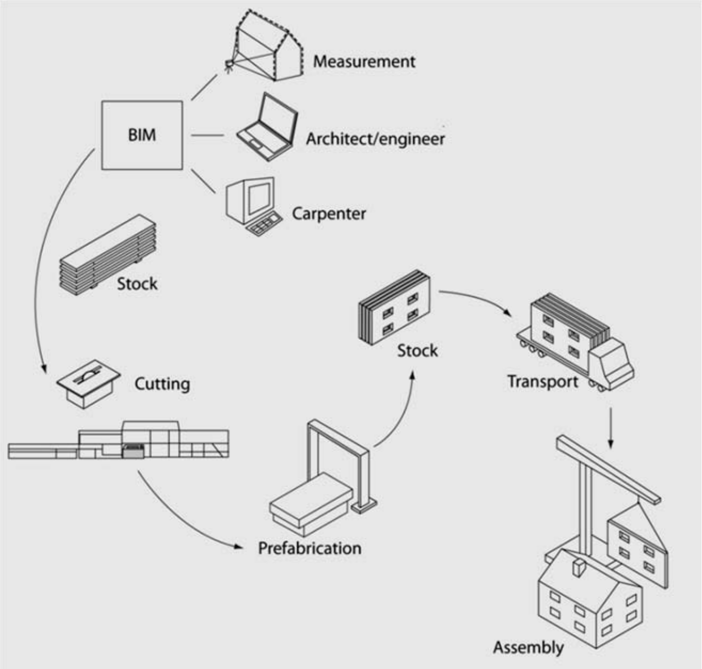


Figure 13 - Renovation process from planning to production

3.1 Project Planning and Management

The Grüntenstraße refurbishment was initiated and executed by the owner *Wohnungsbaugesellschaft der Stadt Augsburg*[6] (*WBG*), a communal residential homeowner with a strong commitment to social housing. *WBG* employs architects and construction technicians to manage most of the maintenance and refurbishment work. After a competition, *lattkearchitekten* were contracted to develop the project. During the design phase, the team decided to split responsibilities. *WBG* planed and managed the renovation of building services and bathrooms, *lattkearchitekten* were responsible for the exterior work of the building envelope, elevator and concrete corridor renovation. In the following description, we concentrate on the improvement of the building envelope.

[6] www.wbg-augsburg.de (02.05.2014)

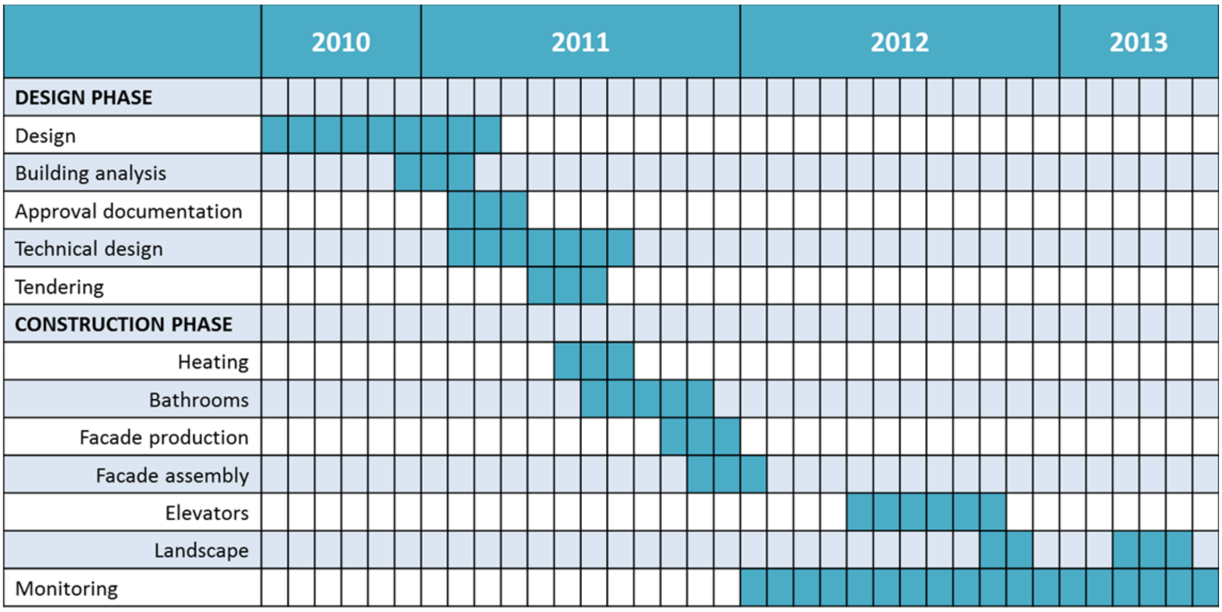


Figure 14 - Project timeline

The design phase with a deep analysis of the building structure, the approval documentation and technical design documentation resulted in a public tendering which finally led to a contract with the timber manufacturer *Gumpp & Maier*.

The on-site construction work of the E2ReBuild demonstration Augsburg began in June 2011with the change of the main heating system and ended in spring 2013. The refurbishment of the gardens and courtyards was the last task [Figure 14].

Tasks and responsibilities

A design team of architects and engineers was responsible for planning and managing the project. Following specific tasks related to the energy efficient design concept were conducted:

Architecture (*lattkearchitekten*, Augsburg)

- Main design concept
- Construction approval documentation
- Construction documentation
- Project management and coordination
- Support in tendering and project calculation
- Site management

Engineering (*bauart Konstruktions GmbH*, München)

- Design and calculation of the façade load bearing structure
- Building physics: simulation and energetic calculation
- Sound performance simulation
- Fire safety approval documentation

Building services, HVAC (*IB Ulherr*, Augsburg)

- Documentation and specification of energy production and supply for heating and hot water

- Documentation of ductwork
- Site management of technical contractors

On site communication (*WBG Augsburg*)

- Direct communication with tenants
- Site management of interior works
- Health and safety (contracted)

Façade (*Gumpp & Maier GmbH*, Binswangen)

- Measurement of existing building
- Production planning
- Production, transportation and assembly of façade (structure, insulation, windows, cladding)

3.2 Renovation Process

Measurement

The building was measured entirely by the contracted timber manufacturer *Gumpp & Maier*, Binswangen. A tachymetry total station was used to gather the relevant data point by point. A connection to a laptop enabled to develop a 3D model on site with the advantage to check for completeness [Figure 15].

Figure 15 - On-site measurement by *Gumpp & Maier*

The production design of the timber frame was later done on the basis of the model defining every piece of timber with parametric information to be processed by a digital cutting machine [Figure 16].

The *TES* elements were completely prefabricated with timber frame, inner and outer paneling, insulation, integrated windows and cladding. Single elements measured approx. 3,2 m in height and up to 12,0 m long.

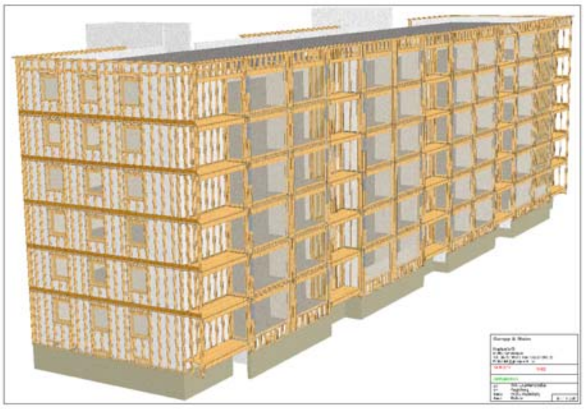


Figure 16 - On-site measurement and production planning

Planning

A comprehensive and accurate building analysis is a vital part in the early planning stage. A thorough recording of the building is recommended to identify the requirements concerning building regulations, fire protection, structural use and technical equipment as a basis for a coordinated action plan.

In this project, a step wise planning and procurement process has so far proven feasible. Architectural design on the basis of existing plans and / or a rough survey as a set of 2D drawings has proven a sufficient basis for tendering and production planning made by the following contractors. Timber manufacturers use similar CAD software tools for production planning. Hence the planning process is well established on the basis of the experience of construction of new buildings in wood.

Logistics and assembly

TES elements are produced in a controlled workshop environment by timber manufacturers. The process is based on the competence of the timber construction sector which is known for its high quality. Quality management (e.g. Ü, CE) is well established. The spatial situation of the construction site affects trans-port and assembly logistics. The degree of prefabrication and the alignment of the façade panels are dependent on the geometry of the building. Elements are prefabricated including frame, insulation, paneling and windows and transported by truck weather protected to the site.

Possible crane locations are chosen in relation to the accessibility, the dimensions and the weight of the elements. Safety of all participants is supreme premise during the entire construction phase. During the assembly process the handling of the elements requires thorough attention. A splash of rain does not hurt, but the elements need to be weather protected if they are exposed over a longer period. It has proven best to seal the surface, finish the cladding and joints or use elements with mounted cladding.

In Augsburg, plenty of space on the own property allowed two large storage places. The site was organized into two mayor working areas:

- Façade storage and crane zone (*Gumpp & Maier GmbH*)
- Zone for interior construction workforce (plumbers, builders etc.)

Tenants were informed about disturbances and to keep off dangerous areas. Routes to their apartments were secured to guarantee access at all times as delivery route crossed existing paths and the parking lot.

The transport and delivery of construction material and façade elements was made by truck and trailer using the existing pathway alongside the taller building (Grüntenstraße 34-64) as access. This was also the main route for the fire brigade in case of emergency, thus it had to be cleared at all times.

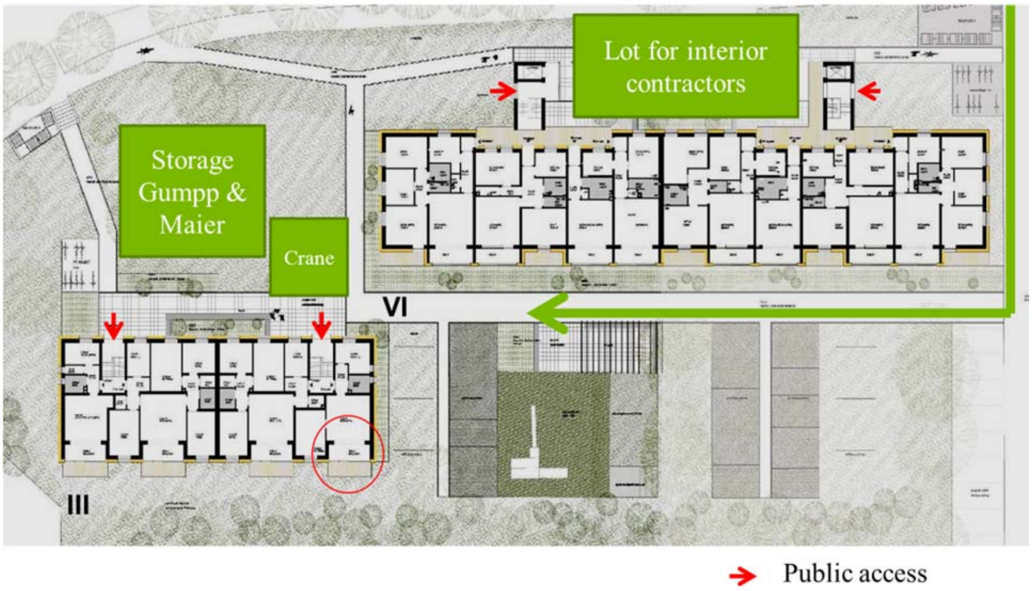


Figure 17 - Site Management at Grüntenstraße, Augsburg

Dealing with large prefabricated panels requires scheduling of appropriate tolerances in order to absorb bumps and deviations, without having to destroy and adapt the own work again on site. Joints and connection details, which have been proven in the field of new built timber construction, ensure the structural function and viability of the façade on the outside. The structural conditions of the existing building are decisive for correct connection to the stock to ensure fire protection, air tightness and sound insulation. Cavity-free design is a premise to prevent uncontrollable convection and fire spreading in the construction.

The Augsburg project has proven a feasible way of blowing in cellulose fiber into a 6-8 cm wide gap between the *TES* element and the existing brick wall.

Mounting windows, the brick overlay of the reveal towards the window frame was cut and removed to the outside. After loosening the screws of the old window frame an interior dust screen was installed to protect the inhabited apartment. The frame was removed to the outside prior to the assembly of the *TES* elements, thus closing the building envelope very quickly.

The existing balconies were built of cantilevering concrete slabs and walls. To convert them into winter gardens, the concrete side walls and the balustrades were partly removed. The *TES* elements with integrated glass sliding doors were mounted against the remaining concrete slab of the ceiling.

Figure 18 - Dismantling and mounting of balcony façade

4 Results

4.1 Conclusions and Experiences

The Augsburg demo is one of four E2ReBuild projects based on a holistic retrofit of the building envelope by applying prefabricated wall panels in the method of *TES EnergyFaçade*. Concepts applied and experiences made are a valuable basis for recommendations regarding the workflow from design, production planning, off site production, transportation and assembly. The summary can be read in deliverables D4.1 and D4.2/3.

Augsburg Grüntenstraße – a success story

Following energy consumption figures clearly give evidence for the success of the demonstration. The heat energy demand significantly dropped from 145 to 33 kWh/m²y based on real consumption data which was distributed by the energy supplier and analyzed by the E2ReBuild project.

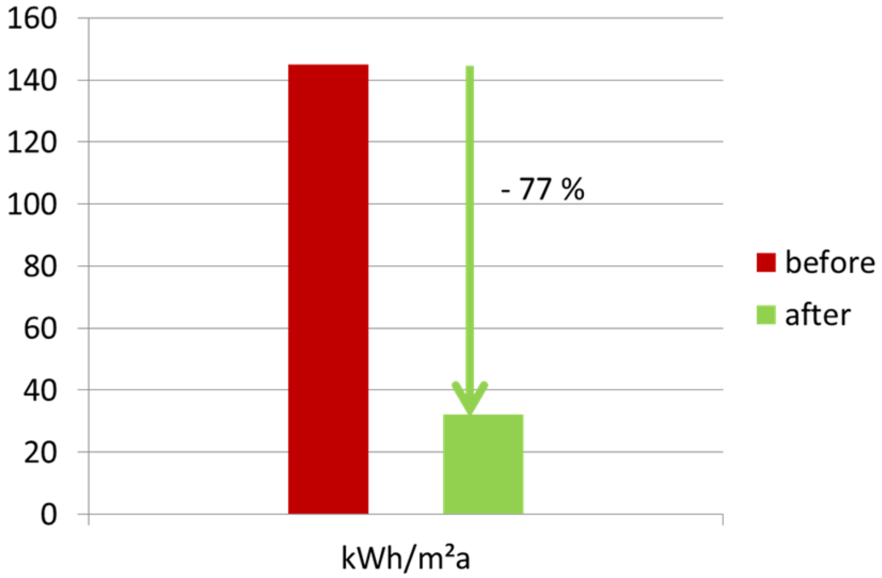


Figure 19 - Heat energy demand before and after

The monthly rent level increased from 7, 21 €/m² to 7, 39 €/m² which includes basic rent, maintenance and energy cost.

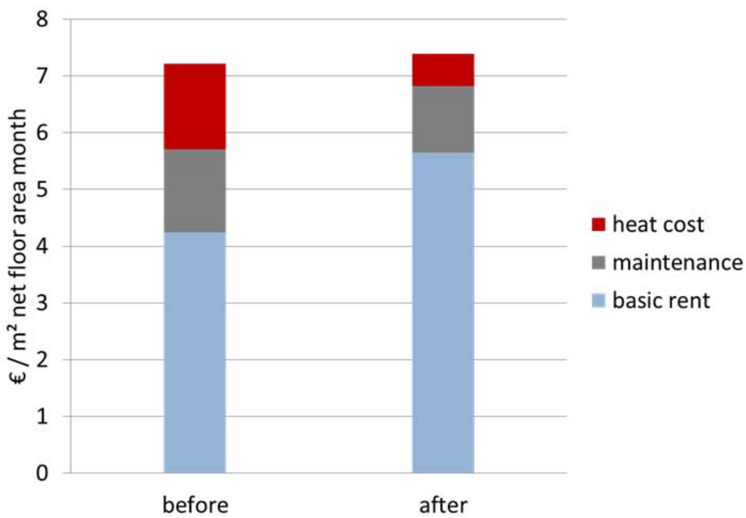
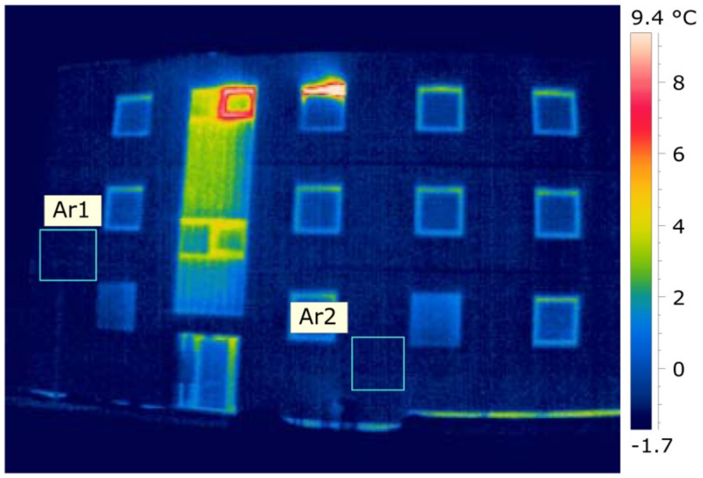
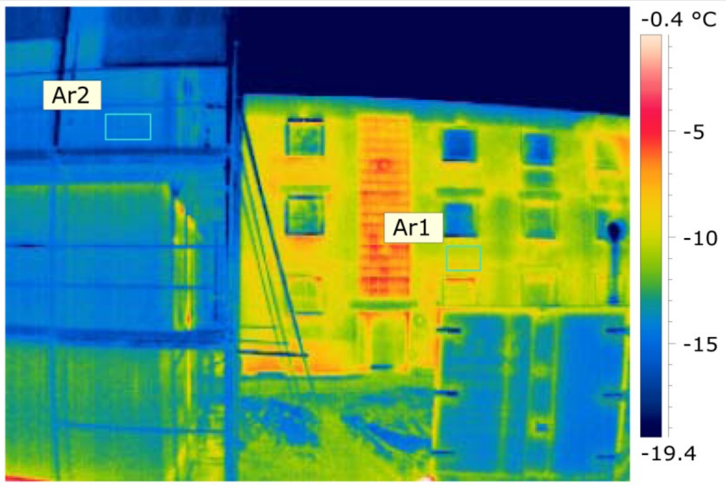


Figure 20 - Renting costs before and after renovation

Thermal imaging can reveal weak spots of the finished surface rather effectively. Following example of Grüntenstraße shows the stage prior and past retrofit. The efficiency of the additional envelope is clearly visible. The internal staircase, which is defined as an unheated buffer zone shows as the weaker part in the *TES* façade. Warmer temperature around the windows and the basement can be explained due to a higher thermal conductivity of the constructive parts (e.g. window frame).



AR01 Maximale Temperatur	**-0.6 °C**
AR01 Minimale Temperatur	**-1.8 °C**
AR02 Maximale Temperatur	**-0.4 °C**
AR02 Minimale Temperatur	**-1.6 °C**
Emissionsgrad Messoberflä-che	**0.91**
Raumtemperatur	**20**
Außentemperatur	**-1**



AR01 Minimale Temperatur	**-10.8 °C**
AR01 Maximale Temperatur	**-7.6 °C**
AR02 Minimale Temperatur	-15.0 °C
AR02 Maximale Temperatur	-13.7 °C
Emissionsgrad global	**0.92**
Raumtemperatur	**20**
Außentemperatur	**-16**

Figure 21 - Thermal image after (above) and before (below) construction works visualizes the difference made. Respect the different condition of outside temperature when the images were taken.

The application of fully off-site fabricated *TES* elements requires precise management of tolerances especially at window joints and openings for built-in devices. Timber manufacturers can rely on their experience of production of new buildings. The project has proven the practicability of a high prefabrication standard based on prior precise building survey for refurbishment. In this case, the measurement and product planning was conducted by the contractor *Gumpp & Maier* on a high accuracy level. The elements included timber frame, insulation, cladding and windows and fitted well on to the existing structure of the building. Minor differences on window joints were adjusted on site by an additional multi-layered reveal of gypsum board inside.

Off-site production allows for a high quality result. In the case of Grüntenstraße, even the large sized elements (9.996 x 2.830 mm, approx. 5 to.) for the closer of the balconies with two sliding doors and integrated air inlets were planned and prefabricated.

Figure 22 - TES production plan and fabrication, integrated air inlet and gap for venetian blinds

A separation of interior installation of building services in the old chimney shafts and the *TES* façade has proven to be a robust solution and that it avoided difficult overlaps of different contractors.

The conversion of the balconies is appreciated by the tenants and works well as a thermal buffer zone. One tenant stated in an interview, that as soon as the sun was shining into the additional space, the air heated up and after a short time the effect was perceptible in the whole apartment. The closer also reduces significantly the noise of the nearby street.

Figure 23 - Winter garden - adding extra space to the apartments

The invisible integration of venetian blinds into the timber frame element is seen as an added value to the design aspect of the building. Moreover, the sun shading device is weather protected as the electrical motor and the blinds in parking position hide behind the cladding of the façade. The wiring through the TES element needed special attention during the planning and construction phase.

Figure 24 - Detail of sun shading device

Building for generations

Besides the advanced energetic performance of the building based on a solution using renewable materials the main achievement of all measures taken was the improvement of the general access to the building. People who moved in when the building was erected in the 60's still live in the house. They admire their home and the urban neighbourhood. Only the access via a couple of stairs from street level into the staircase and from the elevator again to their corridor platform became a threat to spend remaining years in a loved environment.

By filling up the pit like front yard converting into an attractive public space on street level and additional elevators ending at apartment level barrier free access is now possible. The post questionnaire gave a clear evidence of the successful effort taken by the owner *WBG Augsburg*.

Grüntenstraße demonstrates the importance of the issue of adapting our buildings to an older growing society.

Figure 25 - Access to Grüntenstraße before (page before) and after (above)

After nearly two years of works, the building was officially inaugurated on May 23rd, 2013 under the presence of several high ranked representatives from the city of Augsburg and the federal state ministry for building and construction.

Edgar Mathe, CEO of *Wohnungsbaugesellschaft der Stadt Augsburg* representing the client, welcomed the result of the efforts, which had been taken during the last 24 months. The modernization of the residential block in Grüntenstraße with 60 apartments is an outstanding flagship in the portfolio of the company and an important statement for the surrounding neighbourhood. The final result represents high end building refurbishment which is not the usual case in Augsburg.

4.2 Replication Potential

The demonstration in Augsburg is a multi-storey residential building in southern Germany with typical post war characteristic features from the 60's and early 70's. The building was fully retrofitted including building services and bathrooms. Residents remained in their apartments during the construction work. The envelope was retrofitted, using a prefabricated envelope system based on *TES EnergyFaçade*. The project serves as a pilot example for the implementation of prefabricated timber elements (Uw-value 0,13 W/m²K) with modern highly insulated windows. Thermal bridges will be almost eliminated through integrating the balconies into the heated space. This demonstration has proven the effectiveness of façade modernisation with prefabricated timber elements.

The project is one of ten pilot projects supported by the *Oberste Baubehörde*, the state building ministry, in the program *e% Energieeffizienter Wohnungsbau*[7] and thus has raised the interest of public decision makers.

[7] http://www.experimenteller-wohnungsbau.bayern.de/ms_modell/ms_ew.html (02.05.2014)

WBG Augsburg manages currently a portfolio of approx. 10.400 apartments, 9.641 are property of *WBG* in the city of Augsburg. The returns are re-invested into the stock in order to obtain good, close relations with the tenants. Furthermore, continuous updating and quality improvements are planned in the coming years to obtain even better living quality. This means that any improvement in design, technology or processes from the E2ReBuild project can have direct implementation in the remaining stock to be retrofitted.

Economy, ecology, social and cultural aspects should be taken into account to generate future oriented results. Our building stock is divers and asks for a multitude of solutions to be developed. Innovation will be a driving force to combine different interests of all stakeholders involved.

The experience made at Grüntenstraße truly indicates that this high end solution conducted was a tightrope walk between innovation and economic borders. Future tasks in building modernization will need to focus more on building typology as a starting point for decision making of suitable solutions. Especially the load bearing capacity of the existing façade determines the solution. For load bearing exterior masonry walls it is rather feasible to add extra insulation whereas steel glazing façades or concrete skeleton and/or sandwich façades need to be partly or entirely replaced by new façade elements.

In addition to residential buildings, the renovation of public buildings such as schools, kindergartens and administration buildings requires holistic refurbishment methods in the ongoing operation. Wood construction can offer intelligent and resource-efficient solutions in many areas. The opportunities lie in the individualized prefabrication to offer tailor-made solutions for the modernization of our building stock.

Another aspect of building renovation is the possibility of adding extra space through extensions for example as a new roof top floor or a horizontal extension. Timber construction offers a wide range of proven details which can be adapted to such requirements and thus deliver a method with a set of systematic solutions based on a holistic planning process and a proven production and construction process with only a few responsible companies involved.

Generally building modernization covering aspects of enhancing building performance, adding space or adapting to today’s requirements will be the task of the years to come as most of the buildings are in need for clever refurbishment solutions.

Appendix A Original BEST Sheet

Building Energy Specification Table (BEST)

Community / site: Augsburg | WBG | BEST no.

1,1 **Building Category**: residential retrofitted [1]

total area / category / BEST sheet [2]: 4186 m²

1,2 **Local Climate**

Climatic Zone (national definition): central europe; temperature 16,5-18,0 °C

January average outside temperature	°C	-1,8
August average outside temperature	°C	16,7
Average global horizontal radiation	kWh/m² yr	1076
Annual heating degree days [3]	°Cd/yr	4265

1,3 **Maximum requirements of building fabric**

			Existing building [5]	National regulation for new built [6]	suggested specification [7]	Energy savings [%] [8]
Façade/wall	U	W / m2K	1,161	0,35	0,13	63
Roof	U	W / m2K	0,338	0,3	0,3	0
Ground floor	U	W / m2K	1,478	0,4	0,28	30
Glazing	U_g	W / m2K	1,3	1,5	0,83	45
Average U-value	U_{av}	W / m2K				
Glazing	g	total solar energy transmittance of glazing [%]				
Shading	Fs	Shading correction factor				
Ventilation rate [4]		air changes/hr		0,7	0,5	29

2 **Building Energy Performance**

2,1 **Energy demand per m2 of total used conditioned floor area (kWh / m2yr) incl. system losses**

energy carrier existing	suggested energy carrier		specify energy efficiency measures [13]	Existing building [5]	National regulation / normal practice for new built	suggested specification [7]	% Energy savings [8]
Heating + ventilation							
central	decentral	kWh/m² yr	building envelope, ventilation	180	70	29,8	57
Cooling + ventilation							
		kWh/m² yr					
Ventilation (if separate from heating/cooling)							
		kWh/m² yr					
Lighting							
	electricity	kWh/m² yr		20	15	10	33
Domestic Hot Water (DHW)							
		kWh/m² yr	central regenerative heating	25	20	5	75
Other energy demand							
		kWh/m² yr					
		kWh/m² yr	Subtotal sum of energy demand	225	105	44,8	75
Appliances (please indicate, but costs are not eligible)							
	electricity	kWh/m² yr	low energy appliances	25	15	10	33

2,2 **RES contribution per m2 of total used conditioned area (kWh / m2 yr)**

total production kWh/yr	m² installed	kW installed	specify RES measures	Existing building [5]	National regulation / normal practice for new built	suggested specification [7]	RES contribution [%][8]
		kWh/m² yr	Subtotal sum of RES contribution	0	0	0	

3 **Building Energy Use**

per m² of total used/heated floor area (kWh/m2 yr)

kWh/m² yr	Subtotal sum of energy demand	225	105	44,8	
kWh/m² yr	Subtotal sum of RES contribution	0	0	0	
kWh/m² yr	Total Building Energy Use	225	105	44,8	

4 **Other national overall energy performance targets or criteria** (additional information, mandatory if existing)

	Units [9]	explain content and scale [10]	Existing building	National regulation for new built (2006)*	suggested specification

Appendix B Energy Data

Augsburg Before	EnEV 2009 - average consumption over 3 years					
	Energy Demand Before [kWh/m2 NFA]	Source	PE conv. fact. fp [kWh PE / kWh S] national /local	PE national [kWh/m2 NFA]	PE conv. fact. fp [kWh PE / kWh S] acc. EN 15603	PE based on EN 15603 fp [kWh/m2 NFA]
Heating Source 1	115,5	Gas decentral	1,1	127	1,36	157
Heating Source 2				0		0
DHW Source 1	26,8	Electricity	2,6	70	3,31	89
DHW Source 2				0		0
Auxiliary		Electricity	2,6	0	3,31	0
Losses Source 1				0		0
Losses Source 2				0		0
Total	**142,3**			**197**		**246**
Delivered to the grid	0			0		0

Augsburg Afterwards	Calculated according to EnEV 2009					
	Energy Demand Afterwards [kWh/m2 NFA]	Source	PE conv. fact. fp [kWh PE / kWh S] national /local	PE national [kWh/m2 NFA]	PE conv. fact. fp [kWh PE / kWh S] acc. EN 15603	PE based on 15603 fp [kWh/m2 NFA]
Heating Source 1		District heating	0,7	0	1,3	0
Heating Source 2	25,3	Wood pellets	0,2	5	1,06	27
DHW Source 1		District heating	0,7	0	1,3	0
DHW Source 2	12,5	Wood pellets	0,2	3	1,06	13
Auxiliary	1,4	Electricity	2,6	4	3,31	5
Losses Source 1	24,3	Wood pellets	0,2	5	1,06	26
Losses Source 2				0		0
Total	**63,5**			**16**		**70**
Delivered to the grid	0		0	0		0

Conversion factors fp (total) acc. EN 15603:2008* Table E1 - Annex E		
Electricity (UCTE Mix)	3,31	[kWh PE / kWh S]
Wood shavings	1,06	[kWh PE / kWh S]
Local-/District heating	1,3	[kWh PE / kWh S]
Reference national conversion factors: DIN V 18599/1 2007		
Conversion factors fp (total) acc. German DIN V 18599/1 2007		
Electricity	2,6	[kWh PE / kWh S]
Timber	0,2	[kWh PE / kWh S]
Local-/District heating	0,0-0,7	[kWh PE / kWh S]

Appendix C Information map of other E2ReBuild deliverables

Further information related to the Augsburg demo project can be found in the following deliverables:

Deliverable	Information
D 3.4	Holistic strategies and cost break down. Further analysis and ratio of cost, energy performance and outcome
D 4.1	Measurement methods as part of the planning process as conducted prior to the planning stage
D 4.2/3	Planning and production methods for the application of prefabricated façade elements
D 4.4	Building envelope: Solutions for the integration of building services into *TES EnergyFacade*
D 5.1	Monitoring scheme
D 5.2	Measured data from demonstration projects
D 5.4	Evaluation and tenants questionnaire