Retrofitting of existing housing stock

Unterrainer, Walter

Publication date:
2015

Document Version:
Early version, also known as pre-print

Retrofitting of existing building stock – an architectural challenge on all scales

W. Unterrainer
Aarhus School of Architecture
Nørreport 20 8000 Aarhus DK
walter.unterrainer@aarch.dk

Abstract - This paper is a case study in retrofitting social housing of the 1950´s and 1960´s - a model project in Amberg/ Germany. It presents applied ´acupuncture´ and innovative strategies on very different scales as well as on different layers, to meet the goal of a sustainable retrofitting project in a holistic sense, including cultural, social, environmental and economic sustainability. The project is an example of integral design from competition level and it was given advice, support and will be evaluated by Technische Universität Muenchen and Coburg University / Department of Sociology. The paper explains the built project which was informed by data provided by sociological and technical research before the competition. The simulation data will be examined over a period of 3 years.

Keywords - sustainable retrofitting; architectural acupuncture, prototypic solutions; upgrading space; monitoring and evaluation

1. Introduction

Although barely accurate and counted in too long intervals, we know that more than 50 % of the European housing stock has been built before 1970. The figures differ from country to country and the data also differ depending on statistical method. In 2010, for the first time 50% of all building activities in Germany were retrofitting, modernization and rehabilitation of existing buildings and environments, with growing tendency.

The energy consumption/m2 of new buildings in Germany was constantly lowered since the 1st and the 2nd ´petrol crisis´ by lowering the legal maximum consumption. By nature, this did not affect the relevant number of most energy consuming buildings built before. **Figure 2**

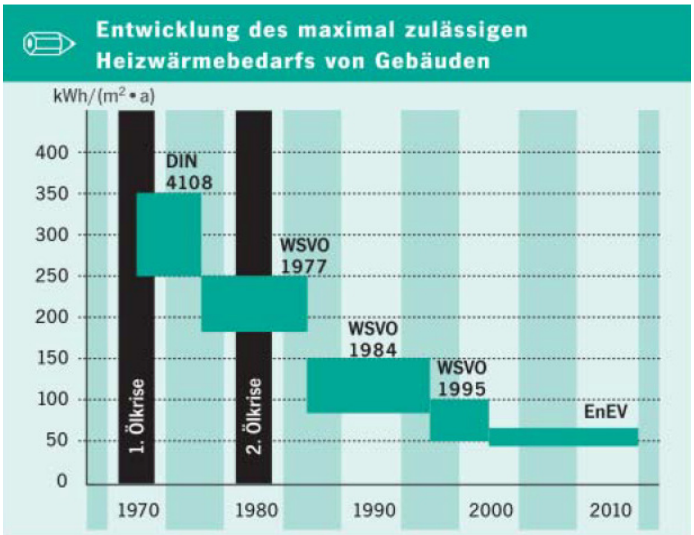


Figure 2 ´Verband Dämmstoffindustrie Deutschland´

2 ANALYSIS ´E% SANIERUNG AMBERG´ – A CASE STUDY´

2.1 The situation

In spring 2009, an architectural competition for a pilot scheme in retrofitting called ´Modellvorhaben e% Sanierung Eglseestrasse/Plechstrasse in Amberg´ was announced by the Bavarian Government. Amberg is a town with 80.00 inhabitants, situated 60 km East of Nuernberg. The chosen social housing area was designed and built between 1959 and 1963. It was built in the same way, how literally hundred thousands of flats were similarly designed and built in Germany and other European countries. The preparation of this competition and the support of the whole process by the governmental building authorities was of an exemplary high quality and can be suggested without exaggeration as a shining example for competitions elsewhere: The Department of Sociology of Coburg University did a research project in the forefront of this competition by questionnaire and multiple personal visits of all inhabitants. The Institute of Climate Design of Munich Technical University presented a differentiated energy status of the existing buildings and their components as well as providing thermography analysis.

2.2 The existing environment Eglseestrasse / Plechstrasse in Amberg

The area is characterized by ribbon development with orientation SW and NE **Figure 3.** It is a car free environment, simply because built before the dominance of cars in Germany. There is even no access by cars to the building entrances and there is only one ´central garage´ for 18 cars only at the entrance of the green space **Figure 4.** These 18 garages were built for 78 flats. According to investigation by Coburg University, only 45% of the inhabitants did have a car in 2009 and about 55 % of the garages were used for general storage by the inhabitants.
Green spaces with old trees are assets of the area **Figure 5,** but the access to all houses is monotonously only from ´back side´ by rather narrow and dark staircases. Linear and not very useful balconies 6,20 x 1,1 meters are the only outdoor spaces for the flats **Figure 6**. There was a lack of appropriate facilities for waste collection and there were no bicycle rooms.


Figure 3


Figure 4


Figure 5


Figure 6

2.3 key results of fore front sociological investigation by Coburg University

The average age of the inhabitants was 62 years in 2009. Most of them have been living in their flat for decades, some of them their whole life. 55 % were pensioners. There was only one family with one child moving in 2009. The inhabitants expressed a high satisfaction with their existing living environment. Their rents are considerably below local average and they articulated rejection to ANY change or even improvement. They a) articulated fear of losing their identity by ´modern´ transformations and they b) were afraid they would have to pay unwelcomed architectural ´fashions´ with higher rents. They also were most concerned about the building process and building time, as it was clear from the beginning that they could not relocate during the building period. Most were willing to keep accepting the discomfort of extremely poor thermal qualities in their flats. The energy costs were lower than expected, simply because the older inhabitants were not heating all habitable rooms of their apartment. The legal requirement, at least ground floor flats to be suitable for wheelchairs was objected by a clear majority despite their high average age. Only inhabitants who had nursed their (then already dead) partners were in favor to this improvement. All these preliminary investigations were confirmed by statements of the inhabitants in open planning meetings after competition **Figure 7**

Figure 7

Figure 8

2.4 key results of energy investigations by Technical University Munich

The housing estate was built by 30 cm thick clay brick walls. None of the building parts (walls, roof, slabs) had any thermal insulation **Figure 8**. About 70 % of the original windows had been changed to low quality plastic windows. There was no central heating in the buildings: originally each room was provided with an individual chimney and a stove heated by wood or coal. Over the years, this was replaced in about 65 % of the flats by an individual gas heating system. The primary energy consumption with 314,5 kWh/m2/a was not surprisingly very high. But it was more surprising, that the non-heating period (in the south of Germany) was only 2 months from mid- June till mid- August. TU Munich provided differentiated energy diagrams which were very informative for the design team. The impact of different building parts, ventilation losses and thermal bridges for energy efficiency were clearly visible from start. **Figure 9 and 10**

Figure 9

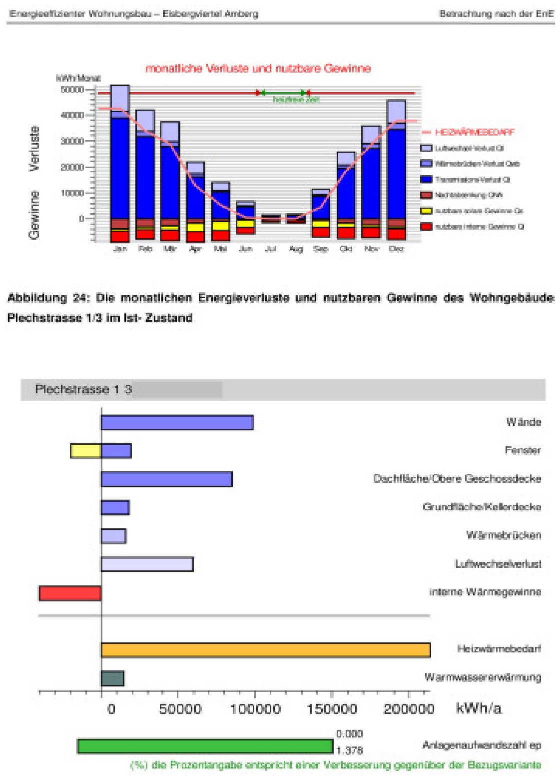


Figure 10

3 THE ASSIGNMENT

As there was an ambition by the Bavarian government to find prototypic solutions, the assignment was very unspecific and general. The architect´s entries were based on individual analyses. The housing association expected a concept, where *´intelligent design, innovative technological approach and integration of the inhabitants makes unexploited potentials useful´*. There were 4 fixed preconditions only:

a) all ground floor flats should be disabled-adapted

b) the execution work must be possible while inhabitants stay in their apartments (except handicapped accessible apartments)

c) after the refurbishment, the maximum primary energy consumption may not exceed a figure 50 % of the legal maximum determined in 2007 (the maximum primary energy was calculated with 92 kwh/m2/a – so the competition entry may not exceed 46 kwh/m2/a.
The maximum overall transmission losses may not exceed a figure of 50% of the legal maximum determined 2007 (50% of 0,59 W(m2K) or 0,29 W(m2/K)

d) From start, the architects had to constitute and register a qualified team of engineers, who provide all demanded calculations and are an integral part of the design process.

4 THE COMPETITION ENTRY

The title for our entry was ´Architectural Acupuncture´. We based our design on a catalogue of 19 different, well connected and well integrated measures from urban scale down to details which we found through thorough analyses and discussions. Key issues were smooth interventions, which provide substantial and understandable improvements of the existing situation for all inhabitants and which interfere on low level their life during an optimized building period. Keywords were cultural and social sustainability and most important appropriateness of all measures - grown identities versus ´the spectacular´.

Representative for the applied method in the whole project, this paper focuses on three key questions and their interactive solution:

4.1 Finding a combined solution for upgrading the existing green space and turning it into a usable common and communicative space. Providing disabled access on ground floor level and mitigating the narrowness and darkness of the entrances

We proposed a new network of walkways in the green space and opened up the buildings from/to the park side. The existing park is changed into a common space with new disabled - adapted entrances. New garbage and bicycle boxes are built opposite the existing garages. The new entries to the buildings make them now accessible from both sides **Figure 11**.
We took favor of the fact, that each flat had two main rooms with about 21 m2 each **Figure 12**. So taking away 90 cm or 3,5 m2 of both ground floor flats was not a big disadvantage for these flats. These new entrances allow connection with the green space, with a playground for children who will move in in the near future **Figure 13**.

These transparent entrances create generosity, park view and daylight for the staircases as well as handicap access by a hydraulic lift. In contrast to all other competition entries, we avoided wheelchair ramps: With their calculated legal minimum length of 26 meters, they are not only very difficult to handle as spatial elements inside the existing green space but also express a subtle discrimination, forcing handicapped persons to do a wide detour. Executing investigations on the competition stage, we found out the lifts were even 5 % cheaper than the ramps **Figure 14 and 15**. A three meter deep ´entrance tunnel´ in front of each new entrance shows respect to the privacy of the park side rooms as well as protecting and defining the new entrances. A green ´umbrella roof´ **Figure 16 and 17**, widely cantilevered over the existing garage building, forms a new 5th facade visible from the upper floors like a ´virtual´ increase of the green space. The already existing entrances were also transformed into a larger and glazed space useful for prams, postboxes etc. and they got a larger entrance roof.

Figure 11

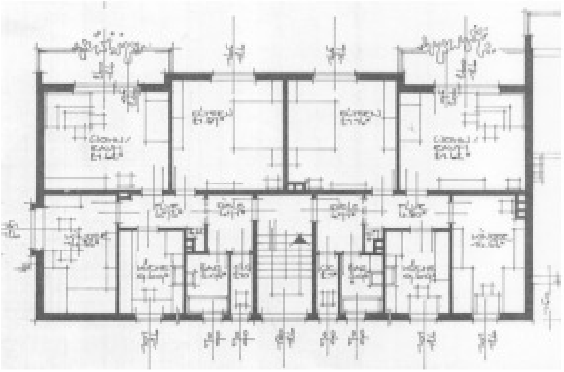


Figure 12

Figure 13

Figure 14 lift rendering

Figure 15 lift built

Figure 16

Figure 17

4.2 Changing all linear and not very useful balconies into small terraces. Providing privacy for these new private outdoor spaces pluse giving them a storage room.

The private outdoor spaces were monotonous balconies with 6,20 x 1,10 meters. The fact, that the houses follow the topography, created even worse situations of unlimited visual control to the balcony of the neighbor **Figure 18 and 19.** We extended half of the length of the existing balconies to a useful geometry for sitting around a table as well as allowing wheelchair access. The remaining part of the 1,10 meter balcony was equipped with a storage box for terrace furniture etc., which at the same time blocs the visual control towards the neighbor balcony. Instead of eliminating the thermal bridge of the balcony by ´amputating´ the slab and replacing it by an in Germany very common ´permanent scaffold´, our acupuncture approach was making use of the 14 cm existing step between the flat to the balcony **Figure 20**.

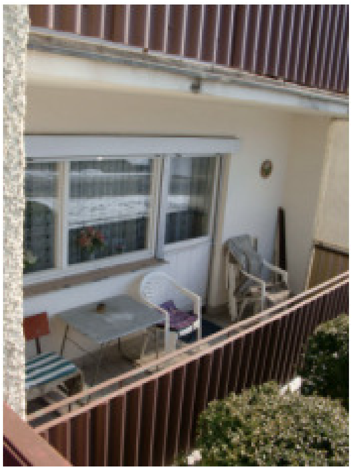


Figure 18 Figure 19 Figure 20

We insulated the balcony to reduce the thermal bridge and proposed to put on top a prefabricated balcony element in wood including the new storage compartment. Structurally, a 40 mm thick 5 layer laminated wooden board in connection with laminated wooden ´compression ribs´ spans towards the concrete slab and stabilizes the extension **Figure 21.** The balconies were designed like prefabricated ´drawers´ including storage room and railings that could be inserted in a minimum of time with a minimum of building activities **Figure 22.** This would have been no problem in Austria, but in the region of Amberg we did not find any contractor who was able or willing to work that way.

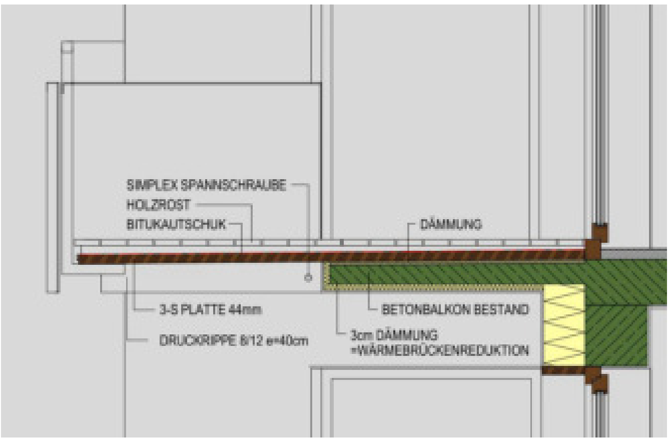


Figure 21 Figure 22

4.3 Finding an ambitious conception for energetic improvement stronger than the requirement of the competition document by minimizing technical systems and using low impact ´building surgery´. Handling this as a chance to change the facade and window proportions to the state they had when the building was new, before the windows were changed individually to the worse.

The existing building was dynamically simulated by our engineers on competition stage. We proposed a high quality thermal insulation that allows vapor diffusion and decided to keep the original plaster facade as a typical facade of its time and of the urban quarter. We suggested that the former geometry of the windows consisting of a square part to open and a narrow rectangle could be reintroduced, but in a transformed way: The square window has passive house standard with triple glazing and is a normal ´contact window´ to the common space, the narrow rectangle was turned into a ´Zuluftkastenfenster´ **Figure 23**. This window type has a

´micro winter garden´ effect and became part of a low tech mechanical ventilation system by pre-warming incoming air. We took advantage of University research being done on this issue **Figure 24**.

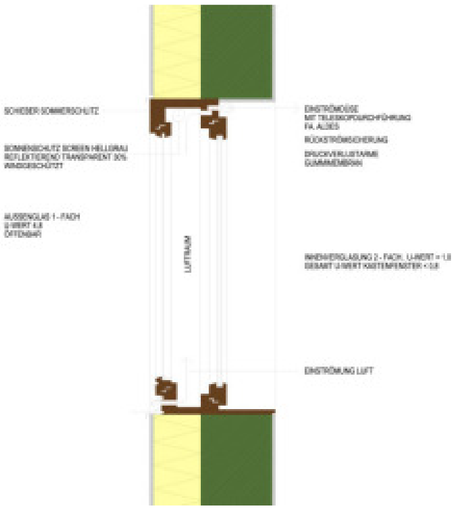


Figure 23

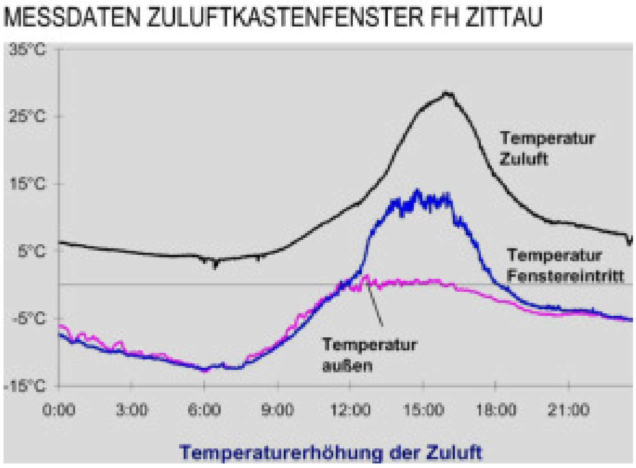


Figure 24

In the living rooms, there was no further need of radiators therefore the walls under windows were removed and replaced by a ceiling-high window providing more daylight, generosity and view **Figure 25 and 26.** By own experience, we knew that we had to provide a ´micro heating pipe´ at the air inlet **Figure 27**, otherwise there would be a comfort problem making the inhabitants close the air inlet by tapes.

Figure 25

Figure 26

The existing chimneys in the kitchen and bathrooms were equipped with a ventilator on attic level for each flat and transformed into air pipes for outgoing air. The ventilator is controlled according to the level of CO2 in the flat. This ventilation system did not require any new ventilation pipes inside the flats and was ideal for a low impact intervention. It was a combined solution providing high quality windows plus reducing energy losses by ventilation and guaranteeing hygienic air conditions **Figure 28.** At the same time, this was the heat source for the hot water production: throughout the year, we had an air temperature between 20 degrees and 26 degrees. Instead of blowing out warm air, we used it as a 365 day thermal source. It crossed a heat exchanger air/liquid and the pre-warmed liquid was the heat source for a highly efficient heat pump for hot water production with a calculated working figure 5,0. The high working figure of this heat pump is a result of the fact that the source temperature has already


Figure 27

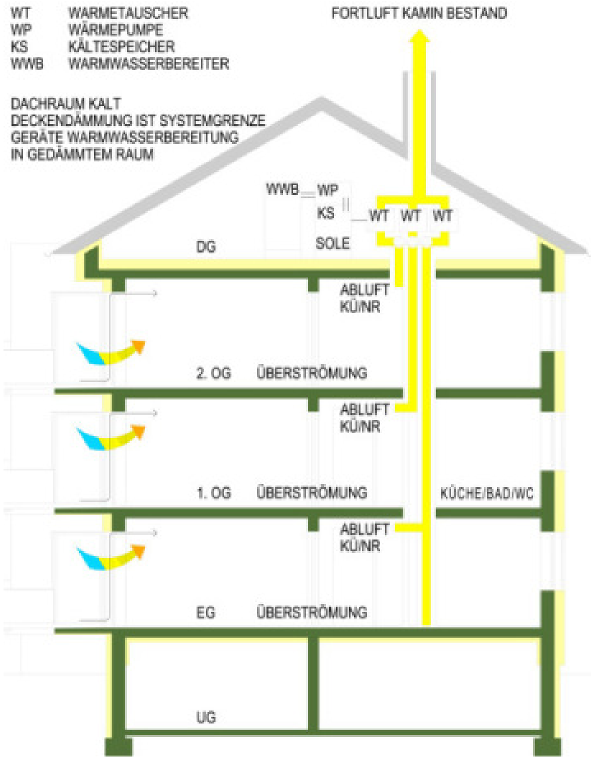


Figure 28

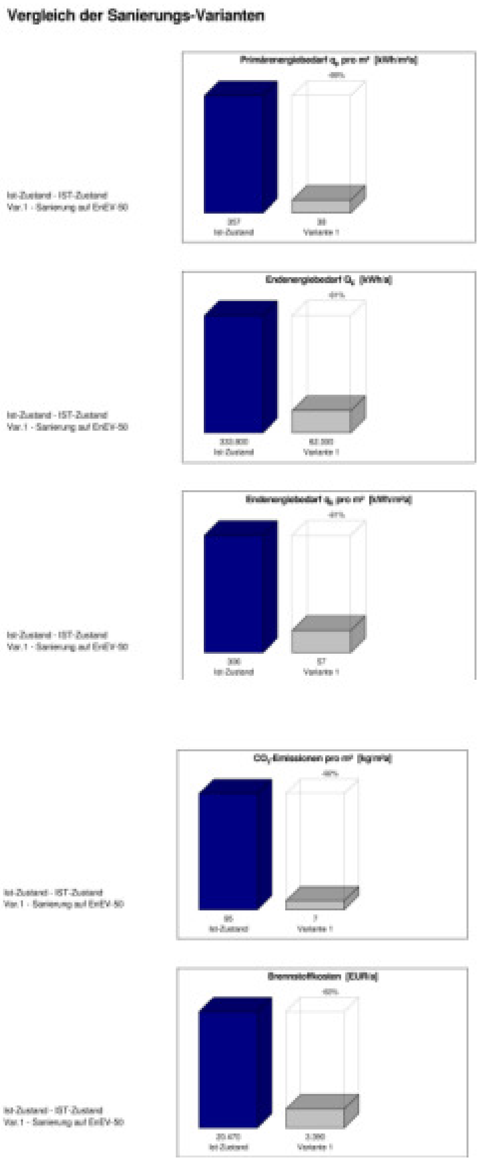
18 or 20 degrees. More important: our proposal was the only competition entry that could avoid solar panels, which might not be effective in many cases because of shading, orientation etc. in other projects. Also with solar panels, which could provide in Germany about 55 % of warm water over the year, a heat pump or other system for the missing energy would be needed anyway. Our contribution avoids an addition of systems and is critical to the aesthetic problems of solar equipment on old roofs as well as to the common practice, defining attachments of technical appliances as a sustainable solution.

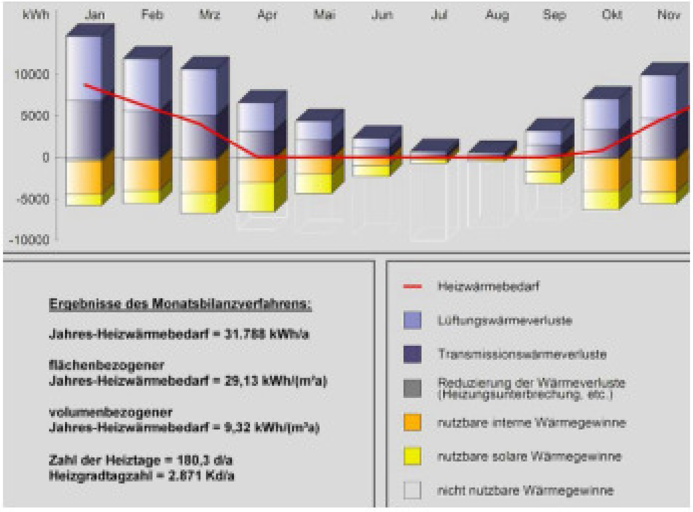
By combination of our integrated measures, we managed to improve the energy consumption by factor 10 and the CO2 reduction by factor 13, and prolonged the period without any heating requirement by 4 months/year **Figure 29.**

The missing heating source for the strongly reduced energy consumption is provided by a ´micro district heating´ for the whole quarter burning wooden pellets. For that, we integrated an underground heating room and underground pellet containers **Figure 30**.

5 THE DESIGN, DETAILING AND TENDER PHASE AFTER THE COMPETITION

´Wohnungsunternehmen Amberg´ is a 107 years old housing association (Genossenschaft) owning about 1700 flats. All inhabitants are members of the association, which legally gives them a strong position between renting and owning the flat. This historic specialty (which could be a reanimated example for not neo-liberal housing schemes) required the signature of minimum 90 % of the inhabitants for all interventions and changes. This was only possible in a transparent process, where the inhabitants were well informed, could express their wishes, fears and ideas and therefore were part of the decision making. Therefore, serious and trustful tenant´s integration was the biggest challenge from start.





Figure

Figure 30

6 THE BUILDING PHASE

The most sensitive problem in the building phase was communication with the tenants and effective organization of the work. Although from start we minimized impact by building activities, every impact is a strain for inhabitants, especially when they are older and home all day. The site supervisor did a great job, but for future projects we recommend a professionally trained and independent ´site moderator´, who is not the supervisor and whose only duty is information, communication and moderation with the tenants.

On one hand, the working period should be as short as possible, but the fact that people live in the buildings prolong the working period by necessary additional measures which would not exist if the building was empty. It was an advantage that all building activities were tested and optimized in one empty ´testing flat´, with testing samples of the new windows, balcony and bathroom. One problem got bigger than expected: A lot of the electric cables did not fulfill legal standards and had to be changed with high building impact.

One decision by the housing association was done during building phase which is not contradicting the project but acts against its concept: on the roofs of four of the houses, the housing association fixed PV panels. The panels have nothing to do with the concept but were a financial profit to the association. PV panels were strongly subsidized in Germany so they are a private and profitable business with tax money.

There was also a strong pressure to implement more covered parking in addition to the new handicapped parking we offered. The reason for that is also more business by renting out more parking space than actual needed in the houses.

7 MONITORING AND EVALUATION

During the building process, there were several site visits by Technical University Munich to examine the building progress and check if things were built the way they were designed and approved. These visits resulted in reports. From Winter 2013/2014 over a period of 3 years, there will be a digital energy monitoring in some chosen flats by Technical University Munich. About two years after finishing the flats and the outdoor spaces, another field investigation will be done by the Sociological Department of Coburg University about tenant´s satisfaction after retrofitting. All results will be published and accessible for future projects.

8 SUMMARY

Apart from inevitable smaller problems to be solved and the unpleasant surprise with not acceptable electric cables to be changed, the project went satisfactory on all stages and it can be seen as an example for future retrofitting of similar homes. It was verified during the execution phase that the biggest challenge for such a project is the logistics of building phases in a building where people live. In this project in Amberg, there was no need for extensions and new apartments. Otherwise a strategy to finish this extension and use it as apartments for temporary relocations appears a less conflict-laden solution.

More precise facts about measured energy performance and user satisfaction after a longer period will be documented after these evaluations are finished. There would be significant cost reductions if not applying ´unspoken´ German housing standards, which are often safeguarding one solution twice and which would allow visibility of structural or technical parts (rough surfaces, visible pipes etc.) at least in non-living zones.