

“BRAND NEW SECOND HAND”

Upgrading of a block of flats (b.1956) through energy efficient renovation

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ABSTRACT: This paper presents a study for the renovation of a 50 year old, 8 floors high apartment building, in Graz, Austria. In this project different measures, concerning energy performance, design and comfort for the user, are united in one concept. Several upgrading steps are tuned to each other, each to carry its part of the total energy reduction. Lowering the heat loss in general during the heating season and the use of local energy resources like solar radiation, it is nowadays possible to reduce the energy consumption of the entire building to passive-house standard. In this case the fossil energy reduction in the end is more than 80 % and the reduction of CO₂-emissions proportional. In this approach the block of flats becomes more flexible to different situations of living, more space and comfort for the occupants is offered and the building is transformed with a new up-to-date design. Compared with a new building, construction costs and primary energy use are reduced. This result means not only maintaining the value of the real estate for the owner, but also increasing it.

Keywords: energy, comfort, reuse, upgrading and rehabilitation of buildings

1. INTRODUCTION

The part of the world's energy consumption, that can be put down on buildings amounts to 50%. About 40% of the energy used in housing is used for heating and hot-water supply – that's about 1,850,000. litre of mineral oil. [1]

The renovation of old buildings is a main factor in successful politics of climate protection, because about 40% of the entire energy consumption is related to heating. [2]

1.1 Existing Situation

The building, located in the north of Graz, was built in 1956 to inhabit workers of a factory and their families. The factory is located in the same area. The house consists of 8 main floors and has no basement. There are four dwellings per floor: 2x two-room apartments with 50m² and 2x one-room with 27m². The ground floor, is used for storage and contains the central heating equipment. The building is north-south orientated and the dwellings east-west.



Figure 1: different views

The entire building is made of Durisol-concrete-bricks reinforced with steel (very similar to common reinforced concrete). The three non-structural inner walls contain the water piping and are therefore

hollow. There is no thermal insulation. Electricity installations come together in the staircase across the elevator.

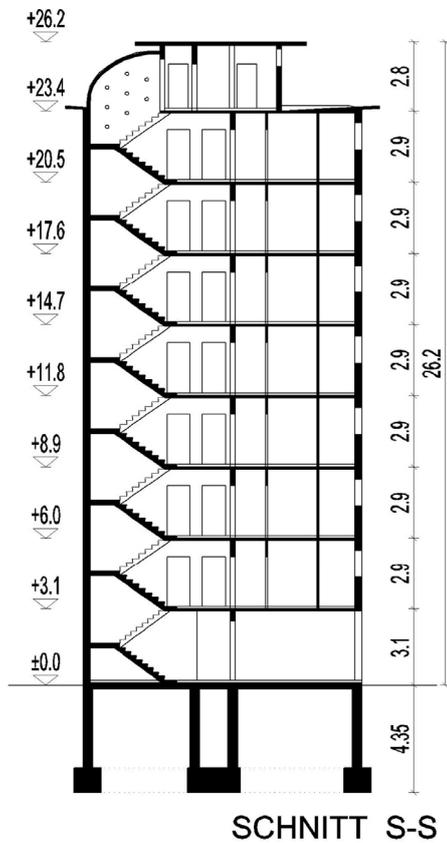


Figure 2: Section S-S

Another reason is the positive urban situation, the image of the block in an area of low rise houses and the acceptance of the users. These positive aspects are accompanied by a good natural light situation because of quite big existing windows at the east and west facades, and a very nice view from the higher floors.

In terms of construction, volume and organisation there are a lot of buildings very similar to this one in the middle of Europe. For that reason the measures and the design of "brand new second hand" can be seen as an example.

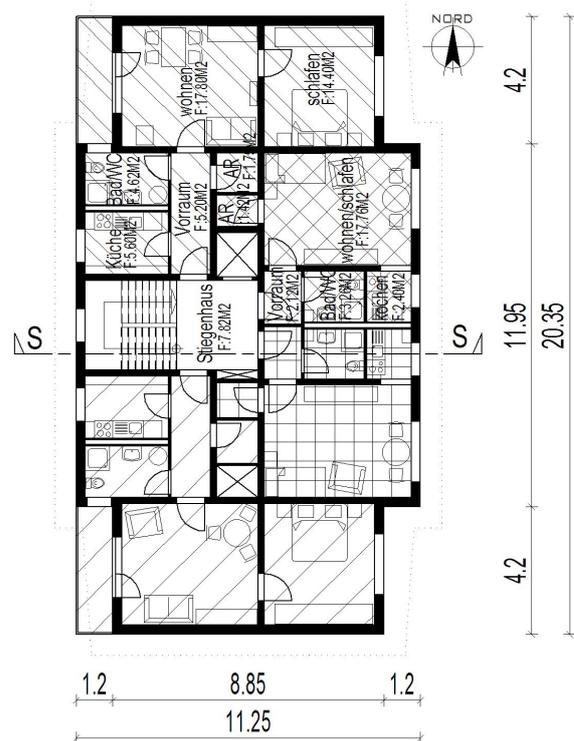


Figure 4: Typical floor layout.

-  Type 1 apartment 50 m²
-  type 2 apartment 27 m²

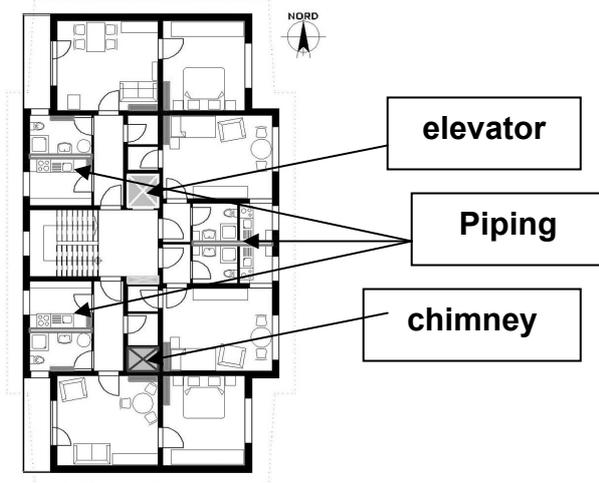


Figure 3: General floor layout

The building was, is and will be used for living. One reason for that is the ownership, who is employer for the tenants, too. This situation has positive economic and financial aspects for both parties.

1.2 Why Renovation?

After a certain service life every object becomes more or less outdated in different ways and needs maintenance and problems are to be solved. Of course there are always different possibilities and ways. In this case the main problems coming are related to the buildings entire energy performance, which can in general be described with the word "poor". Especially the energy consumption for heating is, mainly because of the non-existing thermal insulation, very high compared to new buildings. There are different reasons for that:

Various technical equipment, like the whole heating system (gas-tank, pipes and radiators), is

outdated and should be renewed anyway. No thermal insulation is applied.

The old windows with wooden frame were very draughty and have been replaced by PVC windows in 1999. Instead of solving the problem another one occurred. The now airtight rooms become far too hot during the heating period and with a non-functioning thermostat radiators that only run with a temperature of 60°C or not at all. For that reason mildew started to appear in corners and behind sofas near the north façade. To stop this people just kept the windows open and the heating working all the time. After the renovation of the windows, which should make the rooms more comfortable and reduce the heating costs, the costs for heating are higher than before.

Another weak point are the reinforced concrete ceilings, that go over to balcony floors and therefore acting as thermal bridges working like cooling fins.

For some reason, that is not comprehensible any more nowadays, there are almost no windows in the south façade, which means that the exploitation of possible passive solar gains is just at their minimum. Especially that offers a lot of possible using concepts for that façade.

MAIN BUILDING DATA (EXISTING)		
Volume (brutto)	4972.00	m ³
Floor area (brutto)	1701.00	m ²
Floor area (netto)	1198.00	m ²
Surface total	1963.00	m ²
Surface windows	244.00	m ²
Relation A/V	0.39	
U-Values		
Outer Walls	0,9	W/m ² K
Roof	0,9	W/m ² K
Ground Floor	0,9	W/m ² K
Windows	1,3	W/m ² K

Table 1: main building data

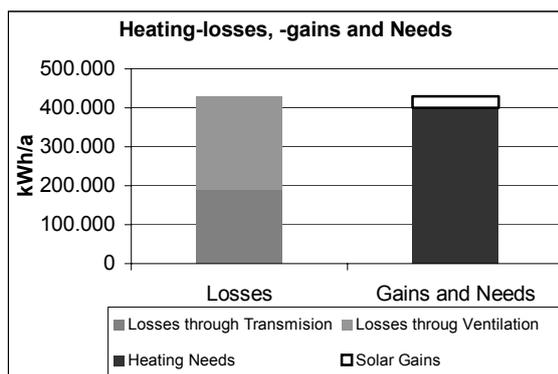


Table 2: Heating-losses, -gains and needs (Values: Solar gains: 30.000kWh/a or 17,6kWh/m²a, Heating-needs: 400.000kWh/a or 235,2kWh/m²a, Ventilation-losses: 240.000kWh/a or 141,1kWh/m²a, Transmission-losses: 190.000kWh/a or 111,7kWh/m²a). Transm.-losses are further to be splitted in losses through walls (58%), roof (10%), ground (3%), windows (10%) and thermal bridges (19%). internal gains, like machines and humans, are not considered because they stay the same.

In general it can be concluded that the required heating energy is extremely high as heating losses are also high. The main reason for this is the absence of a thermal insulation, the thermal bridges (balconies) and the ventilation problem as explained. Improving the energy performance of the whole building means to face and solve these problems first.

2. APPROACH

Considering the poor energy performance may be the main impetus to start a renovation project but also there are other circumstances important to mention.

Reduction of CO₂-emissions should be one of the tasks to be solved, regarding the goal of the Kyoto-protokoll.

The inner structures could be better in terms of flexibility, openness and space. Kitchen and bathroom are too small for different kinds of housing situations. Nowadays people prefer cooking space connected with space for eating and living. Different sizes of dwellings and more flexible systems for using them offer more potential for the real estate market and attract different social- and age-groups.

The building will get a brand new design in the end, which can be seen as "a second chance for architecture". [3]

As mentioned, the use will be the same after a possible renovation of the whole building. This means that the tenants are to stay in their apartments during renovation and are a part of the design concept.

Because of the need of being a "good investment", the costs should be minimized. Compared with the option of pulling down the existing building and build up a new one, the renovation project should have more advantages and therefore be a better investment for the owner.

3. ENERGETIC APPROACH

The final design can be splitted into different measures affecting the energy performance in different ways. Nevertheless all parts are linked to each other and, in the end, work as a whole, which is definitely more than the sum of its parts. The following explanations can be divided into two, methodological different parts. In the first part the method is to reduce the losses (3.1 - 3.6) and the second method is to make use of local energy resources to provide the energy you still will need (4.7 - 4.10).

3.1 Thermal Insulation

To apply external thermal insulation is the first and most fundamental step, because it solves existing problems and reduces transmission heat loss significantly. Also the costs of material and construction are cheap compared to the potential of energy saving. A quite thick thermal insulation (200mm and more) is recommended because construction costs are more or less the same regardless the material thickness. It is possible to reduce heat-losses in an easy, relatively cheap way. In this case the difference between using 80mm and

200mm for example still would be 15.000kWh/a. That is about the same like the whole building would need with the final design. Special attention is needed by connecting the frames of the windows with the insulation, to avoid thermal bridges as good as possible.

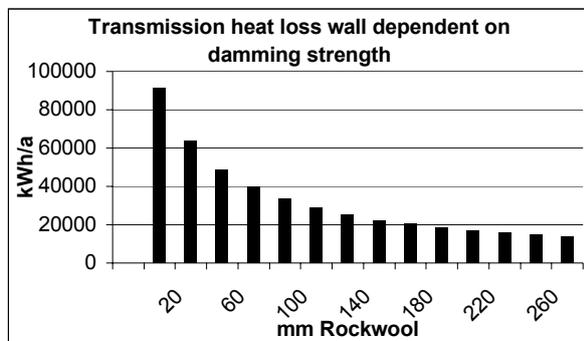


Table 3: Heat-losses through a wall in relation to the thickness of thermal insulation (Rockwool)

3.2 Thermal Bridges

The natural geometric thermal bridges at the corners of the north façade should be neutralized enough, so that mildew will no longer occur. To solve the problem of the existing balconies, they are added to the inner space at a whole and new balconies will be built instead. This measure results in more inner and outer space and in an effective removal of the cooling fins. Bigger triple-glazed windows bring more light and passive solar gains.

3.3 Passive Solar Measures

New windows, in the south- and west-façade especially, result in pleasant warmth for the dwellings. This solar gains are for free during the whole existence of the building and need very few maintenance to function. External sunshades are added at the west-façade, although the balconies work as shading devices, too.

3.4 Natural Light

The inner-light-situation changes with the mentioned measures. As the existing situation can be described as good, because of big windows, the situation of the new design can be described as even better. The rooms, especially the living room, are better illuminated and there is more daylight in the corners. Bigger glass surfaces in the west and new windows in north and south are responsible for that.

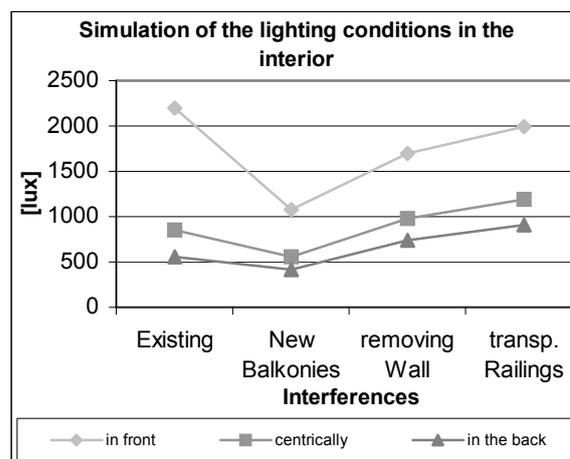


Table 4: Natural Light Situation (front, middle, back of the room), Situation existing, with new balconies, with bigger windows, with transparent railings.

3.5 Ventilation

With solving the mildew problem and installing functional radiators the heat-losses through natural ventilation should go down about 60%. That's already a lot, but to make the energy consumption of the whole building common to passive-house standard it is necessary to add a central mechanical ventilation system with heat recovery. There would be enough space between the hollow-installation-walls for the different tubes. Different thoughts about comfort and user-friendliness are to be considered when doing so.

3.6 Windows

New openings should get triple-glazed windows with an entire (frame and glass surface) U-value of at least 1,1Wm²K. The existing windows from 1999 (U-value 1,3) are not as bad that they should be thrown away and will stay. Although it is better to put them into them same layer as the new thermal insulation. The passive solar gains will be higher and the user gets more space in the inside, either for living or storage.

4. DESIGN

The final design, as a result of reflecting about energetic and architectonic criteria as well as about contentment and comfort for the user, can once again be splitted in steps of explanation as follows.

4.1 Improvement of inner structures

To offer more and open space with natural light some walls are removed and beams will carry the weight of upper constructions instead. Kitchen changes place with the bathroom. Existing balconies become part of the living room. This new room opens to the new kitchen and has enough space for a dining area. More external space, a bigger living and cooking area and more natural light together with the possibility of different housing situations are the result.

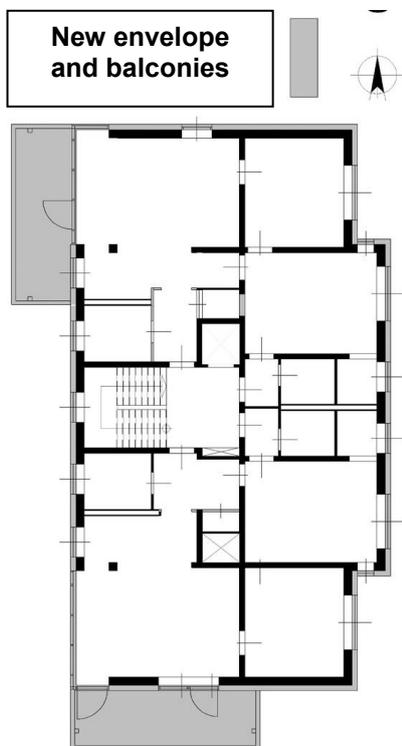
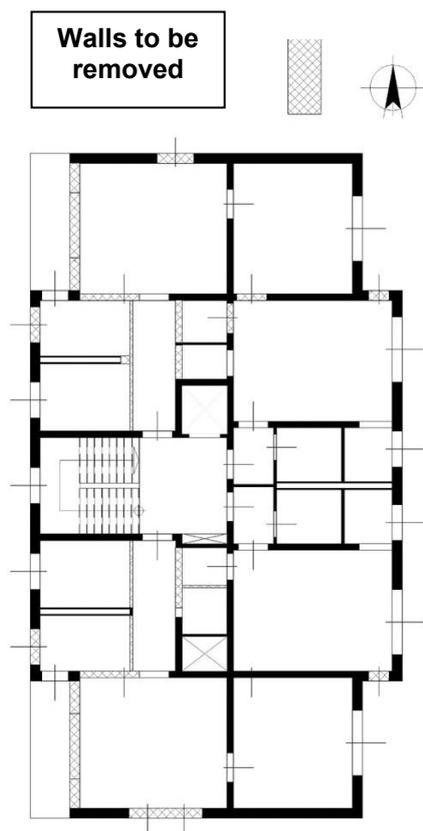


Figure 5: Removal of walls, adding openings, balconies, new thermal skin and façade.

4.2 New Thermal Skin and Façade

The new building envelope adds 220mm of thermal insulation (Rockwool) and a new ventilated façade with panels on a grid of I- and U-profiles. This construction is bearing the weight of itself, parts of the thermal insulation (outer layer) and the upper construction explained in 4.4. The visual and architectonic manifestation of the whole building is mainly influenced by the new façade. Nevertheless the chosen system still offers different possibilities and variations independent of the construction type.

4.3 New balconies and shading device

The balconies of 13m² are connected to the steel grid of the façade and make the whole new construction self-bearing and stiff. Especially in the south they are working as shading device for the new, big glass surfaces, and avoid unpleasant hot temperatures during the summer months. In the west, horizontal movable shading devices are added, because on this side, highest outer temperature and highest solar radiation in summer come together. The shading panels are placed to avoid direct sunlight to come in during the summer months, and to direct sunlight in during winter. This measure supports the heating concept, but because the panels are shiftable, the user can decide.

4.4 Active Solar Measures

As mentioned above, the vertical I-profiles of the new east- and west-façade go over into the upper roof-above-the-roof construction, which is inclined to the south and offers the space for thermal-solar-collectors and photovoltaik-modules. The inclination is 15°, but the collectors themselves are to be installed with angles up to 35° at the roof and up to 55° at the south façade.

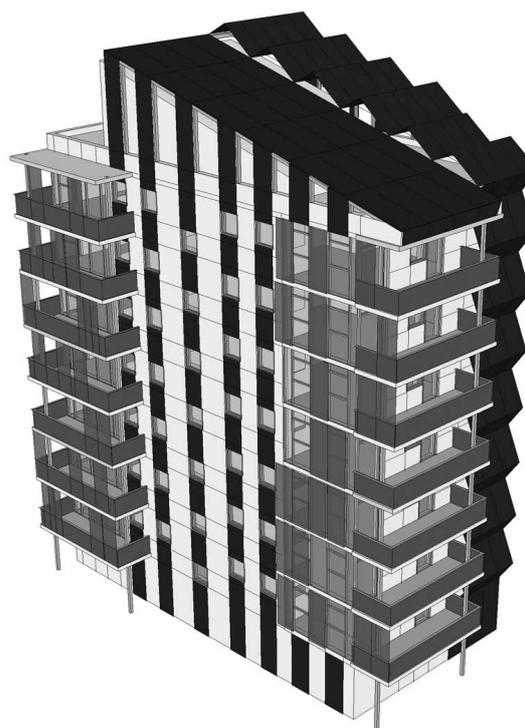


Figure 6: Final Design

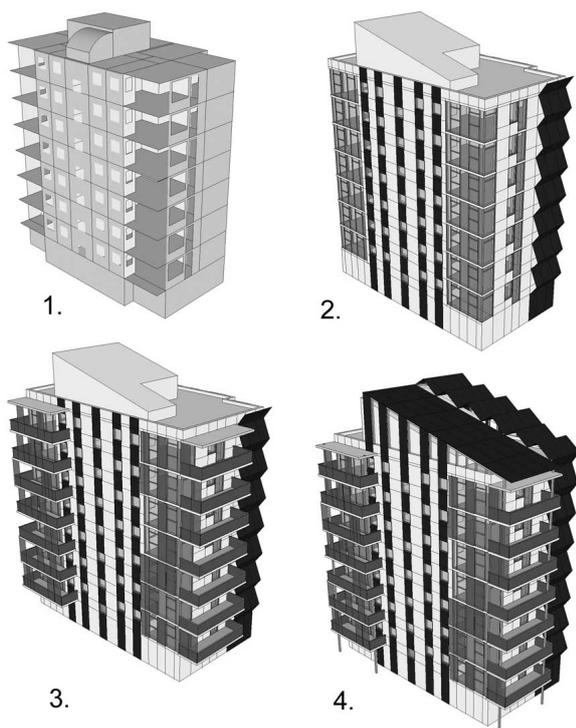


Figure 7: Steps of Design, 1. adding openings, 2. adding new building envelope, 3. adding balconies and shading device, 4. adding solar panels.

4.5 Heating System and Hot Water Supply

The heating system consists of a combination-tank-system with 120m² of thermal collector-space.

4.6 Electricity

118m² of PV-modules with 15° inclination producing approximately 10,000 kWh/a.

Aspects like construction statics and building technology are not further discussed in this paper regarding the limited space.

5. ENERGETIC RESULTS

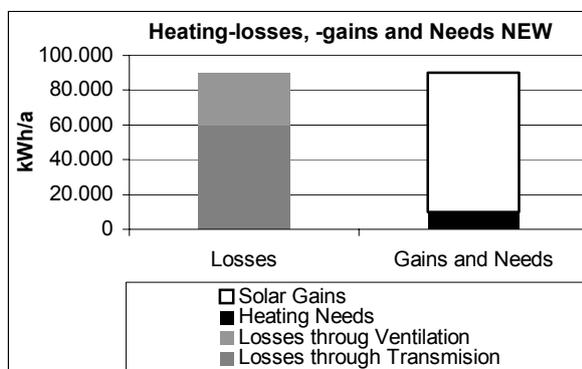


Table 5: Heating-losses, -gains and needs (Values: Solar gains: 80.000kWh/a or 44,6kWh/m²a, Heating-needs: 10.000kWh/a or 5,6kWh/m²a, Ventilation-losses: 30.000kWh/a or 16,7kWh/m²a, Transmision-losses: 60.000kWh/a or 33,5kWh/m²a).

MAIN BUILDING DATA (NEW)	
Volume (brutto)	5250.00 m ³
Floor area (brutto)	1792.00 m ²
Floor area (netto)	1258.00 m ²
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Surface windows	244.00 m ²
Relation A/V	0.39
U-Values	
Outer Walls	0,15 W/m ² K
Roof	0,1 W/m ² K
Ground Floor	0,1 W/m ² K
Windows	1,2 W/m ² K

Table 6: main building data (NEW).

6. CONCLUSION

In this design case a renovation method is developed for an existing outdated building and the results have been analyzed. Fossil energy consumption can be reduced from 235,2 kWh/m²a to 5.6 kWh/m²a. Not only the energy performance of the building is improved, also comfort aspects like space for the tenants is regarded enabling a stretch of life span of some 30 years for this outdated building.

More comfort and less use of fossil energy is possible. In the end the reduction of CO₂-emissions is 80% and energetic amortization period 3 years.

Because of the very poor energy performance of the existing building, the costs of the final design will be amortized after 15 years of use. The alternative to tear off the building and to make a new one instead would cost much more and amortize only after 41 years, which is far to long to think about an lucrative investment. This reckoning only takes the building and using costs into account. Different types of housing are also possible and so are the ways of selling the product on a changing market. The idea is to do a more extensive reorganization than the law asks for and less extensive than building up a new house instead.

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