D7.2

Eco-Buildings

Synthesising Report with the Hand-Over Certificates Signed

SINFONIA

"Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions"

CONTRACT NUMBER	**609019**	**INSTRUMENT**	**COLLABORATIVE PROJECT**
START DATE	**01-06-2014**	**DURATION**	**60 MONTHS**

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 609019

Publishable executive summary

This report summarises the actions carried out in Task 7.2, as described in the SINFONIA Description of Work (DoW). It comprises the innovative building refurbishments in the pilot city Innsbruck and gives detailed information about the implemented measures.

Within Innsbruck, more than 70.000 m² of gross floor area were refurbished as part of the project SINFONIA (building stock from 1930s to 1970s). The refurbishments comprise both residential buildings (social housing, almost 60.000 m²) and school buildings (approximately 14.000 m²), with the objective to reduce the heating energy demand by 70-90%. Therefore, integrated, intelligent and comprehensive measures are implemented in the buildings, such as:

- Optimisation of building envelope (insulation, exchange of windows, reduction of thermal bridges)
- Ventilation system with highly efficient heat recovery
- Integration of renewable energy sources, especially photovoltaics (PV)

The refurbishments in Innsbruck are realized in EnerPHit standard – this is the equivalent to the Passive House standard for new constructions, the energy consumption is comparable to low energy buildings. Additionally to technical conditions, also social (tenants, refurbishing in inhabited state) and legal aspects need to be considered for refurbishments, this report provides conclusions on these topics, as well as a discussion about the process of implementation.

Additionally to the refurbishments themselves, detailed examinations and studies were carried out in Task 7.2 about the following topics:

- Drain water heat recovery for showers: These systems were tested in selected apartments within the SINFONIA residential buildings.
- Optimization of PV self-consumption: Different PV-models were implemented within SINFONIA buildings, the legal framework has a big impact on the optimization potential.
- Prefabricated timber façade systems: They offer an alternative to conventional external insulation composite systems, consisting mostly of ecological and renewable materials.

The refurbishments performed in Task 7.2 contribute towards achieving the three Sinfonia project aims: energy reduction of 40-50%, reduction in CO_2-emissions by 20% and increase in the share of renewables by 30%.

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1 TECHNICAL DESCRIPTION OF REFURBISHMENTS

As part of the project Sinfonia, more than 70.000 m² of gross floor area were refurbished in the pilot city Innsbruck. The refurbishments were carried out by the two housing companies IIG (Innsbrucker Immobiliengesellschaft) and NHT (Neue Heimat Tirol), comprising both residential buildings (almost 60.000 m² = nine buildings) and school buildings (approximately 14.000 m² = three schools). The following measures were implemented within the project Sinfonia:

- Building envelope (insulation, exchange of windows, reduction of thermal bridges)
- Ventilation system with highly efficient heat recovery
- Integration of renewable energy sources, especially photovoltaics (PV)

This chapter gives a detailed description of the technical aspects of the refurbishments from the perspective of the two housing companies. It describes the performed measures as well as the underlying considerations for implementation.

1.1 REFURBISHED BUILDINGS BY PROJECT PARTNER IIG

1.1.1 OVERVIEW

The table below provides an overview of the buildings of IIG.

TABLE 1: OVERVIEW OF REFURBISHMENTS BY IIG

TYPE RESIDENTIAL BUILDING	GROSS AREA [M²]	NUMBER OF FLATS	BEST SHEET NR.	YEAR OF REFURBISHMENT
SILLBLOCK 18, 18A, 18B	2,115	34	3	05.2015-11.2016
SCHUBERTSTR. 6, 8, 10, 12	3,650	39	4	03.2018-12.2019
MOZARTSTR. 5, 7	1,897	20	5	03.2018-12.2019
SUBTOTAL RESID. BUILDINGS	7,662	93		
TYPE SCHOOL BUILDINGS (PRIMARY SCHOOLS)	**GROSS AREA [M²]**	**NUMBER OF CLASSROOMS**	**BEST SHEET NR.**	
VS NEUARZL[2)]	3,185	17	16	06.2017-11.2018
VS PRADL-OST/SIEGMAIR PART 1[2)]	3,786	18	17	06.2015-01.2016
VS PRADL-OST/SIEGMAIR PART 2[2)]	1,830	8	17	06.2018-11.2018
VS ANGERGASSE[1)]	3,073	19	18	07.2016-11.2016
SUBTOTAL SCHOOL BUILDINGS	13,940	62		
TOTAL	**21,602**	**155**		

[1)] Primary school Angergasse: refurbished area reduced (Best = 5.139m²) because of rising residential building development (possibly medium-term densification); listed m² from HOC.

[2)] Cultural heritage; VS NEUARZL: architectural art such as paintings within the school building

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Extent of refurbishment:
IIG manages and refurbishes the school buildings for the city of Innsbruck, as a result the area of refurbished school buildings was significantly higher than of residential buildings within Sinfonia.
The criteria for a major refurbishment include, in addition to the structural measures on the thermal shell, minor improvements to the usage of the school, renovation of the sanitary units and, in particular, measures to improve accessibility. The major refurbishment also covers the expansion of the existing building control technology to include Sinfonia-measuring technology.
Sinfonia-metrology can be used for the aftercare in residential buildings, for example, by consulting tenants on reducing energy consumption.
Measures implemented in schools: fire protection renovation, renewal of the electrical system, replacement of lighting (LED), accessibility, renovation of the thermal shell (window replacement, facade [exception: cultural heritage schools], roof, earth-contacting walls), mechanical ventilation system, renovation of sanitary areas, renewal of floor coverings in classrooms, building management systems and Sinfonia-metrology.
Measures implemented in multi-unit residential buildings: renovation of the thermal shell (window replacement, facade, roof, earth-contacting walls or lowermost floor), staircase renovation (fire protection, electrical risers, handrails and railings), renewable energy (photovoltaics (PV) or solar energy), conversion of heating systems, renovation of cellars, fire protection in the apartments and Sinfonia-metrology.

1.1.2 TECHNICAL DEVELOPMENT OF RENOVATIONS THROUGHOUT THE PROGRAMM

This final report shows the latest refurbishments and thus depicts the technical status. The most suitable objects for implementation are pointed out in this report. For example for early adopter cities who, as imitators, may want to use this information, reliable and economically acceptable solutions are shown. In these later projects, measures that were considered necessary in the first projects and therefore were implemented, have been adjusted and reduced by the stakeholders (real estate companies NHT and IIG) to the actually significant measures to achieve the project objectives. These reductions and optimizations were carried out taking into account the preservation of the technical qualities and the benefits for the tenants and users. The periodic technical reports show the precise links to all renovation projects.

1.1.3 SCHUBERT-MOZARTBLOCK – SCHUBERTSTRAßE 6-12 & MOZARTSTRAßE 5-7 (BEST SHEETS NO. 4 & 5)

URBAN CONTEXT

The "Tyrolean late home style" in the block development with the typical five-story construction (built about 1939) distinguishes the inventory structure of the 6 staircases and 60 apartments in the dress of the architecture of Theodor Prachensky.
In 2014, the IIG decided to announce an architectural competition for an increase by two storeys including barrier-free access and to refurbish the existing building within the project Sinfonia. The architectural solution proposed underground parking in the inner courtyard, preservation of the

inner courtyard and elevator systems for each staircase to increase accessibility for the existing building.

EXISTING BUILDING BASICS

Due to the increase of the building and the necessary underground parking a rented apartment had to be abandoned, which is why 59 existing apartments remain for the refurbishment. With start of the planning, an inventory analysis of the existing heating system and the evaluation of the fireplaces in use was carried out. In addition, the willingness of the tenants to install a ventilation system, new windows, new apartment entrance doors, new front doors and to assume operating costs for the elevator system was requested. The tenants were informed that the major refurbishment would be carried out in the inhabited state (without any temporary relocation). As a precautionary measure, the IIG has not renewed the apartments with a tenant change since the beginning of the Sinfonia program. The rights of the tenants and estate companies and the possible structural interventions are regulated in the Tenancy Law. With the exception of thermal renovation, renewal of entrance doors and the roof renewal, law requires approval.

Before beginning the refurbishment, 58 tenants agreed to changing the windows and 37 tenants agreed to the implementation of a central ventilation unit. The straightening of the thermal shell (original loggias become living space) also required approval from the tenants, as well as the construction of a replacement for this area by the so-called access balconies. In the case of existing leases, this additional charge cannot be added to the rent; in these cases, the IIG goes unpaid.

Heating system before refurbishment: 20 flats with electric heating, 6 flats with oil or wood heating, 33 flats with decentral gas heating.

ESSENTIAL PLANNING STEPS

Based on the technical analysis of the existing building and the specification in the best sheets, the examination of various concepts took place. In the following, some elaborated concepts will be elucidated and an explanation for the reasons why they could not be implemented will be given.

Changeover to a central heating system:

One of the variants for a central heating system was the construction of a central gas boiler with buffer storage, supplemented by renewable solar thermal or photovoltaic components.

Advantages:

- Unification of the existing heating mix (gas, wood, coal, oil, electric energy)
- Operating costs for just one device, the central device
- simple billing of heating costs by the IIG and the IIG knows the consumption and could deliberately conduct consultations to reduce consumption for the tenants
- A possible later connection to the district heating (TIGAS) would have been possible in principle but with a time horizon of more than 15 years

Disadvantages:

- The heating room would have had to be built from the given framework in the southern part. There are only two staircases and it would have been necessary to build a transmission line for the remaining six staircases.

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- Not all the apartments would have been able to use the bathrooms for several months and the bathrooms and toilets would have all had to be renewed. A consent of all the tenants, assumption of all costs (also furnishings) by the IIG and a relocation would have become necessary.
- The stairs in the staircases would have had to be rebuilt. The necessary core drilling would have made the use of the staircases impossible for several months and the provisions on the minimum widths for the staircases could not be fulfilled. A relocation into the facade (layer of insulation) was discussed, but discarded due to the long-term disadvantages.
- In the course of IIG's efforts to replace oil and coal with at least gas condensing boilers, the central solution would have had to replace the 33 partly new room air independent gas condensing boilers. This would mean resource destruction.
- This concept is incompatible with the existing tenancy law and additionally not economically feasible.

Use of unused fireplace chimneys for the central ventilation system:

One of the variants of the central ventilation system was to use the existing and unused chimney flues for the air distribution system in order to minimize the structural interventions in the flats. An experiment was carried out involving the essential connections and the technical solution, which should be implemented in this object.

Advantages:

- Existing chimney drafts could be integrated into the air distribution system to minimize structural interference. Means: use of a structurally existing resource.
- Less burden on the tenants.

Disadvantages:

- No airtight connection from chimney draft to telephone silencer in the apartment are available momentarily.
- For the chimney-draft there is currently no hose on the market for this solution.
- Existing electrical installations also cross the chimney groups. The risk of damage through the hole and the associated cost risk for IIG, caused by electrical repair, could not be borne. A minimization would have only been possible if the cut-out had been drilled at a maximum height of approximated 20 cm under the ceiling and thus the wall can no longer be used as a dividing wall. In addition, a lot of furnishing would have to be removed in numerous apartments.

Prefabricated facade element made of wood in a multi-storey residential building for renovation:

As an alternative to the conventional thermal insulation system, the use of a prefabricated timber frame construction including window elements and cellulosic blow-in insulation was tested.

We refer to part 5 of this report: prefabricated timber facade systems (University of Innsbruck).

Advantages:

- Building element integrated facades (insulation, windows, electric cables, ventilation ducts) can be produced as a prefabricated element with very little burden for the tenants (especially because of short construction time).

- Prefabrication and renewable ecological building materials (wood, grey energy, ...)

Disadvantages:

- The current technical status prohibits the use of prefabricated facade elements in family homes unless there is a maximum of two storeys. A use in multi-storey housing or multi-storey education buildings with higher fire protection requirements is not feasible momentarily.
- The unevenness of the facade is currently still a problem, which can only be solved via the mounting bracket with a tolerance of ± 10 cm.
- The planned cellulose blow-in insulation can be installed within the factory. Through the transport and assembly, however, there is a risk that the insulation moves and forms airspaces.
- Economic criterion: At least double, to triple construction costs.
- Horizontal butt joints, which are highly stressed in the alpine area and must be suitable for the long term.

RELEASED VERSION FOR THE CONSTRUCTION IMPLEMENTATION

Heating system: The standardization of the heating system was carried out in such a way that existing gas floor heating systems were preserved. Oil, coal and wood heating systems have been replaced by electric heaters. Existing electric heaters have been preserved.

Ventilation system: One central ventilation system per staircase was installed with the ducting in the basement being moved to the facade (insulation layer). Each apartment with consent from the tenants for a connection to the ventilation system was equipped with such. Apartments without the consent of the tenants were prepared and the transfer point on the facade was measured in order to easily be found later. In the event of a change of tenant, the IIG can connect the newly rented apartment to the central ventilation system. The conception is therefore geared to a long-term and gradual connection. The advantages are obvious: the caretaker can easily carry out the filter change and the operating costs in the final construction are clearly the lowest. Disadvantage: Until the completion of the final construction, the tenants who had agreed to the installation of the ventilation system had in proportion higher operating costs. Note: each block has around 14 apartments (10 existing apartments and 4 apartments from the extension). The theoretically worst possible utilization of the central device could be 28% (with only connected ventilation system in the added storeys).

Thermal insulation composite system: Mineral insulation had to be implemented to meet the national requirements of fire protection. The concept was to place the windows in the insulating layer. In the practical implementation, however, the position of the windows had to be moved to the edge of the brick wall, because the porous bricks produced very large outbreaks in the existing masonry.

Earth-facing walls and basement: The basement serves as an energetic buffer. On the facade facing the road, the insulation ends at pavement level, on the patio side, the earth-contacting walls were

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insulated as well as possible. An insulation of the basement ceiling was not possible because on the one hand, a vaulted cellar was present and on the other hand, the required room height was limiting. So called "tenant electricity model": Together with the project partner IKB, a tenant electricity model was developed in order to distribute the output from the PV system as equally as possible to the tenants in accordance with the principle of equal treatment. The billing of the electricity is handled by our partner IKB. The output from the PV is divided statically into the metering points. An excess from the PV is fed into the national power network and is not used to cover the needs of other tenants. Note: Once the storage technologies have evolved, it would be possible to switch to a more efficient dynamic model. National legislation currently prevents the developer from pursuing these models.

FIGURE 1: SCHUBERT-MOZARTBLOCK – BEFORE REFURBISHMENT

FIGURE 2: SCHUBERT-MOZARTBLOCK – AFTER REFURBISHMENT

FIGURE 3: SCHUBERT-MOZARTBLOCK – VENTILATION DUCT IN THE BASEMENT

FIGURE 4: SCHUBERT-MOZARTBLOCK – MAIN DISTRIBUTION VENTILATION DUCT, ELECTRICITY AND SINFONIA MEASUREMENT TECHNOLOGY

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FIGURE 5: STRANDS OF VENTILATION DUCTS

FIGURE 6: FACADE-GUIDED SYSTEM INCL. ELECTRICS

1.1.4 PRIMARY SCHOOL NEUARZL – ROTADLERSTRASSE 10 (BEST SHEET NO. 16)

URBAN CONTEXT

The Neuarzl district was built around 1893 with the relocation of the shooting gallery as a settlement on the shooting range south of Haller street and in the north of the Inn. In the meantime, the district Neuarzl has grown together with the district Olympic-village. The elementary school is located on a very generous plot of about 12.500 square meters in size. The school has been enlarged repeatedly since the 50s of the last century. The elementary school is located between the two busy streets Schützenstraße and Hallerstraße and enjoys very generous open spaces in a meanwhile urban context.

EXISTING BUILDING BASICS

The existing elementary school Neuarzl was built around 1955, followed by the gymnasium tract in 1958. The Sinfonia refurbishment refers to the extension of the school in 1971, the so called south wing. The fire protection of the whole school was adapted to the state of the art in 2005, followed by the thermal renovation of the northern wing and the school guard building in 2006, the disability access with a ramp to the entrance followed in 2007. In the same year, the roof covering over the main entrance was renewed. In 2013 a large thermal renovation of the gymnasium and the secondary rooms to the gymnasium including the associated sanitary facilities was carried out. Also, the building is a cultural heritage, based on §2a cultural heritage law, due to the "art on the building" by the artists Helmut and Maria Rehm and Gerhild Diesner.

ESSENTIAL PLANNING STEPS

An analysis of the structure including component openings revealed a reinforced concrete skeleton construction with infills partly of masonry, partly of reinforced concrete, but with an internal insulation made of “Heraklith” (insulation material made of wood-wool bound with minerals). This has had a major impact on the window installation situation, the room-side airtight building level and

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in particular on the planning of the ventilation system, because the class partition walls had to be made airtight.

RELEASED VERSION FOR THE CONSTRUCTION IMPLEMENTATION

- Preparation of the heating system for the conversion from NHT´s and IIG's own district heating to the district heating of the project partner TIGAS with a higher proportion of renewable primary energy sources. The reason why the connection has not been made yet is a court-pending case with a third party (not Sinfonia third party).
- Switching to led lighting. In this course, a class was equipped with biological lighting. Biological lighting intends to support users (pupils and teachers) in promoting alertness, concentration and attention.
- A 76.72 kW peak photovoltaic system was built on the renovated roof of the primary school. The energy generated by the sun is used approximately 39% on its own property.
- The complete electro technical system has been renewed and installed with halogen-free cables.
- Central ventilation system: In combination with an intelligent optimization of the fire sections, a low-tech ventilation system with many passive components (= no maintenance) could be implemented. In this major refurbishment, the most advanced ventilation system has been implemented. The essential components are: few fire sections; door leaf with passive overflow; big overflow zones; ventilation control unit on the roof.
- Sun protection with intelligent lamella position: In order to be able to make optimal use of the passive profits during the winter months, the sunshade was equipped with a bus-system, which enables an intelligent lamella position. The control works - explained simplified – as is stated here: In winter, the sunshades will open up with sunrise and can only be changed by the teachers. After the lessons, the sunshades will lower again. In summer, the sunshades prevent overheating by shutting out the sun. Again only the teachers can change it during the lessons. At the weekend and during the summer holidays the sun protection is closed and in winter, the sun protection is open.
- Additional measures: accessibility, hydraulic adjustment of the heating system, improvement of the room acoustics, computer cabling in all class rooms, renewal of sanitary facilities, rainwater infiltration system and object security

FIGURE 7: VS NEUARZL – BEFORE REFURBISHMENT

FIGURE 8: VS NEUARZL – AFTER REFURBISHMENT

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FIGURE 9: VS NEUARZL – INSULATION IN TRANSITION AREA BETWEEN WALL AND EARTH

FIGURE 10: VS NEUARZL – WINDOW SITUATION

FIGURE 11: VS NEUARZL – PV POWER PLANT

FIGURE 12: VS NEUARZL – CLASSROOM

1.2 REFURBISHED BUILDINGS OF PROJECT PARTNER NHT

1.2.1 OVERVIEW

The table below provides an overview of the SINFONIA buildings of NHT.

TABLE 2: OVERVIEW OF REFURBISHMENTS BY NHT

TYPE RESIDENTIAL BUILDING	GROSS AREA [M²]	NUMBER OF FLATS	BEST SHEET NR.	YEAR OF REFURBISHMENT
IN 40	4.932,50	49	7	05.2017 – 05.2018
IN 13	5.709,90	92	8	11.2016 – 06.2018
IN 28	7.359,00	84	11	09.2015 – 04.2017

IN 22/23	6.653,00	84	12	03.2018 - 04.2019
IN 43	4.933,00	60	13	08.2016 – 03.2018
IN 3	22.258,00	269	19	11.2016 - 10.2018
SUBTOTAL RESID. BUILDINGS	51.845,40	638		

1.2.2 IN 40 – REICHENAUERSTRASSE 62-66 (BEST SHEET NO. 7)

GENERAL INFORMATION

Thermal retrofit: Full retrofit of thermal shell with EnerPHit-Standard components U-value<=0,15 W/(m²K) and 48% Passive House windows Uw=0,80 W/(m²K).

Building services: Decentral, flatwise ventilation units with 82% of heat recovery in the hallway. Extended cascade-ventilation system used to gain proper and healthy air volume rates.

Renewables: A PV-plant with 36 kWp and a PV-production of 37.741 kWh/yr could be placed on the flat roof of the building.

More and detailed technical information is laid out in the according hand over certificate BEST 07.

FIGURE 13: IN 40 – AFTER REFURBISHMENT

CHALLENGES AND SPECIAL FEATURES WITHIN THE PROJECT

PV-plant tenant flow model: Together with the IKB was the PV System designed as a tenant flow model. This means that on the one hand side the generated electricity is used by the residents individually in their flats, and on the other hand for the general parts of the property. Any remaining surplus will be fed into the public grid. This model starts in January 2018 - as a pilot project in the state of Tyrol.

Thermal bridges: Special attention on minimized thermal bridges concerning new window installation and improvement of daylight situation by sloping lateral reveal. Existing balconies with big thermal bridge potential were demolished and new, thermal separated balconies were built in front of the newly insulated façade.

FIGURE 14: IN40 – THERMAL SEPARATED BALCONY CONSTRUCTION

Installation of ventilation system: The installation of tubes and units was a real challenge for the tenants due to inhabited state of the flats and the chosen decentral ventilation system.

FIGURE 15: IN 40 – MOUNTING OF DECENTRAL VENTILATION UNITS AND DISTRIBUTION SYSTEM WITHIN THE APARTMENTS

SUMMARY AND OUTLOOK

Installation of a decentral ventilation system at inhabited state could be a hassle. Therefore it is a must to do an extremely tight planned installation procedure together with expert craftsmen and the tenants. Thanks to this highly energy-efficient refurbishment of shell and building services, we were able to save approx. 50% of the previous total average building energy use, nearly 2/3 of the space heating demand and additionally now are able to generate renewable energy directly for the households of our tenants.

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1.2.3 IN 13 – BRUCKNERSTRASSE 2-12, HUGO-WOLF-STRASSE 2-4, VIKTOR-DANKL-STRASSE 11 (BEST SHEET NO. 8)

GENERAL INFORMATION

Thermal retrofit: Full retrofit of thermal shell with EnerPHit-Standard components U-value=0,15 W/(m²K) and 100% Passive House windows Uw=0,80 W/(m²K).

Building services: Decentral, flatwise ventilation units with 84,5% of heat recovery located within the bathrooms. Extended cascade-ventilation system used to gain proper and healthy air volume rates.

Renewables: A PV-plant with 49,95 kWp and 330 m² of PV-modules could be placed on the roof of the building and now can gain a PV-production of 50.480 kWh/yr.

CHALLENGES AND SPECIAL FEATURES WITHIN THE PROJECT

Thermal building retrofit combined with a newbuilt Passive House building extension: 92 existing flats are retrofitted to Passive House EnerPHit Standard and additionally 32 flats with Passive House new-built standard are added at the top of the existing building.

FIGURE 16: IN 13 – AFTER REFURBISHMENT

Thermal bridges: Special attention on minimized thermal bridges concerning new window installation and improvement of daylight situation by sloping lateral reveal. Existing balconies with big thermal bridge potential were demolished and new, thermal separated balconies were built in front of the newly insulated façade. Thermal bridges caused by load-bearing construction penetrating the insulation layer are minimized due to the used principle of “thermal bridge minimized design”.

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FIGURE 17: IN 13 – BALCONIES BEFORE AND AFTER THE REFURBISHMENT (THERMAL SEPARATED CONSTRUCTION)

Installation of ventilation system: The installation of tubes and units was a real challenge for the tenants due to inhabited state of the flats and the chosen decentral ventilation system.

SUMMARY AND OUTLOOK

The extension of the building with 2 new-built storeys at the top of the existing building was a real challenge due to the inhabited state of flats underneath. Thanks to this highly energy-efficient refurbishment of shell and building services, we were able to save approx. 85% of the previous total average building energy use, nearly 90% of the space heating demand and additionally now are able to generate renewable energy for the general power needs of the building.

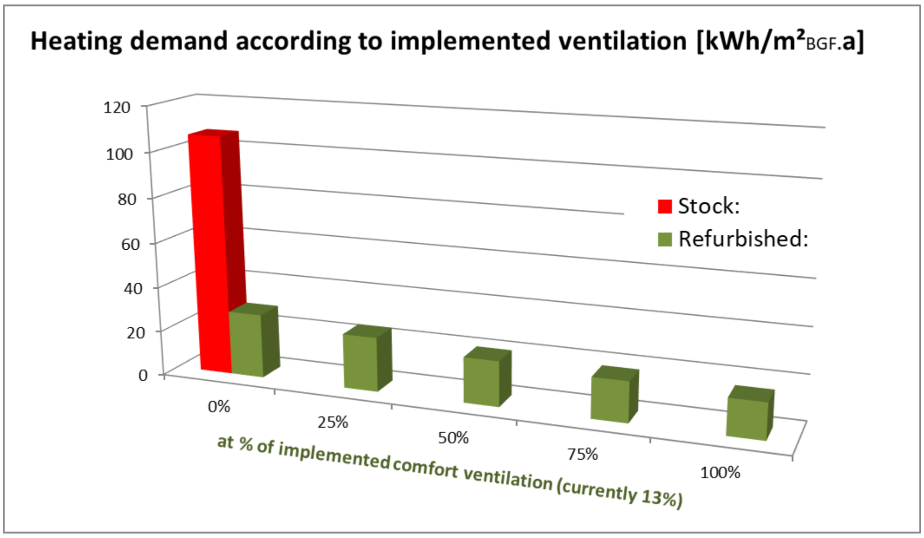

FIGURE 18: IN 13 – HEATING DEMAND ACCORDING TO IMPLEMENTED VENTILATION

Heating demand according to the percent of implemented, decentral ventilation systems will further decrease within the next 10 years.

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1.2.4 IN 28 – FENNERSTRASSE 4-14; OSWALD-REDLICH-STRASSE 7-11 (BEST SHEET NO. 11)

GENERAL INFORMATION

Thermal retrofit: Full retrofit of thermal shell with EnerPHit-Standard components U-value<=0,15 W/(m²K) and 60% Passive House windows Uw=0,80 W/(m²K).

Building services: Central ventilation units with about 82% of heat recovery located in the cold attic. Housewide air distribution system within the staircases. Extended cascade-ventilation system within the flats used to gain proper and healthy air volume rates.

Renewables: A PV-plant with 41,08 kWp and 262,8 m² of PV-modules could be placed on the roof of the building and now can gain a PV-production of 43.755 kWh/yr.

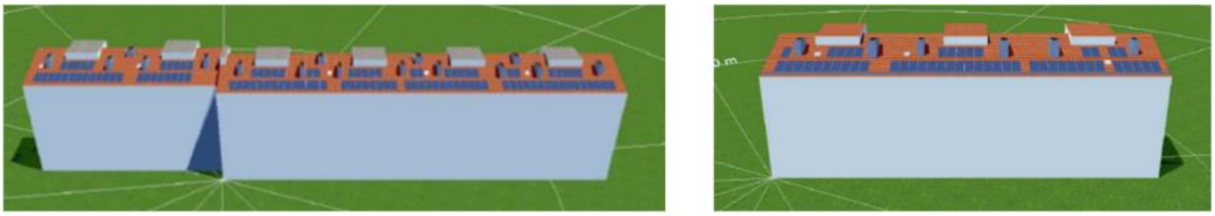


FIGURE 19: IN 28 – PV-PLANT

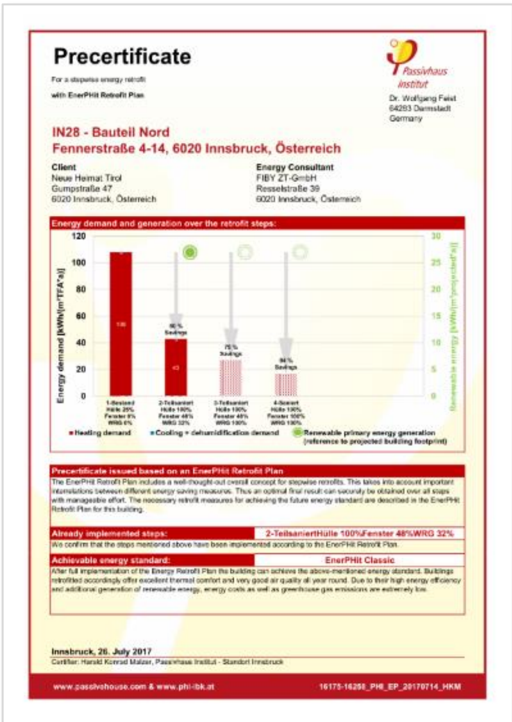
More and detailed technical information is laid out in the according hand over certificate BEST 11.

CHALLENGES AND SPECIAL FEATURES WITHIN THE PROJECT

Thermal bridges: Special attention on minimized thermal bridges concerning new window installation and improvement of daylight situation by sloping lateral reveal. Thermal bridges caused by load-bearing construction penetrating the insulation layer are minimized due to the used principle of "thermal bridge minimized design".

Installation of ventilation system: The installation of the air distribution system within the staircases was a real challenge because existing landing stages had to be broken without sustainably weakening the statics and jeopardizing the escape route in the event of a fire. The installation of tubes within the flats caused a lot of detailed work for the craftsmen and needed patience at the tenants.

Passive House EnerPHit-Step certificate: These two refurbishments are the first in Austria with an detailed EnerPHit-Step certified retrofit plan.



Precertificate

For a stepwise energy retrofit
with EnerPHit Retrofit Plan

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Precertificate issued based on an EnerPHit Retrofit Plan

The EnerPHit Retrofit Plan includes a well-thought-out overall concept for stepwise retrofits. This takes into account important interrelations between different energy saving measures. Thus an optimal final result can securely be obtained over all steps with manageable effort. The necessary retrofit measures for achieving the future energy standard are described in the EnerPHit Retrofit Plan for this building.

Already implemented steps:	2-TeilsaniertHülle 100%Fenster 48%WRG 32%

We confirm that the steps mentioned above have been implemented according to the EnerPHit Retrofit Plan.

Achievable energy standard:	EnerPHit Classic

After full implementation of the Energy Retrofit Plan the building can achieve the above-mentioned energy standard. Buildings retrofitted accordingly offer excellent thermal comfort and very good air quality all year round. Due to their high energy efficiency and additional generation of renewable energy, energy costs as well as greenhouse gas emissions are extremely low.

Innsbruck, 26. July 2017
Certifier: Harald Konrad Malzer, Passivhaus Institut - Standort Innsbruck

www.passivehouse.com & www.phi-ibk.at   16175-16258_PHI_EP_20170714_HKM

FIGURE 20: IN 28 – ENERPHIT-STEP CERTIFICATE

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SUMMARY AND OUTLOOK

Installation of a decentral ventilation system at inhabited state could be a hassle. Therefore it is a must to do an extremely tight planned installation procedure together with expert craftsmen and the tenants.

Thanks to this highly energy-efficient refurbishment of shell and building services, we were able to save approx. 66% of the previous total average building energy use, 70% of the space heating demand and additionally now are able to generate renewable energy for the general power needs of the building.

1.2.5 IN 22 – DOMANIGWEG 2-8, LÖNSSTRASSE 20-24, MÖSSLGASSE 17-19, 36 & IN 23 – LÖNSSTRASSE 26-28 (BEST SHEET NO. 12)

GENERAL INFORMATION

Thermal retrofit: Full retrofit of thermal shell with EnerPHit-Standard components U-value=0,12-0,16 W/(m²K) and 100% Passive House windows Uw=0,80 W/(m²K). In order to get the cold attic into the thermal shell, a static amplification of the roof structure had to be done first. The chimneys had to be extended and a thermal bridge-free connection to the thermal shell was executed.

FIGURE 21: IN 22 & 23: COLD ATTIC INTO THE THERMAL SHELL

Building services: Central ventilation units with about 82% of heat recovery located in the cold attic. The very first time we were integrating the house wide air distribution system to the thermal shell of the building (for more details see conclusions at 5.1.2). Extended cascade-ventilation system within the flats is used to gain proper and healthy air volume rates.

Renewables: A PV-plant with 28 kWp and 155 m² of PV-modules including Lithium-Ion accumulators could be placed on the roof of the building and now can gain a PV-production of 20.000 kWh/yr.

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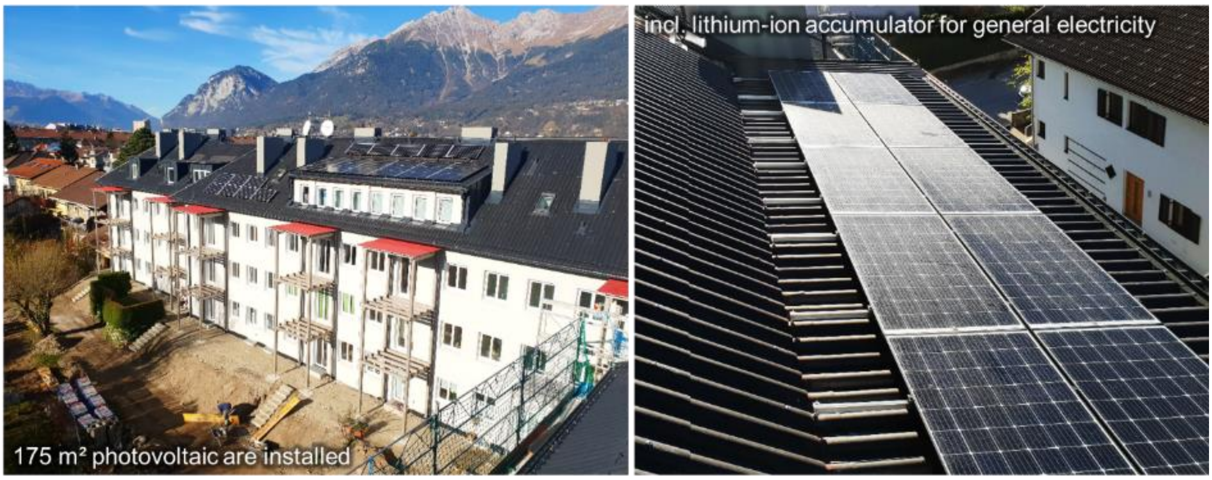

FIGURE 22: IN 22 & 23 – PV-SYSTEM

CHALLENGES AND SPECIAL FEATURES WITHIN THE PROJECT

Installation of ventilation system: Lessons learned out of all previous Sinfonia refurbishments, the installation of the air distribution system within the thermal shell could be done in a cost efficient and less intrusion way. There is no installation of tubes within the flats anymore (for more details see conclusions at 5.1.2 and HoC BEST12). Therefore no “extra-patience” of the tenants was needed.

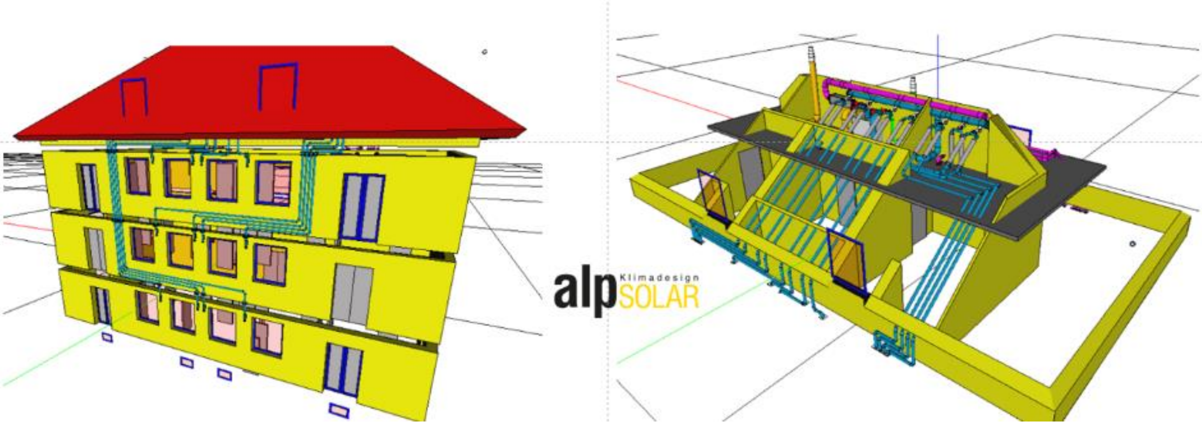

FIGURE 23: IN 22 & 23 – 3D-MODEL OF VENTILATION SYSTEM

Thermal bridges: Special attention on minimized thermal bridges concerning new window installation within thermal shell layer. Existing balconies with huge thermal bridge potential were demolished and new, thermal separated balconies were built in front of the newly insulated façade.

Thermal bridges caused by load-bearing basement construction penetrating the insulation layer are minimized due to the used principle of “thermal bridge minimized design”.

FIGURE 24: IN 22 & 23 – THERMAL SEPARATED BALCONY CONSTRUCTION

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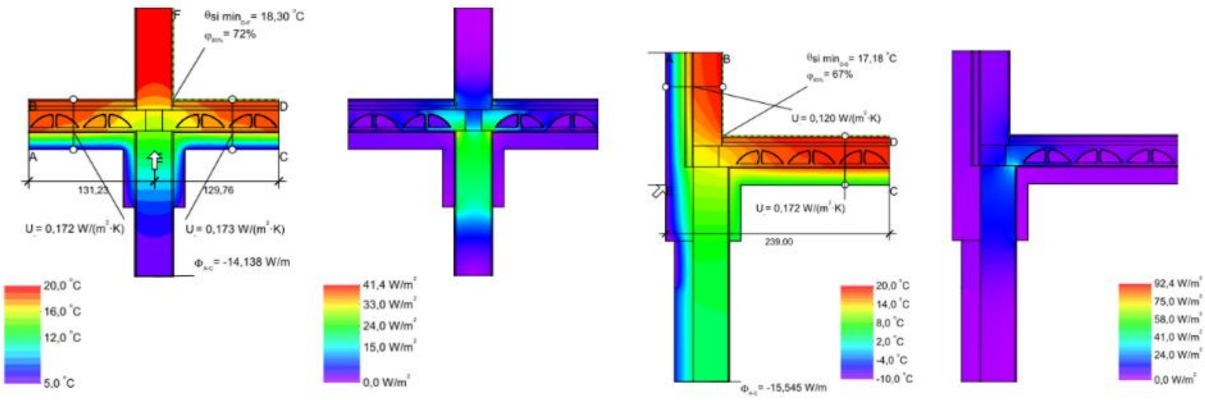

FIGURE 25: IN 22 – THERMAL BRIDGE CALCULATION AND PLANNING FOR LOAD BEARING BASEMENT CONSTRUCTION

SUMMARY AND OUTLOOK

Lessons learned out of all previous Sinfonia refurbishments, the installation of a central ventilation system at inhabited state could be quite nice and cost efficient. Therefore it is a must to be as flexible as possible and have the best and most forward-looking planners at hand.

FIGURE 26: IN 22 & 23 – AFTER REFURBISHMENT

Thanks to this highly energy-efficient refurbishment of shell and building services, we were able to save approx. 69% of the previous total average building energy use, 92% of the space heating demand and additionally now are able to generate renewable energy for the general power needs of the building.

1.2.6 IN 43 – REICHENAUERSTRASSE 94, 94A, 94B, 94C, 94D (BEST SHEET NO. 13)

GENERAL INFORMATION

Thermal retrofit: Full retrofit of thermal shell with EnerPHit-Standard components (U-values 0,11 – 0,19 W/(m²K)) and 100% Passive House windows Uw=0,80 W/(m²K).

Building services: Central ventilation units with about 81% of heat recovery located in the cold attic. Housewide air distribution system within the staircases. New “widly-extended” cascade-ventilation system within the flats used to gain proper and healthy air volume rates and chosen in accordance of minimal intrusion to the inhabited flats while installation.

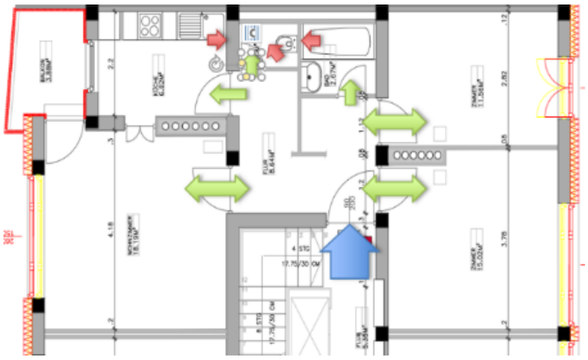

FIGURE 27: IN 43 – NEW “WIDELY-EXTENDED” CASCADE-VENTILATION SYSTEM WITHIN THE FLATS

Renewables: A PV-plant with 21 kWp and 140 m² of PV-modules could be placed on the roof of the building and now can gain a PV-production of 13.083 kWh/yr.
More and detailed technical information is laid out in the according hand over certificate BEST 13.

CHALLENGES AND SPECIAL FEATURES WITHIN THE PROJECT

Thermal bridges: Special attention on minimized thermal bridges concerning new window installation and improvement of daylight situation by sloping lateral reveal. Thermal bridges caused by load-bearing balcony construction penetrating the insulation layer are minimized due to the used principle of “thermal bridge minimized design”.

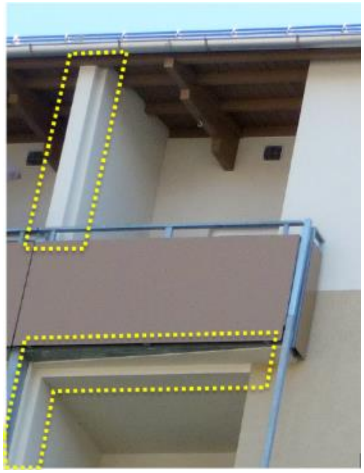

FIGURE 28: IN 43 – MINIMIZATION OF THERMAL BRIDGES

Installation of ventilation system: Lessons learned out of IN28 (BEST 11), the installation of the air distribution system within the staircases was now done in a fairly minimum way. The installation of tubes within the flats were minimized due to the chosen “widly-extended” cascade-ventilation system and therefore “extra-patience” of the tenants was not that needed as at IN28 before.

FIGURE 29: IN 43 – CENTRAL AIR DISTRIBUTION OF VENTILATION SYSTEM WITHIN STAIRCASES

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SUMMARY AND OUTLOOK

Lessons learned out of IN28 (BEST 11), the installation of the ventilation system at inhabited state went much smoother here with a much higher acceptance factor at the tenants.

FIGURE 30: IN 43 – AFTER REFURBISHMENT

Thanks to this highly energy-efficient refurbishment of shell and building services, we were able to save approx. 25% of the previous total average building energy use, about 65% of the space heating demand and additionally now are able to generate renewable energy for the general power needs of the building.

1.2.7 IN 3 – GUMPPSTRASSE 38-52, KOFLERSTRASSE 1-19, PANZING 1-13 & 2-18, KRANEWITTERSTRASSE 13-23, LANGSTRASSE 23-43 (BEST SHEET NO. 19)

GENERAL INFORMATION

Thermal retrofit: Full retrofit of thermal shell with Aerogel insulation components with a Lambda-value = 0,014 W/(mK) and 77% Passive House windows Uw=0,80 W/(m²K) at a gross conditioned floor area of 22.238 m².

FIGURE 31: IN 3 – OVERVIEW WHOLE REFURBISHMENT SITE

Building services: Decentral, flatwise ventilation units with 80% of heat recovery, very low profile built and usually located in the hallway and vertically installed.

Extended cascade-ventilation system within the flats used to gain proper and healthy air volume rates and chosen in accordance of minimal intrusion to the inhabited flats while installation.

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Renewables: Altough this site has to be handled as a local cultural heritage a PV-plant with 33,4 kWp and 192 m² of PV-modules could be placed on the roof of the building and now can gain a PV-production of 44.165 kWh/yr.

CHALLENGES AND SPECIAL FEATURES WITHIN THE PROJECT

Highly energy efficient retrofit and local cultural heritage: The city of Innsbruck has declared this site to be a local cultural heritage due to typical urban style and architecture of pre-war time at 1938. Therefore, during the refurbishment special attention had to be paid to an unchanged façade image. In order to preserve the facade, it was not possible to use conventional insulation material on the facade on certain street fronts. The NHT had to use a new insulation technology, which nevertheless ensured the load-bearing capacity for the special, heavy weight wall plaster surface which has to be used in order to the local cultural heritage plan. This all ended up in the biggest Aerogel construction site for facade insulation in Europe since 2016 and till now.

FIGURE 32: IN 3 – RECONSTRUCTED STONE PORTAL WITH SPACE FOR INTERNAL INSULATION (YELLOW ARROWS)

Tenant flow model: PV System designed as a tenant flow model. This was the second project together with the IKB. It means that on the one hand side the generated electricity is used by the residents individually in their flats, and on the other hand for the general parts of the property. Any remaining surplus will be fed into the public grid.

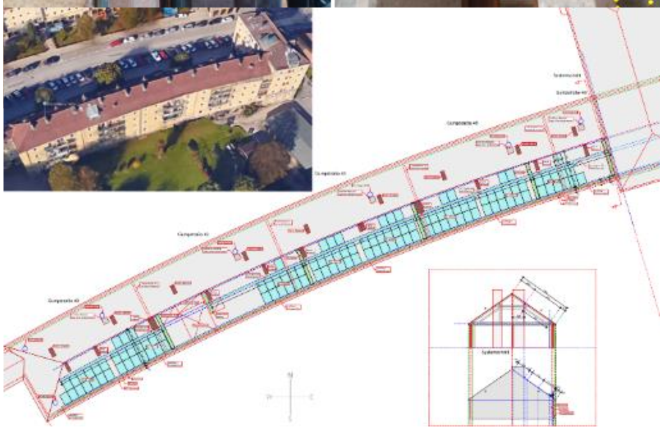

FIGURE 33: IN 3 – PV-SYSTEM

Installation of ventilation system: Special focus was placed on the accessibility and operability of the ventilation unit by the tenant. The chosen system additionally supports a very innovative and small form factor based duct system for less intrusive flatwise distribution.

FIGURE 34: IN 3 – DECENTRAL VENTILATION UNIT AND DISTRIBUTION SYSTEM WITHIN THE APARTMENT

The integration of ventilation units with heat recovery system in such an old building stock (1938) is pioneering. Due to this circumstance, BEST019 has been already the venue of several study visits for several times.

SUMMARY AND OUTLOOK

High energy efficient retrofit of a declared local cultural heritage building stock from the pre-war time (1938) is possible!

FIGURE 35: IN 3 – REFURBISHMENT OF LOCAL CULTURAL HERITAGE; BEFORE & AFTER

Thanks to this highly energy-efficient refurbishment of shell and building services, we were able to save approx. 69% of the previous total average building energy use, about 85% of the space heating demand and additionally now are able to generate renewable energy directly for the households of our tenants.

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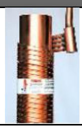
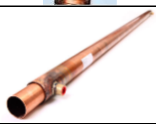
2 DRAIN WATER HEAT RECOVERY

2.1 STATE OF THE ART AND STATE OF KNOWLEDGE OF SHOWER WATER HEAT RECOVERY SYSTEMS

The European market offers a wide range of shower drain water heat recovery (DWHR) systems suitable for household use. These usually consist of a heat recovery unit and are connected to the wastewater, cold water and the hot water distribution system. The **vertical systems** typically consist of a vertical wastewater tube made of copper, in which the warm shower water flows off vertically as a thin film on the inner surface. This film convection ensures good heat transfer to the copper tube. The fresh water to be heated flows upwards in countercurrent to the wastewater. There are various technical versions of the manufacturer for this purpose. Vertical systems must be installed below the drain of the shower tray, for example into the installation shaft. Since the installation on the same floor is not possible, the application possibilities are limited. In the case of refurbishing apartments, it is usually not possible to install the heat exchanger in the floor below and in the case of new buildings, a horizontal installation is usually preferred for maintenance and ownership reasons. Table 3 lists some examples of vertical manufacturers. When comparing the achieved efficiencies, different testing procedures have to be considered. Depending on the manufacturer, the specification refers to different measuring methods and boundary conditions (PHI, CSA and Kiwa) so the achieved efficiencies are not completely comparable.

TABLE 3: VERTICAL SHOWER WATER HEAT RECOVERY SYSTEMS

Manufacturer	Type	Figure	Efficiency	List Price
Wagner Solar	ECOshower Pipe 15		66% PHI 63,7% Kiwa	460 €
Power-Pipe	R4-120		72,8% CSA	1.143 €
Hei-tech	Recoh-Vert V3		65,4% Kiwa	485 €
Hamwells	BLUE (an active system)		58 % Kiwa	3.000 €

Due to the described disadvantages in the installation of vertical systems, **horizontal operating systems** are often preferred. The heat exchangers are installed in the floor structure or directly under the shower tray or even integrated into the shower tray. Thus, all relevant installations are located and accessible from inside the apartment. There are several horizontal systems available on the market. In contrast to the vertical systems, very different technical approaches are used. The

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achieved efficiencies and prices differ greatly. Currently available systems are exemplarily listed in Table 4.

TABLE 4: HORIZONTAL SHOWER WATER HEAT RECOVERY SYSTEMS

Manufacturer	Type	Figure	Efficiency	List Price
Hei-tech	Recoh-Tray		39,6% PHI	2.024 €
Wagner	ECOshower Drain 800		42% PHI	1.170 €
Wagner	ECOshower Tray 900		54% PHI 50,6% Kiwa	1.560 €
Sakal	NELA		40,5% Manufacturer	252 €
Zypho	Double-Walled		31,1% Kiwa	360 €
Nicoll	Ecoshower		24% Manufacturer	unknown

The efficiency of horizontal passive systems installable in housing is in the range of 25 - 55%, the efficiency of vertical passive systems in the range of 60-70%.

2.1.1 INSTALLATION OF PASSIVE SHOWER WATER HEAT RECOVERY SYSTEMS

If a conventional passive (no active components) shower water heat recovery system is installed in the course of renovation or new construction, both the shower tap and the hot water storage tank should be connected to the heat recovery unit in order to achieve the highest possible efficiency. If the fresh pre-heated water after passing through the heat exchanger is only connected to the cold shower tap (and not as well to the hot water storage tank), the two mass flows of drain water and fresh water in the heat exchanger are not balanced and its efficiency decreases relatively between 18-25% based on the system configuration, Figure 36. Therefore, it is very important to connect the domestic hot water tank and the cold side of the shower tap if possible. Figure 37 shows the installation without (left) and with shower water heat recovery unit (right) schematically. The necessary hot water for the mixer tap is provided by a hot water or circulation pipe from the hot water storage tank to the warm side of the mixer tap.

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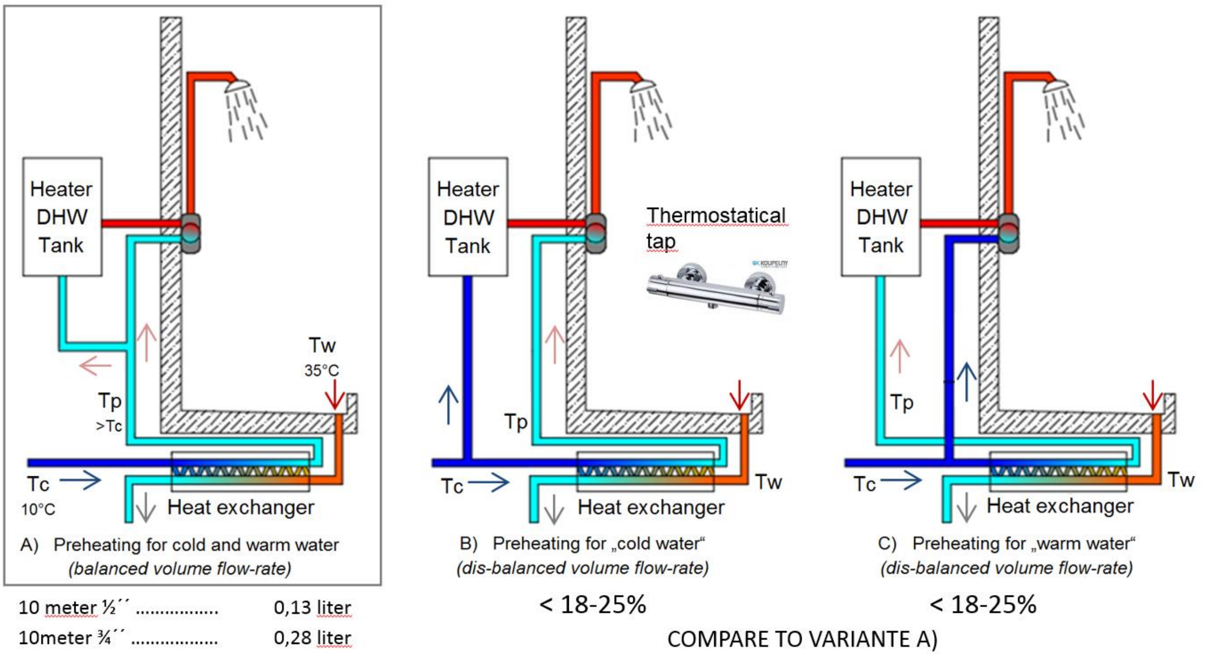

FIGURE 36: CONNECTION VARIANTS OF SHOWER WATER HEAT RECOVERY

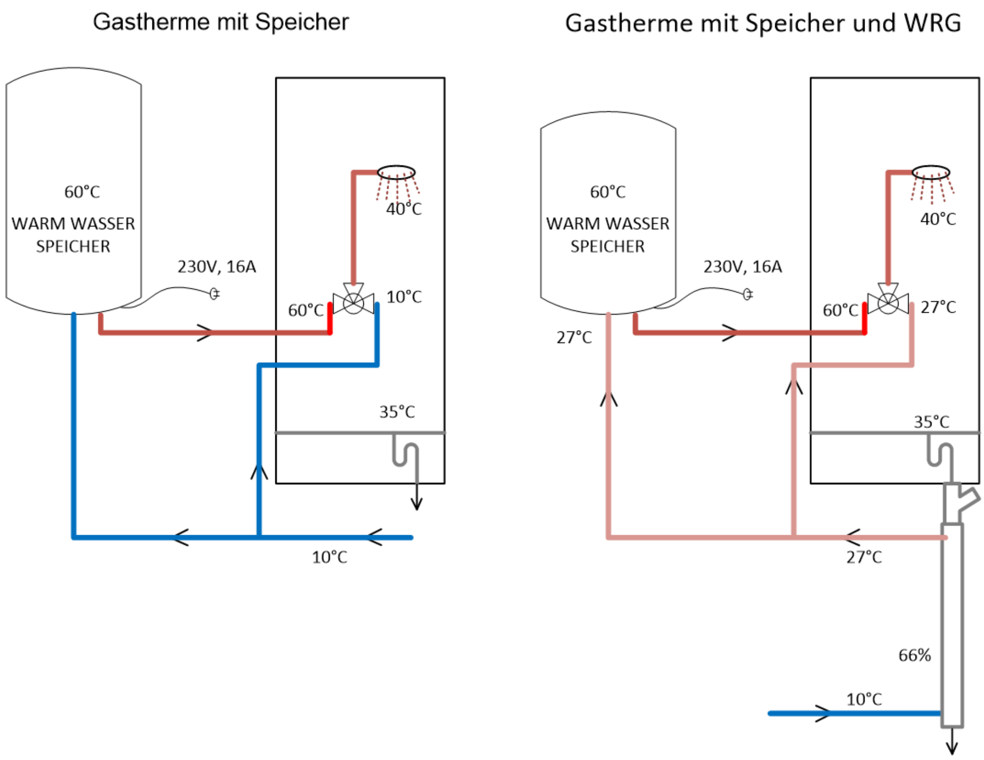

FIGURE 37: SCHEMATIC INSTALLATION PLAN OF A SHOWER WITHOUT (LEFT) AND WITH (RIGHT) SHOWER WATER HEAT RECOVERY UNIT

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2.1.2 ALTERNATIVE SHOWER WATER HEAT RECOVERY SYSTEMS AND PATENT SEARCH

2.1.2.1 COOLING-OUT TANK

An alternative to shower water heat recovery in order to use the energy contained in the wastewater is a cooling-out tank. Here, the resulting gray water is collected within the thermal envelope, cooled by the cool-out tank to near room temperature and then passed into the sewer. Thus, the heat gained during the heating season can be used, but only at a low temperature level (room temperature). The disadvantage here is the high space requirement and maintenance.

2.1.2.2 CIRCULATION SHOWER

Another concept is the circulation shower. A large proportion of the shower waste water is treated, cleaned, filtrated and used again as circulating shower water (for example Hamwells e-Shower up to 70% energy savings, € 4,131), where the cost of water treatment is considerable. The advantage is that the energy efficiency is achieved synergistically together with the high saving of the fresh water demand. In terms of profitability, this overall system offers no simplification of the complexity of warm water systems. The device must be combined with another central or decentral heat generator and so system-related storage and distribution losses as well as regular manual maintenance should be considered.

FIGURE 38: CIRCULATION SHOWER

2.1.2.3 VERTICAL HEAT EXCHANGER WITH A LIFT PUMP

This system called “Blue” from the company Hamwells combines the high efficiency of the "vertical shower water heat recovery systems" and the lift pump allows the installation of the system on the same floor, similar to the vertical heat exchangers. This is possible by removing the glass plate held by a magnetic force located in the shower. The lifting pump with a consumption of only 40 W should be able to withstand even sand and small stones over an expected service life of 20 years. The efficiency is 58% (Kiwa) and the price € 3,000 including VAT.

2.1.2.4 CENTRAL GREYWATER TANK WITH HEAT EXCHANGER

This solution uses a spiral heat exchanger immersed in a central storage tank for collecting so-called gray water. The gray water flows as drain water from the washing machine, shower or dishwasher in the tank and is treated for further use, such as irrigation of the garden. The water heater is supplied with fresh water that enters via the spiral heat exchanger, where the fresh water is preheated.

However, the gray water coming from the shower at a high temperature will be mixed in the tank with already existing water to a lower temperature level. The overall efficiency of the heat recovery is thus rather low, with a high cleaning requirement of the spacious gray water tank. Contrary, this solution allows the reuse of gray water and replaces some of the fresh water consumption.

2.1.3 HYGIENE

Legionella are rod-shaped bacteria that can be dangerous to humans in high concentrations in drinking water.

As can be seen in Figure 39, the potentially endangered temperature range for legionella growth is in the range between 25 °C and 50 °C. In general, therefore, care should be taken to ensure that fresh water pipes cannot be permanently heated to over 25 °C. Hazardous areas are also hot duct shafts and insufficient separation of the cold water pipe from warm circulation pipes.
The hot water tank is usually heated to a water temperature of about 55 °C, which leads to the slow death of Legionella bacteria, for adequate protection against the risk of infection. However, it is not the temperature alone which is important, but above all the stagnation times.

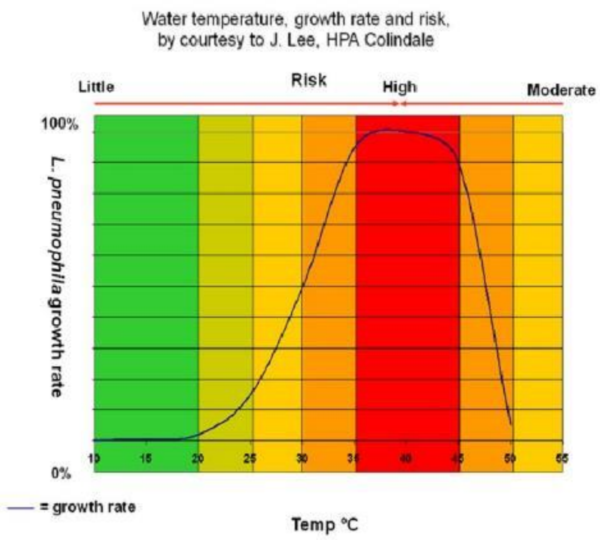

FIGURE 39: RISK OF LEGIONELLA GROWTH AS A FUNCTION OF TEMPERATURE (EXNER, 2009)

As can be seen in Figure 40, the doubling time of legionella bacteria in stagnation is 4 hours for 30°C warm water. According to this, the dynamics play a decisive role, which is why for legionella infestations pipes are especially dangerous, which are rarely used, because otherwise the legionella concentration is again and again lowered by the regular tapping of drinking water (Kisteman, Schulte, Rudat, Hentschel & Häußermann, 2012). **This means that conventional vertical and horizontal wastewater heat exchangers do not pose a higher risk than normal riser pipes in the installation shafts.**

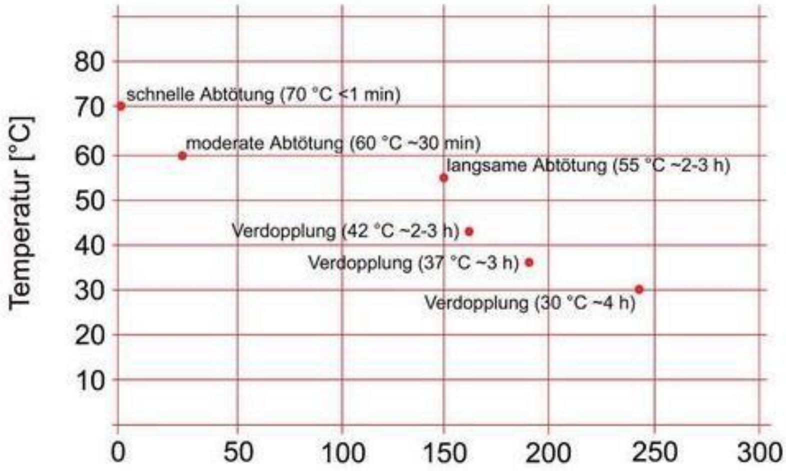

FIGURE 40: RELATIONSHIP BTW. WATER TEMPERATURE AND BEHAVIOR OF LEGIONELLA (BÜRSCHGENS, 2016)

2.2 IMPLEMENTATION

A DWHR system was installed in BEST 3 (IIG Sillblock). The electricity savings regarding domestic hot water were measured "in situ" in the case-study apartment. The measured dynamic-efficiency of this DWHR system was 17 %. This is a positive result in terms of price-feasibility. Nevertheless, for the next installations DWHR, products with higher efficiency will be selected. This will allow comparing the relation between impact of investment costs and the running costs in this developing branch of hot water energy efficient solutions.

An additional pilot-installation of a Drain Water Heat Recovery unit was done in BEST 8 (NHT Hugo-Wolf Straße 4, 4th floor). A detailed measurement documenting a dynamic-efficiency of 41% was carried-out by UIBK (unit EEB). Based on the results of previous measurements a study on energy-saving solutions for domestic hot water (DHW) systems was carried out. This study compares various electrical-based domestic hot water systems in typical Sinfonia buildings in Innsbruck.

3 OPTIMISATION OF PV SELF-CONSUMPTION

3.1 OPTIMISATION OF PV SELF-CONSUMPTION

3.1.1 BASICS

From the analysis of the consumption and the changes to the previous years, it can be calculated – based on statistical assumptions – how high the shares of electrical energy in terms of lighting (luminous flux), other electrical equipment (heating, elevator, ventilation, ..) and normal consumption is.

Depending on these results, the department MUT in the IIG (Human, Environment, Technology) comes up with a proposal for a holistic reduction in consumption, which forms the basis for any project developments or investments made by IIG (E.g. replacing lighting with LED to reduce internal consumption and internal loads, installation of consumption-reducing pumps, units, etc., switching to laptops instead of stand-alone PCs, possibilities to increase the solar energy production).

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3.1.2 OPTIMIZATION OF PV-PLANTS AT MULTI RESIDENTIAL BUILDINGS

A possible solution for optimal consumption on the site may be to make the energy generated on the roof available to all tenants or to install metering points (energy supplier), so that as far as possible no surpluses need to be fed into the public power grid. However, the current legal framework allows only so-called "community production plants", which e.g. can be organized as a club or tenant electricity model in which the energy supplier (IKB) carries out the settlement of credits. In contrast to school buildings with only one user, the yields in multi-storey housing are to be divided among numerous parties and as a result, the ratio between roof area and users is very small. In principle, it is now possible to implement either a stationary or a dynamic distribution model. The big advantage of a dynamic model is the reduction of surplus feed-in, with the disadvantage that the principle of equality is violated, because parties with a higher electricity consumption are preferred. For this reason, static systems were installed at the facilities of the IIG with a fixed assignment of module to the apartment.

Future modern storage technologies can further improve the consumption on properties. The IIG facilities are prepared for this, but in our view the technologies are not yet well advanced. For this reason, they can be retrofitted in the future.

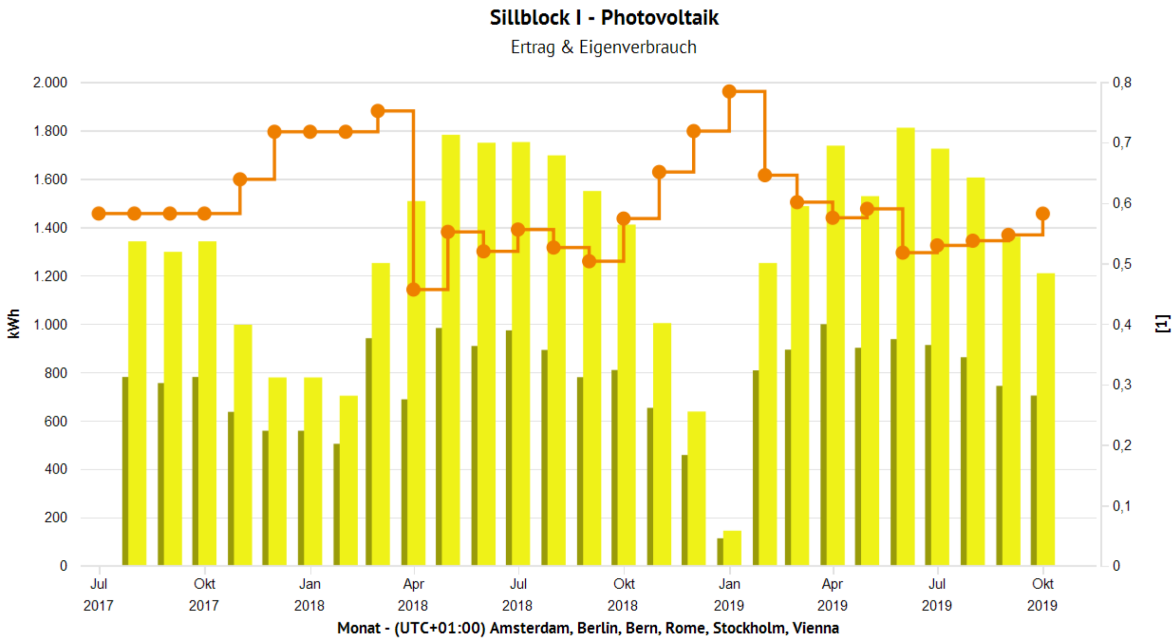

FIGURE 41: PV ANALYSIS SILLBLOCK – ENERGY YIELD (YELLOW) IN CONTRAST TO CONSUMPTION (DARK GREEN)

3.1.3 OPTIMISATION OF PV-PLANTS AT SCHOOL BUILDINGS

Once the basics have been clarified, planning and dimensioning (kWpeak) of the plant can be carried out. The main objective is to not unnecessarily burden the public network (through feeding in the surplus supply) and to obtain a maximum of self-consumption on the property. Outside the Sinfonia project, IIG also constructs and operates PV systems according to this basic strategy. The PV systems at secondary school O-Dorf or at IIG itself have an own consumption of up to 97%. It is possible to deviate from this strategy (reduction of surpluses), as long as there are technical possibilities to supply the electricity from the PV to other objects of IIG, for example to use in another close-by building. An example is the PV plant of VS Neuarzl, which currently has an own consumption of only 39% on average. However, up to 95% self-consumption can be expected due to the connection of the neighboring kindergarten Walderkammweg to the existing PV-plant.

4 PREFABRICATED TIMBER FAÇADE SYSTEM

To minimise the energy consumption of existing buildings the thermal modernisation plays a central role and will contribute to achieve the climate protection goals. An interesting alternative to conventional external thermal insulation composite systems (ETICS) offers a system solution consisting of mostly ecological and renewable materials.

Prefabricated façade systems in timber frame construction provide several advantages, as the high precision in prefabrication and assembly off-site and the short construction time on-site. Also the possibility to integrate windows, insulation, ventilation and solar modules into the façade elements and the fact that no scaffolding is needed illustrate further benefits of this renovation method. The main fields of application are especially schools and multi-storey residential buildings, where large scaled and repetitive elements are used. The concept of this renovation method is well described in the research project TES EnergyFaçade [1] and several objects in Germany, Austria and Switzerland were already refurbished using this renovation method.

New technologies have been developed at the University of Innsbruck (Unit of Timber Engineering) to get more competitive, such as the E.T. (ecological timber-framed) façade system and the SHERPA EFCON façade system connector.

Additionally, the fire behaviour of the prefabricated E.T. façade system, (including the façade connector) was investigated; it fulfils the fire protection requirements and is now fire classified according to European Standards. Therefore, its application up to a fire escape level of 22 m (building class 5) is possible in Austria.

Further fire tests were performed with an adapted prefabricated timber framed façade system to show that the façade can also be implemented on high-rise buildings in connection with a object specific, coherent fire protection concept.

Experiences made in Sinfonia and Expert Workshops show that there are still facts which lead to decisions of building promoters to use ETICS instead. The main reasons are costs and business as usual on one side, but also the lack of systematised solutions for different applications on the other side. Therefore, the Unit of Timber Engineering of the University of Innsbruck is developing systematised solutions for refurbishments with prefabricated timber framed façade elements.

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FIGURE 42: PREFABRICATED FAÇADE ELEMENT FOR THERMAL RENOVATION [2, 3] © FLACH, M; EIBL, R.

4.1 THE E.T. FAÇADE SYSTEM

Conventionally the cladding of prefabricated façade systems consists of a rear-ventilated façade. To reduce costs of the prefabricated façade system the E.T. façade system [4] is developed, where the amount of layers and the amount of work on-site is reduced to a minimum. It can be entirely prefabricated, including the external render system, allows a fast assembly on-site and its fire behaviour is classified.

The reduction of costs plays an essential role and is provided by

- scalability and replicability
- holistic prefabrication
- reduction of layers
- simple structure
- systematised joint details
- systematised fixation possibilities
- fast and easy assembly
- classified fire behaviour
- disassembly and exchange
- easy recycling

The E.T. façade system consists of timber framed elements with a non-rear-ventilated external render-baseboard and an external render system and is entirely prefabricated. Two typical wall structures of the façade are shown in Figure 43, a rear-closed (a) and a rear-open element (b).

The adaption layer of the rear-closed element consists of a ductile insulation material, which is fixed on the rear panel in prefabrication or a blow-in insulation, which is filled on-site. The blowing-in procedure of the cellulose can be done storey-wise according to the mounting process or by the window sills and reveals. To reduce costs and layers and also for building physic reasons it is possible to omit the rear panel.

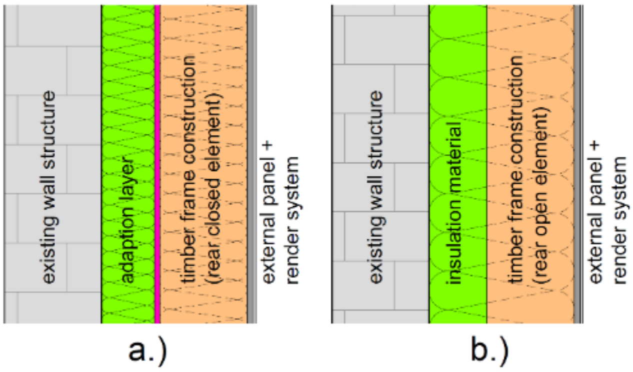

FIGURE 43: TYPICAL WALL STRUCTURES OF THE E.T. FAÇADE SYSTEM, (A) REAR-CLOSED ELEMENT, (B) REAR-OPEN ELEMENT [4] © LE LEVÉ, C.

For an easy and fast mounting process special joint solution are developed. These vertical and horizontal joints have to provide waterproofness, transmission of loads, absorption of expansions and fire safety. In general, the horizontal joint is placed in the area of the ceiling, but can also be placed corresponding to the building geometry and architectural wishes.
The horizontal joint, which consists of a tongue and groove system, provides the transmission of horizontal loads between the upper and lower façade element. For fire safety reasons the joint is backed by an incombustible panel. An additional horizontal board provides a horizontal fire separation between the elements. The waterproofness is achieved by sliding joint profiles, which are developed for this application by using standard profiles, modified profiles and watertight seals (Figure 44).

FIGURE 44: SAMPLE OF E.T. FAÇADE SYSTEM (LEFT) AND HORIZONTAL JOINT DETAIL (RIGHT) [4] © BADERGRUBER, T.; LE LEVÉ, C.

4.2 FIRE SAFETY

The E.T. façade system consists of ecological and renewable but combustible materials. So the fire safety plays an important role. The Unit of Timber Engineering performed in collaboration with IBS (Institut für Brandschutztechnik und Sicherheitsforschung) in Linz several fire behaviour and fire resistance tests to proof the fire safety of the prefabricated façade system (Figure 45). The fire

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behaviour of the E.T. façade system is now classified and allows its application on buildings of class 4 and 5 up to a fire escape level of 22 m as a standardised system using renewable materials.

FIGURE 45: FIRE BEHAVIOUR AND FIRE RESISTANCE TESTS TO PROOF THE FIRE SAFETY OF PREFABRICATED FACADE ELEMENTS [4, 5] © BADERGRUBER, T.; LE LEVÉ, C.

Further fire tests were performed with an adapted prefabricated façade system to show that prefabricated timber framed façade elements can also be implemented on high-rise buildings. In this case mineral wool was used as insulation material and the external layer of the timber frame construction consist of gypsum fibre boards. And the rear ventilated cladding system has to be approved for high-rise buildings [5].
Further information about fire tests and classification reports can be obtained at the Unit of Timber Engineering of the University of Innsbruck.

4.3 THE FACADE SYSTEM CONNECTOR

The facade elements are self-supporting and can be mounted on the existing building in different ways. Depending on the building structure and materials the element might be storey wise hanging on the substructure or standing at the bottom or is storey wise standing. Building geometry plays an important role on the application of the façade elements. It influences the choice of the orientation (horizontally or vertically) as well as the possibilities of fixation. Especially the roof, the balcony, the openings of the building and the building foundation play a central criterion.
The "SHERPA EFCON" Façade-System-Connector is developed at the Unit of Timber Engineering of the University of Innsbruck to get a standardized and multifunctional mounting system (Figure 46) [3]. The company Vinzenz Harrer GmbH has recently included the connector in its product portfolio.

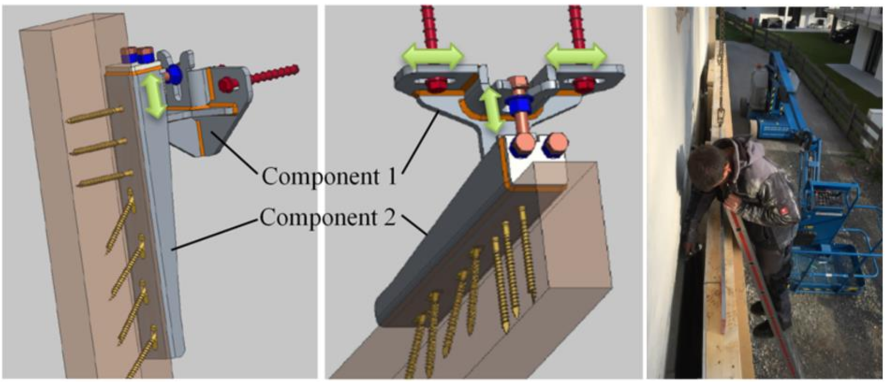

FIGURE 46: THE SHERPA EFCON FAÇADE-SYSTEM-CONNECTOR [2, 3] © LE LEVÉ, C.; FLACH, M.

An important factor is the possibility to lead vertical and horizontal loads storey wise in the existing building, so that at the bottom no concentrated load introduction occurs. Thereby the application of prefabricated façade elements gets more flexible. A central role plays the accessibility of the connector during assembly. Its position on the upper part of the façade element and a detailed consideration of dimensions allow the handling from the top of the respective element (Figure 5, right). It is fixed on the reinforced concrete floor slab, pillars or masonry walls with concrete screws or injectable adhesive anchors. It is able to absorb tolerances in all three directions to compensate an uneven existing wall, inaccuracies in building survey or in prefabrication as well. The most essential requirements of the connector are listed in the following itemisation:

- Fast and easy assembly
- Absorption of tolerances in all directions
- Bearing of vertical and horizontal loads
- Accessibility
- For different building types and materials
- Multifunctional application
- Avoidance of thermal bridges
- Systematised solution leads to cost reduction

4.4 PREFABRICATED FACADE SYSTEMS IN SINFONIA

Within the framework of SINFONIA it was planned to refurbish selected objects with prefabricated facade systems. Unfortunately, for the reasons already mentioned above, this did not happen. The main reasons were costs and business as usual on one side, but also the lack of systematised solutions for different applications on the other side. Also, the fire safety played a central criterion. At the beginning of the Sinfonia project, the use of prefabricated façades was considered for the following objects in Innsbruck:

- IIG: Sillblock 1, SchuMo, Volksschule Angergasse
- NHT: IN 27, IN 40, IN 42, IN 43

The Unit of Timber Engineering of the University of Innsbruck offered following systemized solutions, services and consultations:

- Digital Building Survey
- Thermography
- Blower Door Measurements

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- Fire Safety solutions for mid-rise buildings (Building class 4 and 5)
- Fire Safety solutions for high-rise buildings
- Mounting Systems
- Prefabricated Façade Systems
- Life Cycle Assessment (LCA)
- Detail solutions and detailed plans

As an example, rule details, which were developed for the object IN27, are presented below. In contrast to the E.T. façade system, a non-combustible insulation is used for the high-rise building sector. In IN27 a rear-ventilated façade was desired. A multi-layer planking made of gypsum fibre boards is chosen to protect the timber frame construction. In the extensive final report about prefabricated timber façade systems, additionally detail solutions are presented for junction, mounting, windows and how to realize prefabricated concrete balcony elements by providing disability access with prefabricated façade elements.

The wall construction, shown in Figure 47, consists of following layers (from inside to outside):

33 cm	Building stock („Isospan“ concrete blocks, inner- and outer render- system)
5 cm	leveling layer: mineral wool
1,5 cm	rear planking: gypsum fibre board
16 cm	timber frame construction with mineral wool
3 cm	front planking: two layers of gypsum fibre boards
2-5 cm	ventilation gap
0,5-1 cm	rear-ventilated facade for high rise buildings

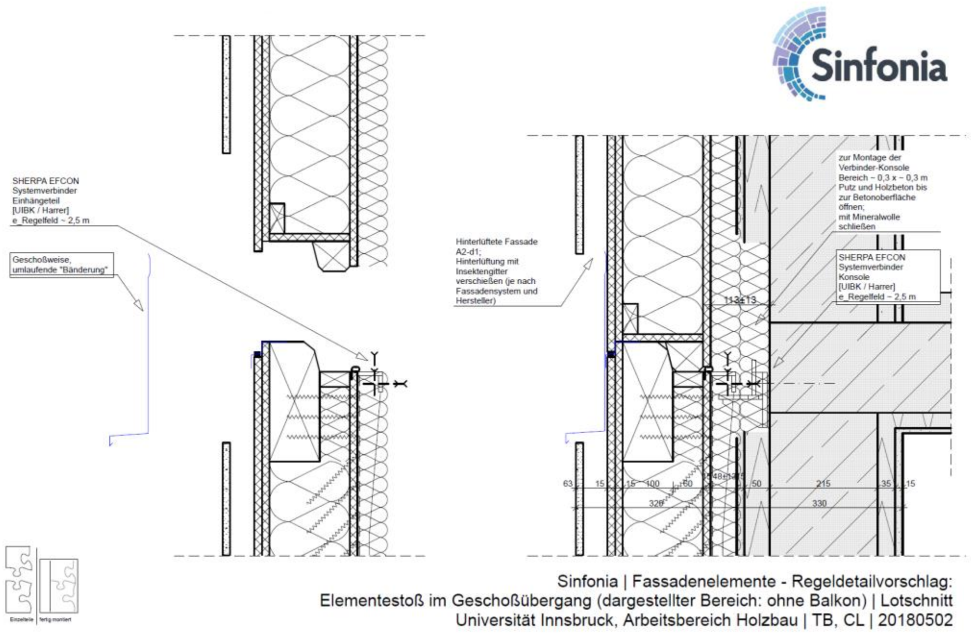

FIGURE 47: VERTICAL SECTION OF PREFABRICATED WALL DURING ASSEMBLY AN MOUNTED [5] © BADERGRUBER T.; LE LEVÉ, C.

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5 CONCLUSIONS

5.1 CONCLUSIONS FROM SINFONIA-REFURBISHMENTS

The developers and real estate companies in the city of Innsbruck (NHT and IIG) have different framework conditions in their building stock, which are decisive for the choice of concrete measures and concepts. For this reason, the experiences are shown separately, divided into IIG and NHT.

The underlying basis and foundation for the implementation of high-quality refurbishments in Innsbruck are the energy strategies of the city of Innsbruck and the state of Tyrol on a higher level.

The currently available energy scenarios for Tyrol – "Tirol 2050 energieautonom" – show that the focused target of minus 50% final energy use by 2050 cannot be achieved. The current forecasts indicate that, assuming a very hard but feasible scenario, a reduction of about 38% final energy use can be achieved. Nevertheless, it is assumed that 100% of the remaining final energy use can be covered by renewable energies from hydropower and photovoltaics.

The particular challenge in the building sector is that it continues to be included in the forecast with its maximum possible contribution in terms of raising energy efficiency. In the currently available energy scenarios 2019, it is already foreseeable that the “EnerPHit” Passive House refurbishment standard will be considered as the target for the refurbishment rate of 1.33%. This has already been accounted for in the most recent studies by the state of Tyrol.

What is the “EnerPHit” Passive House refurbishment standard?

Overall or partial refurbishment or modernisation are perfect opportunities to reduce the energy consumption of these buildings quite significantly by applying appropriate building services and using components developed for new Passive Houses. These allows for significant energy savings in existing buildings.

“EnerPHit” is now the established standard for refurbishment of existing buildings using Passive House components and a ventilation system including heat recovery. Despite the slightly higher energy demand, it offers virtually all the advantages of the newly built Passive House standard. Different qualities of “EnerPHit” classes can be achieved depending on the use of renewable energy sources. Step-by-step retrofits can also achieve “EnerPHit” standard with the help of an “EnerPHit Retrofit Plan”.

Within Sinfonia, all buildings in Innsbruck were refurbished in EnerPhit standard.

5.1.1 CONCLUSION AND RECOMMENDATIONS OF PROJECT PARTNER IIG

The structural solutions, results and concepts within the Sinfonia project can be separated by IIG into the two areas or spheres of school buildings and residential buildings. These have different framework conditions and clearly show where the limits of renovations are in the building stock. Therefore, we will divide them into residential buildings and school buildings.

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5.1.1.1 RESIDENTIAL BUILDINGS

GENERAL LEGAL REQUIREMENTS

Since 2012, IIG has been constructing and leasing only passive houses in the area of the new buildings. In the significantly larger existing building stock, the IIG has so far implemented only a few ventilation systems.

For the implementation of construction measures, the IIG requires 100% approval from the tenants for general measures. From this regulation only measures necessary for the preservation of the building, such as window exchange, door exchange or roof renovation, are excluded.

This consent by the tenants must also be available for applying for public funding (for example KPC /municipal credit public consulting) or self-declaration to retrofit the construction measures to the submitted status in case of change of tenants for housing subsidies (Wohnbauförderung).

TECHNICAL ASPECTS

A quality assurance procedure with surveys on the building stock (EnerPHit, analysis of the stock to electrotechnical system, use of fireplaces, any own contribution of the tenants, detailed use of the apartment and the common areas by our tenants, …) ensures the planned investment can be implemented and meets the planned cost-benefit ratio.

Ventilation systems:

A recurrent first question in relation to the ventilation system is the comparison of decentralized to centralized solution with the potentials and possibilities. Every variant has advantages and disadvantages. The big advantage of the central solution lies in the simple handling of the filter exchange by our janitor and the technical room.

In the decentralized solution, the filters are provided to the tenants for self-exchange. The error susceptibility is higher than with the central solution.

A big piece of work is to explain the advantages of the ventilation system to the inhabitants. The most common fears are still: the ventilation system consumes too much electricity; I cannot open windows anymore; I do not need that; ventilation makes you sick,…

SOCIAL ASPECTS

A questionnaire before starting the planning process is required to consider as much as possible of the improvements to the general parts of the building. These can be: room and outdoor space for drying the laundry, which tenants need disability access (elevator, light bells for deaf people, blind control system, bell system with the possibility to upgrade inductive hearing aid), bulletin board, standard inhabitant number of the apartment, …

In several organized meetings with the tenants, we explained the main topics of the refurbishment and informed the tenants about necessary approvals/consent for the renovation.

Consent is necessary for:

- Deconstruction of the loggia and conversion into living space.
- Assumption of the pro rata operating cost of the elevator.

- Construction of the ventilation system.
- Consent to the data collection (monitoring) of the apartment, stating which data has to be drawn for how long and which project partner has access to this data.
- Approval to the energy supplier (IKB) for the construction of the PV system, the feed-in of surplus electricity into the grid and the offsetting of the credits by the energy supplier …

For many of our tenants, the complex interrelationships (legal regulations) were difficult to comprehend, so that in innumerable individual discussions each tenant had to be informed about the pros and cons.

The main topics are:

- Information and meetings to/with the tenants
- Individual meetings in the flats
- Demo flats with ventilation system, new windows, new doors,…
- Office hours during the renovation time
- Celebrations with the tenants (First celebration, handover ceremony,…)

ECONOMIC ASPECTS

Refurbishment in social housing in Austria can only be achieved with the support of subsidies and the will of the IIG to introduce these existing buildings to the EnerPHit standard. The owner's capital benefit is enormous and serves to extend the useful life and endeavor to minimize future energy consumption for residential use and significantly increase the share of renewable energy sources. With the currently low energy prices, an economic presentation of the renovation is not yet feasible.

5.1.1.2 SCHOOL BUILDINGS

GENERAL LEGAL REQUIREMENTS

In contrast to the residential buildings, the IIG rents the entire building to the city of Innsbruck. Thus, the clarifications and necessary approvals are much easier to handle and only the general legal framework conditions to consider.

TECHNICAL ASPECTS

As part of the Sinfonia project, three school locations were renovated to a state-of-the-art technology standard. Grade II listed buildings are also characteristic of the building stock of the city of Innsbruck, which has grown over the centuries. For this reason, the IIG was particularly interested in taking the Siegmairschule (Best 17) as an example of a listed school (cultural heritage) into the Sinfonia project. The main topics of the refurbishment are the surveys on the building stock, special uses, the pedagogical concept of the school and quality assurance by defining the responsible departments of the IIG. These foundations were brought together in the best possible way in the course of the project development and developed into a conclusive overall concept for the location.

SOCIAL ASPECTS

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The construction work is carried out by IIG with the emphasis on the holiday periods in the summer, subordinate and early measures may be carried out in consultation with the school's head office, if school operation is still possible. Refurbishments can only be carried out in excellent coordination with the school management and the teachers.
Questionnaires in schools were also given to the teachers and pupils before and after the renovation. The results indicate no significant improvement or deterioration of the conditions in the classroom. However, we regard this as a very positive sign because commissioning of the installed ventilation systems (prior to the Sinfonia program) was associated with great resistance, especially among the teachers. Frequent feedback was: "there is a draught" and "the air is too dry".

ECONOMIC ASPECTS

Within the project Sinfonia, IIG's efforts in terms of quality assurance (accessibility, energy efficiency improvements, utilization improvements, increase of renewable energy, reduction of energy consumption, evaluation and – if necessary – change of energy source, building control technology) have been updated and the findings used as the basis for the future renovations. Economic considerations are partially superimposed by so-called higher-level goals such as the "Innsbruck Energy Development Plan", "Tyrol 2050", ... Sinfonia can be understood as an essential and important component of this development.

5.1.2 CONCLUSION AND RECOMMENDATIONS OF PROJECT PARTNER NHT

The results and findings within the Sinfonia project - on the part of the NHT - are multi-layered. Therefore, we will divide them into:

- General Legal requirements,
- technical aspects,
- social tasks,
- economic aspects and findings.

GENERAL LEGAL REQUIREMENTS

The special law for social housing, is the so called "WGG" Wohnungsgemeinnützigkeitsgesetz. This includes a few details which are very relevant concerning the refurbishment of rental housing. The most important factor is, that the NHT needs the approval of at least 75% of the residents. This means that 75 % of the tenants have to be convinced, that the renovation can start legally.
If the tenant's consent is missing, there is only one way to go to the court. This is the so called "Schlichtungsstellenverfahren". It should be noted that this process usually takes a very long time and can last for years.

TECHNICAL ASPECTS

"EnerPHit" Passive House refurbishment as NHT standard for refurbishment:

Looking back on the performed Sinfonia refurbishment of the NHT, we can draw the following conclusions: Quality assurance procedures and refurbishment plans are the basis for every project.

We learnt a lot, from the know-how of the partners e.g. PASSIVHAUS INSTITUT, UNIVERSITIY OF INNSBRUCK and so on.

The ”EnerPHit” Standard is the desired standard for the NHT refurbishment actions for the future.

The “EnerPHit Retrofit Plan” was base of the Sinfonia refurbishment of IN28 (BEST 011) with the following results:

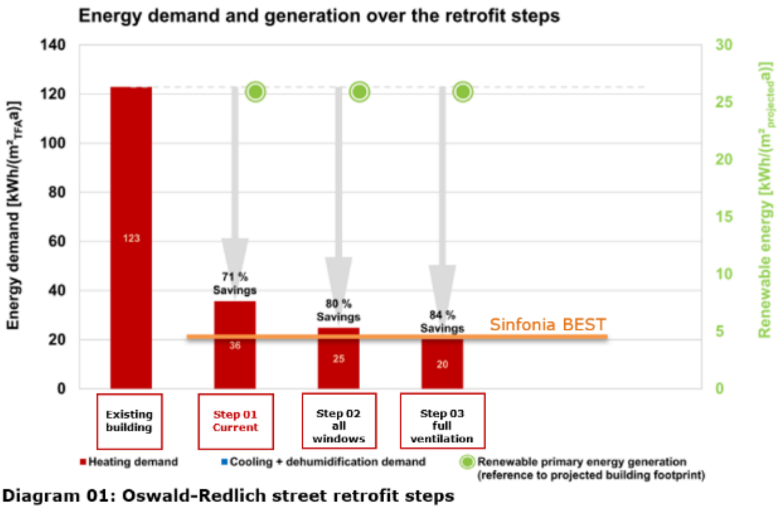

FIGURE 48: IN 28 – BINDING AGREED ENERPHIT RETROFIT PLAN OSWALD-REDLICH STREET

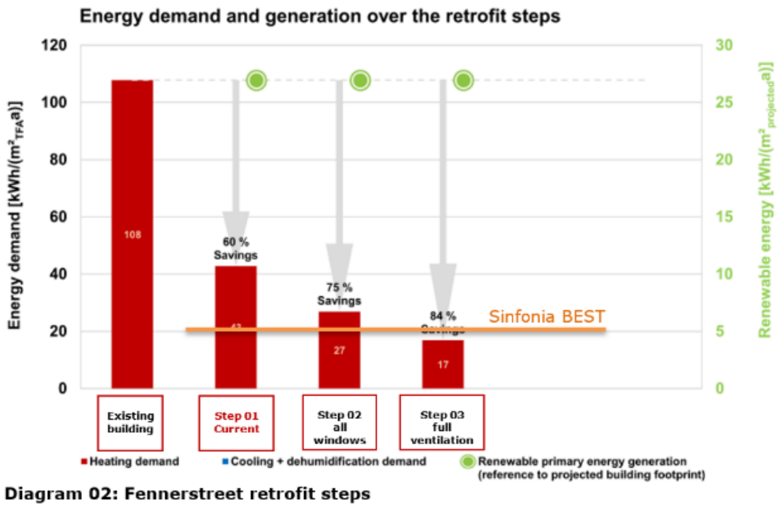

FIGURE 49: IN 28 – BINDING AGREED ENERPHIT RETROFIT PLAN FENNERSTREET

The integration of the “EnerPHit Retrofit Plan” into the usual workflow of NEUE HEIMAT TIROL is an ongoing process (throughout all steps of refurbishment), and we continue to value our activities as a learning organization.

Integration of ventilation systems within existing and inhabitated residential buildings:

Within Sinfonia project the NEUE HEIMAT TIROL has done six individual residential refurbishment projects, which ends up in nearly six different designs of subsequent integration of ventilation systems.

First, we tried to implement ventilation systems as if we know it from our 10 years of expertise doing this in new built passive houses.

This “**usual way**” is described in the following sequence of pictures:

- The central ventilation unit is installed in the cold attic (left), exhaust and fresh air is delivered through pipes penetrating the roof skin at a short way (middle), the central ventilation distribution is located in the corners of the staircase (right)

FIGURE 50: CENTRAL VENTITILATION UNIT (LEFT), PIPES PENETRATING THE ROOF SKIN (MIDDLE), CENTRAL VENTILATION DISTRIBUTION (RIGHT)

- Extended cascade ventilation principle is used in the apartments

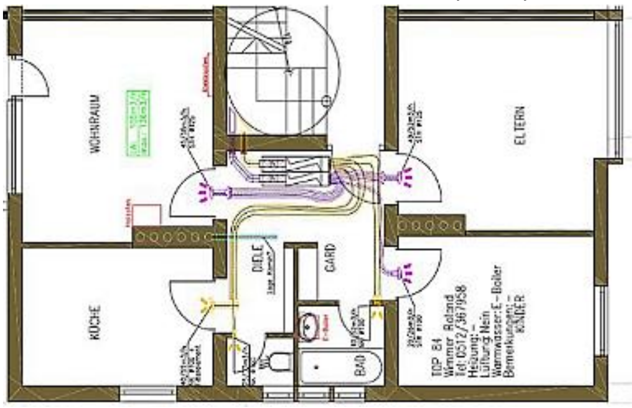

FIGURE 51: CASCADE VENTILATION

- This means a large structural intervention within the apartments:

1. The masonry must be pierced several times to connect the pipes to the rooms
2. A box combining distribution, sound attenuation and volume control is mounted on the sealing of anteroom
3. The suspended ceiling has to be installed underneath the box and the pipes
4. Finishing work wall painting, lighting, service covers and vent valves are installed

FIGURE 52: STRUCTURAL INTERVENTIONS PART 1

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FIGURE 53: STRUCTURAL INTERVENTIONS PART 2

FIGURE 54: STRUCTURAL INTERVENTIONS PART 3

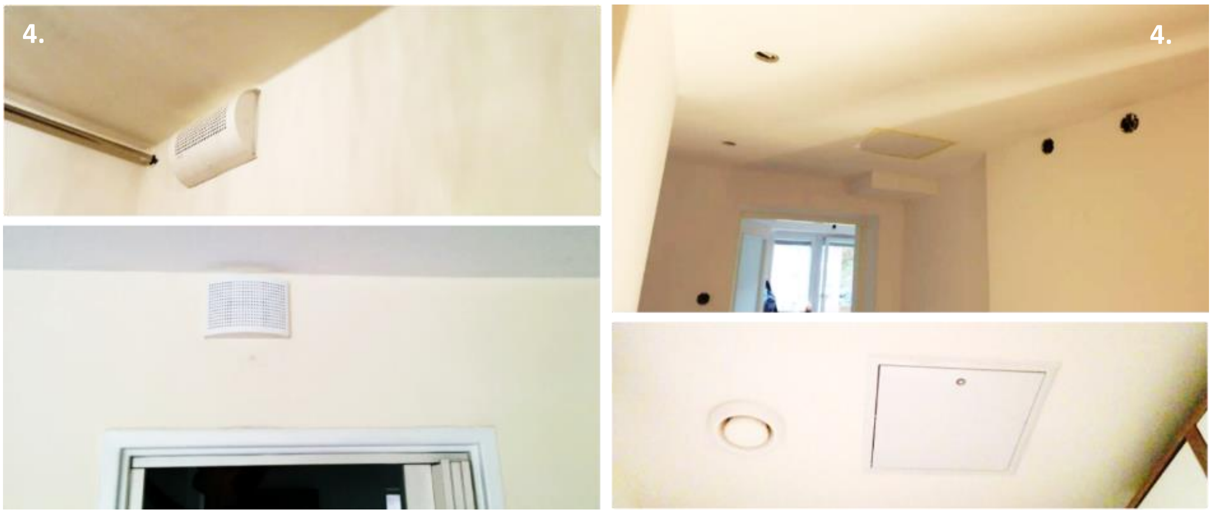

FIGURE 55: STRUCTURAL INTERVENTIONS PART 4

While this kind of integration of ventilation system is state of the art and fully convincing in terms of technology it is hard to accept by the tenants because of high noise and dust pollution while integration in inhabited state of the flat. Therefore, we only gained 10 – 20% of individual agreement of every tenant for these changes inside the flat.

Learning that at the first Sinfonia refurbishment BEST 011, at the end, we realized **five different kinds of integration of ventilation system in our six Sinfonia refurbishments.**

Our **conclusion and recommendation** for the most tenant acceptable, because of less possible intrusion, kind of integration of ventilation system is the realized system in BEST 012, our last Sinfonia refurbishment.

This “**lessons learned way**” is described in the following sequence of pictures:

- The central ventilation unit is located in the warm attic. It could also be placed on a flat roof outside the thermal shell but in that case, it has to be situated preferable directly above the central distribution.
- The central distribution system is realized within the insulation layer of the facade. The air distribution from central ventilation unit to each apartment is provided via separate tubes per room, installed vertically and horizontally within the insulated layer of the façade. This kind of air distribution is brand new and highly innovative. It was designed in order to minimize the work within the flats due to minimal disturbance of tenants while installation.

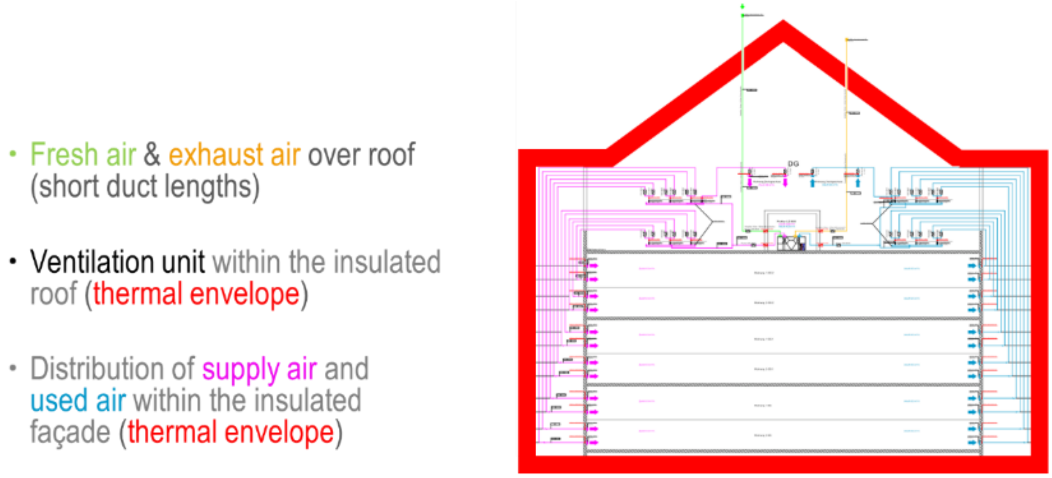

FIGURE 56: VENTILATION SCHEME OF BEST 12

FIGURE 57: BEST 12 – 3 STEPS OF INTEGRATION OF ROOM WISE AIR DISTRIBUTION INTO THE THERMAL SHELL

- Distribution of air within an apartment is designed according to the “extended cascade-ventilation principle”. The fresh air is only provided to the bedrooms. The air is extracted from the kitchen and bathroom. The corridor and living room serves as a transition zone. Thus, it was only necessary to drilling masonry at the same time the windows were changed. Minimal disturbance of tenants while installation was the consequence.

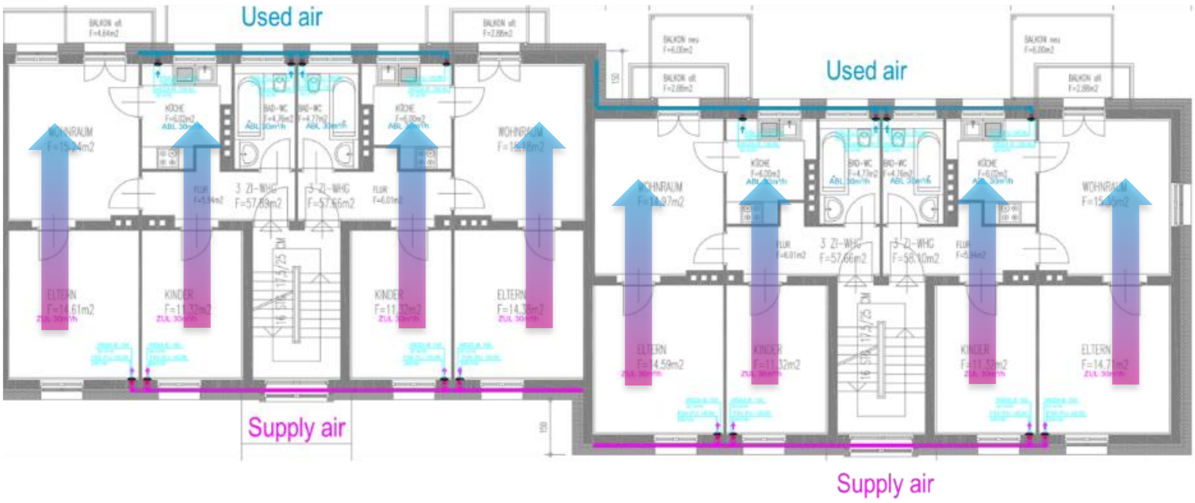

FIGURE 58: DISTRIBUTION OF AIR AS EXTENDED CASCADE-VENTILATION PRINCIPLE

This kind of installation was highly accepted by the tenants, so 68 of 84 apartments (81%) could be immediately connected to the central comfort ventilation system.

Customer involvement and customer agreement:

To explain customers their individual benefits and convince them for the installation of the ventilation, in an existing apartment, is still hard work. In the case of a change of tenants, all apartments are equipped with the comfort ventilation. Different variants are implemented; this means very individual inventory of the apartments can be a challenge for the installation. We also need according the Austrian law (Mietrechtsgesetz) the individual agreement of every tenant for changes inside the flat.

Legal requirements PV system:

One of the big challenges was the inadequate capability of carrying of the roof, for the installation of the PV – especially at IN 3, IN 28, IN 43. (New legal requirements regarding statics – so called Eurocodes). The NHT invested here in the future of residential buildings, with the stabilization of the roof structures, according to the latest legal requirements.

SOCIAL ASPECTS

We have still enormous problems with the tenants to convince them from the advantages of the refurbishment. They have more payments for at least 10 years. Since the change of the law (Wohnungsgemeinnützigkeitsgesetz) in the year 2017 – the period was grown up to 20 years now. To convince our tenants investing their money in climate protection is still a hurdle in our day-to-day work. The individual benefits for the residents must be explained in detail. They save money at the heating costs, gain in living comfort, improved air quality in the apartments and so on, to explain the advantages takes time and need the right words for the residents.

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"We cannot live only for ourselves. A thousand fibers connect us with our fellow men."
Herman Melville (US-autor 1819-1891)

Resident involvement:
In the course of the project in particular insights were gained in the field of inhabitant involvement. During the learning process within the Sinfonia project, insights and important findings were immediately used in the next project and, in some cases, optimized.

Proven approach:
First of all, we organized individual meetings with all our tenants, about 1 month later we had a workshop (externally moderated) with all the tenants together. After that they had the possibility to visit and inspect a renovated apartment with built-in ventilation. Thereafter, all apartments were visited individually to explore the circumstances. This action requires a lot of time but was necessary and very useful for the whole refurbishment process. During the renovation phase, we had weekly office hours at the construction site to give our tenants the possibility to get first hand answers.
One of the very important aspect is: all the tenants need to know, who is my contact partner during the restructuring phase.
After completion of the building renovation, a meeting with the tenants takes place. This final event is of particular importance. On the one hand, any wishes or remaining work can be reported, on the other hand, a concrete act to end the rehabilitation is set.

The main topics are:

- Meeting with the tenants
- Individual visits in the flats
- Demo flats with ventilation systems
- Weekly office hours for the tenants – while the renovation time
- Meeting at the end of the refurbishment

ECONOMIC ASPECTS
The renovation of buildings, especially in the context of social housing in Austria, can only be achieved with the support of subsidies. The Sinfonia EU funding has enabled innovative renovation to passive house standard. The detailed financial aspects were analszed in detail for the buildings of the NHT, this was commissioned under the auspices of Standortagentur Tirol. It should be mentioned that 95% of domestic/in the region situated companies were commissioned to renovate the buildings.

Within the 6 years of the Sinfonia Project, we had the possibility to get in a close contact with our tenants. So we also conducted surveys – before we started the refurbishment and afterwards. Of course, these aspects and results also have economic consequences in the future.

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All in all, we got 309 questionnaires back. With alpS – a very competent and reliable partner within the Sinfonia project – we learned a lot about the fears of our residents.
We are very proud about the fact, that the understanding and the sensitivity of the residents in relation to the factor energy saving, could be increased, while the period - before or after the renovation.

Importance of saving energy in everyday life:

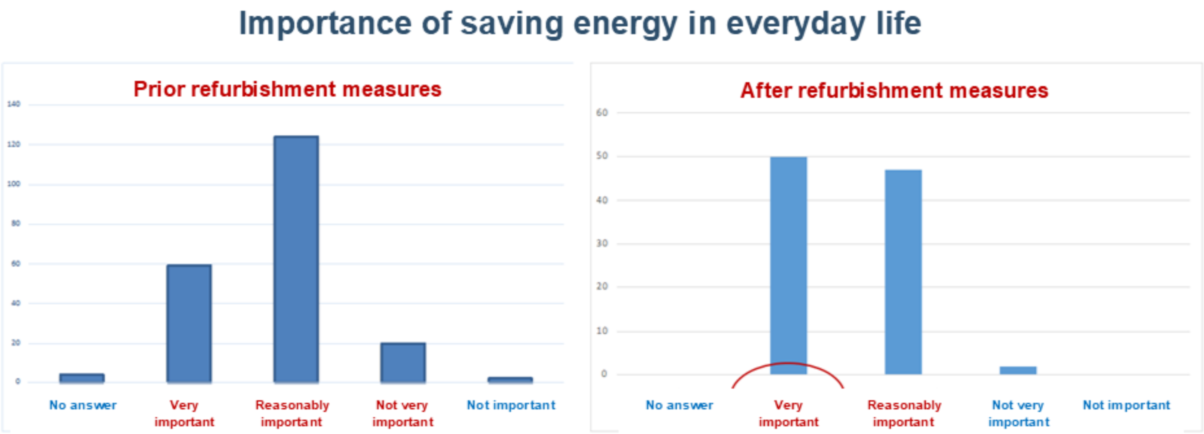

FIGURE 59: RESULT OF SURVEY BEFORE AND AFTER REFURBISHMENT

Particularly pleasing is the factor that the customer regards the energy savings after the refurbishment as an even more important factor, as before the refurbishment.
Sinfonia effect within the NHT:
The NHT fixed an important strategic direction, regarding the quality of future renovations. The NHT will do their next refurbishments in the same quality like the Sinfonia projects. We learnt a lot and we are sure, that we can learn a lot in the future and improve our experience in the field of passive house renovation.
In addition, it should be mentioned, that since 2012 the NHT has been constructing new buildings in passive house quality. With the project Sinfonia we started to renovate buildings in passive house quality – the so called EnerPhit Standard.
The NHT - we are convinced, that this is the right way and the only sustainable way into the future.

5.2 CONCLUSIONS DRAIN WATER HEAT REOVERY

For future DWHR installations, products with higher efficiency will be selected. This will allow comparing the relation between impact of investment costs and the running costs in this developing branch of hot water energy efficient solutions.
Based on the experiences in SINFONIA, the UIBK (Unit EEB) starts a new spin-off project "SOPHIE - smart shower" in December 2019. The aim of the project is to develop a decentralised wall-integrated shower unit with active heat recovery that operates independently of the existing central hot water system. This stand-alone unit will be quick and easy to install without encountering the difficulties of integrating the DWHR system into a renovated building.

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5.3 CONCLUSIONS OPTIMIZATION OF PV SELF-CONSUMPTION

The basis for any PV project development is a holistic analyzation of electricity reduction potentials, e.g. replacing light bulbs with LED, installing consumption-reducing pumps, units, etc. Then the possibilities to increase the solar energy production are studied, the legal framework has a big effect on this aspect.

5.4 CONCLUSIONS PREFABRICATED TIMBER FACADE

A standardised solution for thermal refurbishments with ecological prefabricated façade systems is developed in order to reduce the construction time, the disturbance of inhabitants and costs. For a wide range of application possibilities up to mid-rise buildings the fire behaviour of the E.T. façade system is classified. Thereby it is permitted to use variable products for external and internal panels, render systems or insulation, so it is not depending on individual producers.

Further investigations on fire safety shall contribute to use prefabricated façade systems even on high-rise buildings.

The presented details allow the prefabrication of the entire façade element, even including the external render system and require no additional work on-site or scaffolding. In combination with the SHERPA EFCON Façade System Connector a fast and easy, modular construction system is ensured. The assembly on-site of the prefabricated, pre-rendered and integrated elements can be done in few days. An implemented refurbishment project, which was not part of Sinfonia, offered the opportunity to attempt, analyse and demonstrate the newest developments and to prove the user-friendly feasibility.

6 LITERATURE

[1] Ott, S.; Kaufmann, H.; Winter, S.; Lattke, F.: TES EnergyFaçade prefabricated timber based building system for improving the energy efficiency of the building envelope, final report. München, 2010.

[2] Le Levé, C.; Badergruber, T.; Flach, M.: Ökologisch sanieren mit einem neuen Fassadensystem am Beispiel des Mayrhofs in Trins. In: Passivhaustagung 2018. München, 2018.

[3] Le Levé, C.; Badergruber, T.; Kraler, A.; Flach, M.: Neue Wege in der thermischen Fassadensanierung und ein Systemverbinder zur schnellen und einfachen Montage. In: Bauingenieur 93 (2018), Ausgabe 7/8-2018. Springer VDI Verlag, Düsseldorf 2018.

[4] Le Levé, C.; Badergruber, T.; Kraler, A.; Flach, M.: Ökologisches Sanieren mit verputzten, vorgefertigten Fassadenelementen in der Gebäudeklasse 5 mit mehr als 6 Vollgeschoßen. Endbericht, Innsbruck 2016.

[5] Le Levé, C.; Badergruber, T.; Kraler, A.; Flach, M.: Vorgefertigte Fassadensysteme in Holzbauweise bei einem Fluchtniveau von mehr als 22 m. Endbericht, Innsbruck 2018.

[6] Bürschgens, A. (2016). Legionellen in Trinkwasser-Installationen: Gefährdungsanalyse und Sanierung. Berlin: Deutsches Institut für Normung.

[7] Exner, M. (20. Oktober 2009). Hygiene in Trinkwasser-Installationen - Erfahrungen aus Deutschland. Legionellen-Fachgespräch UBA/BfR. Berlin.

[8] Kisteman, T., Schulte, W., Rudat, K., Hentschel, W., & Häußermann, D. (2012). Gebäudetechnik für Trinkwasser. Springer Vieweg.

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Annex: DOCUMENT INFORMATION

SINFONIA DELIVERABLE FACT SHEET		
PROJECT START DATE	1 June 2014	
PROJECT DURATION	60 months	
PROJECT WEBSITE	http://www.sinfonia-smartcities.eu	
DOCUMENT		
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DUE DATE OF DELIVERABLE:	10/2019	
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AUTHORS:	NHT (4), UIBK (5), IIG (25)	
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CO (CONFIDENTIAL, ONLY FOR MEMBERS OF THE CONSORTIUM INCLUDING THE COMMISSION SERVICES)		
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