Façade integrated heat and cold dissipation system in a multifamily residential building - Vienna

The EXCESS replication plans aim to identify suitable replication cases and provide a structured approach for replicating EXCESS PEB solutions. The plans include technical details and business models as well as regulatory and social aspects of specific replication cases. The EXCESS demo building in Graz uses a multifunctional façade element that includes integrated energy producing active elements (PV), insulation and activation elements for the use of existing facades as heat/cold storage and heat dissipation system. The proper operation of this multifunctional façade element and the replication of this solution on other buildings requires the fulfillment of following replication criteria.

<u>Plain wall:</u> The building must have a plain wall to ensure a proper thermal connection between the wall heating element of the multifunctional façade and the existing wall of the building. This means that buildings with a structured façade (mainly buildings before 1945) cannot be equipped with this façade elements. Furthermore, the building must not have monument protection of the façade, as the elements completely cover the existing walls of the building.

<u>High U-value:</u> The U-value of the existing wall must be higher than ~1 W/mK as lower U-values cannot ensure sufficient heat conduction from the wall heating system to the building's interior spaces. This criterion therefore excludes most of the buildings built after 1990 as the walls of those buildings already have better insulation and therefore lower U-values.

<u>Heating supply after renovation:</u> As the renovated buildings will be only heated with the active wall heating part of the façade element, the heat energy demand after renovation must be below a certain limit. This limit is defined based on existing wall insulation level, ratio between façade area and useful floor area as well as the heat energy demand.

The present replication plan outlines a replication case in the city of Vienna, which is the capital and most populous city of Austria with just over two million inhabitants. The replication case is located close to the city center and quite typical for about 25% of the Viennese building stock. The building is owned and managed by the Sozialbau AG limited profit housing association.

As one of the largest limited profit housing associations in the country, Sozialbau AG plays a central role in providing high-quality and affordable housing for a wide range of income groups. The building is also a demo case of the national flagship project "RENVELOPE – Energy Adaptive Shell", which is funded by the program Vorzeigeregion Energy – Green Energy Lab of the Austrian Climate and Energy Fund and the KPC (Kommunal Kredit Public Consulting).

Table of Contents

1 Baseline assessment of the implementation environment

1.1 Building description

The residential building owned by the Sozialbau AG, located in Vienna was built in 1977. The building contains 23 apartments on a floor space of 1,573m² and is supplied with decentralised gas heating systems. This form of energy supply is typical, especially for a very high number of buildings in Austria and Vienna. Estimates by the Wien Energie, the largest energy (and gas) supplier in Austria, range from 450.000 to 500.000 decentralised gas boilers still being used in the city. These decentralised solutions make the overall refurbishment of a building energy system highly complex (technical and social challenges) and require well thought out solutions to reach a total decarbonisation of the energy supply.

The 7-storey building has a non-insulated concrete structure and a resulting primary energy demand of 205 kWh/m²y. The building should be renovated and transformed to PEB standard to achieve CO2 neutrality. Prefabricated modular panels will be installed with minimal disruption to building occupants. The modular façade will include all elements necessary to deliver complete façade integrated heating and cooling to each flat providing high comfort of radiant heating from exterior walls. Electric Heat Pumps will be used to generate hot and chilled water at low temperature levels supplied to the piping within the envelope. The heating demand of the building can be reduced from **179.691 kWh/a** through around 80 % with targeted energy measures to an average of **35.938 kWh/a** by the serial renovation package. The natural gas consumption can be reduced to zero by switching to a ground source heat pump supply. The existing gas boilers will be fully replaced by heat pumps. The heat supply system will be changed primarily to external concrete activation via the façade, which is integrated in the prefabricated modules. Through building integrated PV and energy flexible operation, the electricity demand from the higher-level grid can be reduced by 25%. On the building, two axes of simple windows are framed in vertical wall panels that extend from the first floor to the roof. Two recessed axes of wide windows in between create horizontal accents. One of the requirements from the building owner was that the existing windows need to remain in place during the refurbishment since they were renewed in 2020.

Figure 1: View of the existing building from south-west (left) and 3D rendering of the finished building with new façade structure form the same angle (right). Source: Nussmüller Architekten, Austria.

Figure 2: Schematic of the panels including layer for heating and cooling (left) and cross section of the refurbished building (right). Source: Nussmüller Architekten.

1.2 Regulatory aspects and public support schemes

The goal of the Austrian Federal Government is to achieve Austria's climate neutrality by 2040 at the latest. An important interim goal is to reduce greenhouse gas emissions by 3 million tonnes of CO2-eq by 2030. All sectors contribute to the complete decarbonisation of the energy system, with the building sector playing a central role. After all, about 27% of Austria's final energy consumption is used for the provision of space heating, hot water and cooling in buildings.

The Austrian government has set itself an ambitious goal in its government program: 100 percent of electricity is to be generated from renewable energies by 2030. This is an important step for the energy turnaround and on the way to climate neutrality. This requires a good legal framework: this will be created by the "Erneuerbare-Ausbau-Gesetz" (EAG, Renewable Expansion Act). The EAG creates new participation opportunities for citizens and companies.

Several regulatory aspects have to be considered in building renovation projects. In Austria, the implementation of the EPBD (Directive (EU) 2024/1275) is guided by the OIB Guideline 6 and in the responsibility of the provinces. Renovation projects in Vienna therefore must comply with the Vienna Building Act (Wiener Bauordnung) and its associated ordinances. This building regulation defines the requirements for performance, structural integrity, fire safety and environmental sustainability of building renovation projects. Building renovation projects require permits and approvals from the Vienna Building Authority (Magistratsabteilung 37 - Bau- und Anlagenrecht) or the district building authorities (Magistratische Bezirksämter). Thus, renovation projects in Vienna must comply with energy efficiency standards outlined in the Vienna Building Energy Efficiency Regulation (Wiener Bau-Energieverordnung). This regulation sets requirements for thermal insulation, heating systems, ventilation, and energy performance certificates for buildings undergoing renovation.

Energy sharing between tenants could be done with a collective self-consumption model. Collective self-consumption, refers to a model where multiple energy consumers collectively generate renewable energy through solar panels, and then consume that energy locally within the community. In collective self-consumption schemes, surplus energy generated by one participant can be shared with others in the group, often through a shared grid or virtual net metering arrangements. The Renewable Energy Act (Ökostromgesetz) in Austria sets the legal framework for renewable energy production, including provisions for collective self-consumption. This law includes regulations related to feed-in tariffs, grid access, and support mechanisms for renewable energy producers.

The following national public support schemes are suitable for the replication case:

- Heating system replacement ("Raus aus Öl und Gas")
- Renovation bonus ("Sanierungsbonus")

- Heating optimisation for multi-storey residential buildings ("Heizungsoptimierung im mehrgeschossigen Wohnbau")

1.3 Social Dimension

The replication case building is owned by the limited profit housing association Sozialbau AG. The owner includes the tenants in the planning and implementation process and thereby increases the social acceptance of the tenants. For that, the company hosts various channels to reach their tenants, including video messages, user apps and a dedicated platform https://www.gemeinsam-staerker.info/home. The present replication case in Vienna has high upscaling and replication potential in the whole city of Vienna. Vienna is renowned for its progressive approach to social housing, which has become a model for many cities worldwide. The city boasts a long history of providing affordable and high-quality housing to its residents, dating back to the early 20th century.
It seems surprising, that limited profit housing associations would opt for very high quality and thus higher cost solutions like prefabricated refurbishment. They are subject to very strict cost coverage by law and are often within tight budget situations. However, serial refurbishment with prefabricated façade panels offer a unique combination of key benefits to them that no other solution can offer.

Non-intrusive and faster renovation: The non-intrusive renovation process ensures that tenants do not have to move out during renovation process, as well as a significant short renovation duration in general (3-4 weeks for the entire building). For conventional processes, a building needs to be completely emptied to implement deep renovation, due to the necessary construction measures that affect the indoor spaces. Since the owner has binding contracts with the tenants, this is usually done by not re-renting the empty flats and waiting for the remaining contracts to be cancelled by the tenant or run out. This is a very time-consuming and expensive process. On the contrary, the serial refurbishment process offers the possibility of **deep renovation in a fully occupied and operational building**.

In the case of this building, the two core requirements from the social housing company were (i) no changes or construction work within the flats and (ii) no need to replace the existing windows. The presented approach can fulfill both of these criteria. Since the heating and cooling of the building, including all necessary piping, is located within the building hall, no work on existing heat dissipation systems within the flats is necessary. They can remain as backup and will be phased out whenever there is a change of occupancy since the flat will temporarily be back under the direct management of the social housing company. Also, the windows will remain in place, a suitable connection solution between the new panels, the soffits and the windows has already been designed.

Higher indoor air quality and comfort: The renovation process will increase the level of comfort and therefore increase the wellbeing of inhabitants. Indoor Environmental Quality (EQ) addresses indoor air quality and thermal, visual, and acoustic comfort. This comfort has been shown to enhance productivity, decrease absenteeism, and improve the building's value. These comfort and wellbeing factors can of course be positively connected to indoor air quality and health of residents. Examples for health factors which have proven to be influenced are respiratory illnesses, allergies, asthma etc.

Furthermore, the renovation work reduces energy costs, which, in case of disadvantaged groups, is recognized as important strategy to mitigate energy poverty. In particular, the system allows the use of locally generated renewable energy and therefore creates independence from high-temperature based systems that rely on important fossil fuels which are subject the global market disruptions as current crises have illustrated.

2 Technical information

Key technologies installed

Besides 22 cm of mineral wool as thermal insulation, the prefabricated panels most importantly include active elements to refurbish the overall energy system. These façade integrated systems are supported and supplied by auxiliary installations such as a geothermal probe field in the inner courtyard and solar collectors in the roof.

The **façade-integrated heat and cold dissipation system based on external component activation** will be used to distribute hot and chilled water at low temperature levels via piping within the facade. The conditioning of all apartments is consistently carried out as low-temperature heating via concrete core activation from the facade. The existing, gas-based units within the flats remain in place since no construction is allowed in the inner rooms – however, they serve no technical purpose anymore and are expected to remain out of operation. The design system temperatures are **40° / 30 °C for heating** and **17°/ 21 °C for cooling**. A change-over device (change-over operation) is provided in the boiler room, which ensures that cold water enters the pipes of the concrete core activation (component activation) for room cooling in summer. The building heating is supplied via two separate heating circuits, a low-temperature circuit (30-40°C) for space heating and a high-temperature circuit (40-50°C) for domestic hot water. From the buffer storage tanks for hot water preparation, heat is supplied to the wall-mounted combination hot water storage tanks arranged decentrally in the flats. The heat is metered per flat via heat meters. Heat buffer tanks are installed in the plant room (cellar) for both systems, twice 1,500 litres per rail.

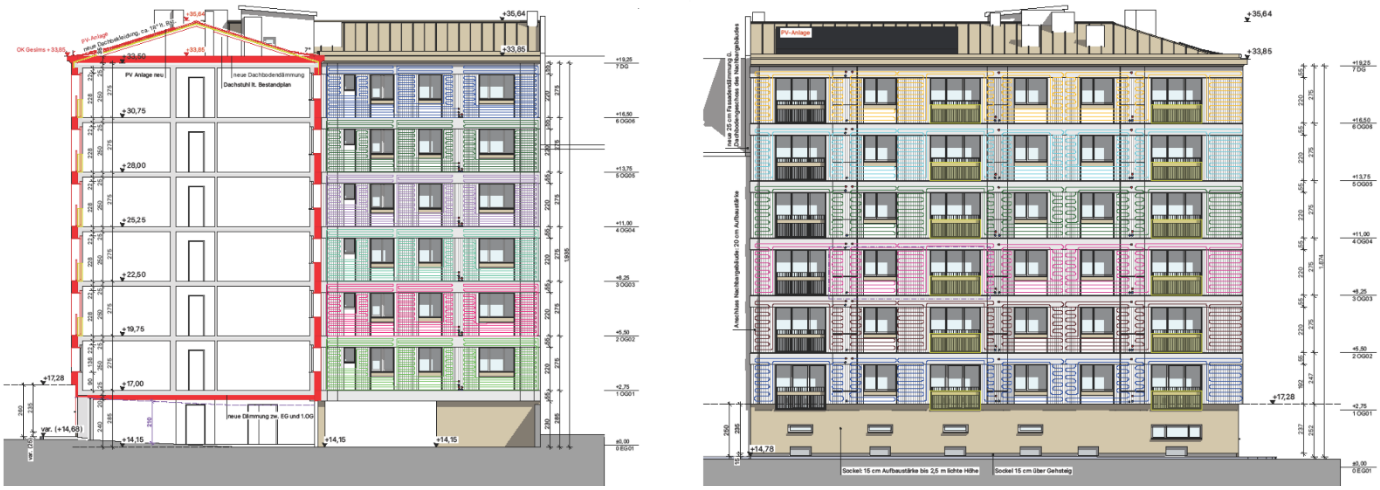

Figure 3: Schematic of the hydraulic heat and cold distribution lines within the façade elements from North (left) and South (right). Different colored circuits are used for individual flats and building. Source: Towern3000.

The system is **supplied by locally generated renewable energy**. The energy generation is implemented by a brine-to-water heat pump that draws energy via geothermal energy with deep probes. The design of the deep probe fields ensures seasonally thermally balanced operations. Assuming a Coefficient of Performance (COP) value of 5 for the heat pump, this results in a total geothermal extraction capacity of 38 kW, which must be provided by a heat storage tank underneath the building. With an output of 30 watts per metre of deep borehole 10 probes are needed for heating and domestic hot water. The requirement for seasonally thermally balanced operation of the geothermal heat storage makes it necessary to recharge the amount of heat extracted in winter during the summer months. For this purpose, 220 m² of solar thermal modules (Flat plate collectors) are installed on the south facing roof of the building. The heat extracted in summer will be used to heat water, but it is particularly important that this allows the geothermal heat reservoir to be regenerated over the summer months.

200m² PV Area /18 kWp will be installed on the south facing roof for a high degree of self-consumption via smart heat pump operation and domestic hot water heating.

The **drinking water** is supplied to the flats via distribution pipes in the riser shafts and metered individually for each flat. Hot water is produced decentrally by means of wall-mounted combi hot water tanks, which are located in the bathrooms above the washing machines. Heating is in two stages, with the basic heating system heating the drinking water directly in the hot water storage tank to a temperature of 45°C via a separate heating network from the heat pump using an integrated smooth-tube heat exchanger. The storage tank also has an electric heating element that brings the hot water to a higher temperature. Hot water circulation is therefore not required.

In combination with **smart control approaches,** the thermal storage and flexibilisation elements, a dynamic load shift is possible on site, which allows a shift of the cooling and heating load in times with surplus electricity from own production. This can significantly increase the degree of self-sufficiency at the city quarter and even offer flexibilities to the overarching electricity grid.

3 Business model details and possible financing arrangements

Well-suited financing schemes and business models are of central importance for a large-scale roll-out and replication of PEBs. The main benefits of PEBs stem from energy efficiency and the use of renewable energy sources. However, serial renovation with multifunctional façade elements lead to multiple additional benefits that can have an economic impact. The following list outlines relevant value propositions and revenue streams for the PEB renovation with multifunctional façade elements as realized in the Excess demo and the present replication case.

Lower heat energy demand: The deep renovation of the building significantly reduces (~80%) the heat energy demand and therefore heat energy cost. The heating system is changed from gas heating to a geothermal heat pump.

Cost savings and price stability through a switch to renewable-based supply for thermal energy: Typically, buildings required energy at temperature levels of up to 70°C for space heating and hot water. The newly installed heat dissipation systems with wall heating decreases the required temperature level for space heating, enabling overall low operating temperatures. These low supply temperatures can be provided at high conversion efficiencies by the installed heat pump.

No floor heating system needed: The wall heating system of the multifunctional façade element replaces existing heat distribution systems with radiators and does not need a change to a floor heating system, which is one of the main advantages of a renovation with the multifunctional façade element. No revenue is lost for the owner due to empty and therefore unused flats.

Non-intrusive renovation process: One central benefit is the non-intrusiveness of the renovation process. This means that tenants do not have to move out during the renovation process, as the multifunctional façade element is placed on the outside of the building. Renovation with multifunctional façade elements therefore save the cost of relocation of tenants.

Speed of renovation: Another financial benefit of the serial renovation approach is the speed of renovation. As the façade elements are prefabricated, the renovation process onsite is faster (around 50-60% time saved) compared to conventional renovation processes.

PV production: The multifunctional façade element also contains a building integrated PV module that leads to additional revenues from electricity brought into the grid.

Flexibility revenues: Buildings with wall heating systems activate a high thermal mass, and therefore, have a high potential for heat energy demand shifting. Flexible demand shifting could lead to additional revenues sold to markets.

This replication case could take advantage of all the previously mentioned benefits and revenues. The replication case is financed by the Sozialbau AG through the conservation and improvement contribution fund, reserves and funding.

4 Possible PEB upgrade timeline

The concept development for this building started about 6 months ago. Currently, the preparation of the tendering process is ongoing, including exchange with the national funding authorities to comply with the respective requirements. The construction team expects that this phase will be finished late fall 2024 after which the tendering should start. The goal is to place the order in spring 2025, start prefabrication and construction in summer 2025 and have an energy active, **fully operational building in place come fall 2025**. After implementation, the building is subjected to scientific monitoring of at least one year, gathering data for optimization and further improvement of the deployed technical solutions.

5 Policy Recommendations

The multifunctional façade element fits best for renovation projects of buildings with construction year 1970 to 1990 as those buildings mostly have plain walls with low insulation levels. Therefore, there is high replication potential in Austria and in particular Vienna as there are many suitable buildings from this period. Especially in urban environments, the increased building dimensions must be taken into consideration when planning serial refurbishment – many buildings are adjacent to public sidewalks and wall-to-wall with neighboring buildings. Currently, national regulation requires (i) special solutions of about 2.5 m above ground for the walls where no additional building thickness is allowed in order to not narrow down the sidewalks and (ii) enforces maximum increased thicknesses for refurbishment. These allowed thicknesses range from 22 – 30 cm depending on the chosen system. These values limit the dimensions and functionalities of the prefabricated panels and are therefore prohibiting for more complex systems. An adaption of these limits to allow thicker panels is expected with the novella of the Vienna Building Act (Wiener Bauordnung) in winter 2024/2025.

Currently there are no dedicated support schemes for serial renovation of buildings with multifunctional façade elements. There are also no support schemes available that target the holistic approach of PEBs, rather only separate support mechanisms for insulation and RES installation. Thus, new innovative support schemes for serial renovation to PEB standard could increase the replication potential. Since serial refurbishment can be carried out most effectively by general contractors, this reality also needs to be reflected in such funding schemes. They need to allow tendering for general contractors as opposed to tender for individual trades. Renovation with multifunctional façade elements and heat pumps lead to a higher complexity of the buildings energy system, which requires highly skilled companies that could plan, build and operate the energy system. Therefore, important drivers for PEB replication can be facilitators, One-Stop-Shops or specialized integrators that help to overcome the complexity barrier of the complex buildings energy system of PEBs.

Finally, more ambitious obligations (minimum performance requirements) and strict and effective transposition, implementation and enforcement of existing legislation could boost the replication of PEBs with multifunctional façade elements.