1.1 Novel Solution #3 – Energy efficient installations in existing buildings (Alingsås pilot)

This novel solution applied in the Alingsås pilot focuses on the impediments of introducing new applications such as elevators and PV cells in existing buildings in comparison to new ones, and what systematic decisions that were needed to support these installations. The applications themselves have been developed and described within the BEEM-UP development WP4.

1.1.1 Location in building – Alingsås

Figure 1 below shows what parts of the building that are affected by these applications.

Figure 1 Location in building for PV cells (on roofs and balconies) and elevator wells.

1.1.2 Existing Construction

The Alingsås dwelling area has been identified as an area of architecturally valuable buildings, a typical example from the years of MHP; the Swedish Million Housing Programme. Among the aspects identified as of cultural-historical interest are; the layout of the area; the green courts between buildings; the coherency and overall shape of the buildings.

During the MHP years, building regulations allowed for three-storey buildings to be built without an elevator. As a consequence, to this day most lower buildings from this time still have no elevators.

Figure 2 Original layout of buildings/courts and the original skyline of rooftops for Houses N, Q, O, P of the Alingsås pilot

1.1.3 Identified Problems

The needs of tenants and society have changed since the buildings were erected. Today, elevators are needed for accessibility reasons in order to grant access to flats on all floors. However, to fulfil the energy efficiency targets of the retrofitting such lifts must have a very high energy performance. In parallel, local renewable electricity generation has been investigated to support the need for common electricity in buildings.

1.1.4 Solution

Energy efficient elevators were introduced inside the buildings, where 60% of the new flats now are serviced by an elevator or situated on the ground floor. This was foremost a structural challenge, since buildings from the MHP era have a much optimised load-bearing capacity. There were many restrictions in where holes could be cut in the floors. An additional steel structure was also required inside the elevator well.

Firstly, the MRLH Hydroware elevator was used. This solution was found to be one of the most energy efficient elevators ever used in Sweden. However, through BEEM-UP technology development, the analysis of energy efficient elevators was taken even further. The key aspects were found to be;

- For taller buildings with frequent service, generating elevators can be used to generate electricity when going downwards. For buildings like the low ones in Alingsås (≤four floors) with little traffic, the most energy efficient elevator is the one with efficient machines and lighting for a low energy performance in service as well as in standby
- Depending on the suspension of the carrier, additional space will be needed beside, below or above the carrier. The suspension and balance of the elevator cantilevers also affect the energy performance. Since space is restricted in existing buildings this is of utterly importance. In Alingsås, digging and building a deeper pit below the elevator was expensive and sometimes very complicated. Negotiations were made with the municipality to get permission to break the even line of the roof tops to gain working space to service the elevator
- For an elevator with efficient machinery, the standby mode and the lighting become a greater share of the total use of energy. For the new lifts, standby mode machinery, efficient LED lighting and service controls were introduced

The elevator MP Go! was investigated as an alternative to the MRLH Hydroware, with lower energy use in servicing mode. LCC analysis of energy performance vs costs showed a better energy performance for the MP Go!, but since the MRLH Hydroware was still very energy efficient, the difference per year was not very large. Altogether, 13 of the MRLH Hydroware was installed and 2 MP Go!'s. The choice was depending on the LCC analysis, the installation conditions and the foundation and ground conditions for a pit at each actual building.

Through the excavation of deeper pits, that was possible for buildings on clay grounds, and a permission of extension of the elevator shaft through the original roof, the construction process for elevators was facilitated from House K and onwards.

For PV cells, a few different locations were analysed technically and their corresponding impact to the exteriors were assessed by the building owner.

- In Sweden, the solar load for electricity generation is very small during winter. The system should therefore be designed for the base load of common electricity during summer, not for HVAC winter loads, for sustainability reasons
- Building attached PV cells (BAPV) placed on the south-facing roofs had the highest efficiency, but inflicted with the municipality's wish of clean roof areas
- Vertically building integrated PV cells (BIPV) were discussed to be applied as balcony fences or to substitute parts of the screen tile façades. In vertical applications, the PV cells have less capacity and can easier be exposed to vandalism. On the other hand, the effect is very visual and the tenants will be more aware of the PV cells and the local electricity generation in their everyday life

PV cells were mounted on the last four buildings in Alingsås to be retrofitted. With permission of the municipality, south and east sloping roofs were used for PV cells. Balcony fencing of south and east-south-east facing balconies of houses Q and N were covered with PV cells (as BAPV instead of BIPV, for an easier installation), see Figure 3 (from north-east). Façade BIPV applica-tions were not used at all since the systems of PV cells and façade tiles fixtures did not match.

Figure 3 Final skyline of Alingsås rooftops for Houses N,Q,O,P. The PV cells of houses N and P, facing east, is very visible from a bird's view but not from the ground. The elevator rooftops of houses Q and N are identified by the shadows from this perspective, but neither of them are very clearly seen from the ground.

1.1.5 Energy Experiences

For the elevators, the nominal demand per year (category 1) is

- 390 kWh for MP Go!
- 893 kWh for Hydroware

Both have a Class A standby energy use but they differ in service mode. The VDI numbers per elevator are presented in Table 1. Despite the large difference in nominal energy demand, the influence on the energy use as a whole is rather small since the lifts are so rarely trafficked.

Table 1 VDI comparisons MP Go! vs MRLH Hydroware

	MP Go!	MRLH Hydroware
Stand-By Energy Use	36 W - Class A	46W - Class A
Specific Travel Demand	0.45mWh/kg,m - Class A	4.73mWh/kg,m - Class G
Nominal Demand/year Category 1	390 kWh	893 kWh
Energy Efficiency Under Usage Category 1	A	B

The PV cells were installed in September 2014. The short reporting period means that there no monitoring results to show as of yet. Calculated values of electricity generation are

- Roof modules 74 kWh/yr (82 kW_{peak})
- Balcony fences 7.7 kWh/yr (10.3 kW_{peak})

Figure 4 PV cells mounted on roof tops and balcony fencing.

1.1.6 Lessons Learnt

Since the elevators themselves show a great performance thanks to low energy machinery, LED lighting and standby mode, the key point has been to effectively introduce the elevators in the existing buildings. Space for shafts was found in the layout, but since the listing of the area did not comply with exterior machine rooms on the roof, the later permission to extend the shaft through the exterior roofs for the last buildings was the final key to the elevator challenge. Regarding PV cells, it is clear that the purpose is more complex than just to maximise the efficiency of the installation. Through a broad analysis, a combination of the most effective and most pedagogic installation location could be used.

For a sustainable retrofitting, introducing energy efficiency and accessibility at a larger scale, a few measures regarding elevators and PV cells might conflict with architectural values:

- Exterior elevator towers can completely change the expression of a building
- In Alingsås, the original pitched roofs were very coherent and with no superior hatches or different heights. Consequently, the municipality would not want any abrupt changes to the skyline caused by new installations.
- The possibilities of introducing an elevator pit are depending on the ground conditions and the existing foundation of each building. For structural reasons, some pits in Alingsås could only be a few decimetres deep.

Figure 5 Some of the operations involved for elevator pits. Left: Excavating by hand inside a building. Center: Reinforcement on the gravel floor. Right: After excavation and casting of pit, House J