Heat pump retrofit projects for multi-family buildings – An obstacle run

Nicole Calame, Switzerland

The use of heat pumps in existing multi-family buildings represents an important underexploited potential to help decarbonize the building sector in terms of the heat requirements of urban areas on a large scale. However, challenges may arise which could either turn out to be obstacles or a complete "no-go" for heat pump projects. Legal, technical, administrative, financial and awareness considerations are reviewed here in a Swiss context. Lessons learned provide specific examples that can help to address the situation. Proposed solutions for addressing the difficulties are presented, as are identified paths to improved adoption of heat pump solutions.

Introduction

Supplying sustainable heat for households plays a key role in the Swiss energy strategy. Heating and domestic hot water needs account for about 30% of national CO_2 emissions. Heat pumps sold in Switzerland are increasingly used for retrofit projects but still only marginally for large buildings. More than 72% of the Swiss population currently lives in multi-family buildings, which make up about 43% of the built environment. And it is the existing building stock that will comprise most of tomorrow's housing. If this is a major target in the hunt to decarbonize the domestic heat sector, why is retrofitting large buildings with heat pumps still lagging behind? Mainly because it has long been considered unrealistic. The truth is, such projects are cross-disciplinary with a tendency to multiply the challenges. Here is a review of various practical considerations that might hinder a project, both country-specific and generally applicable.

Regulatory and financial considerations

The energy prescriptions model application proved to be an efficient tool in the Cantons where it came into effect with more heat pump retrofit projects realized in MFBs where a minimum of 10% or 20% of renewable energy is mandatory for heating system replacements. Feasibility studies revealed the difficulty of complying with these requirements in an urban context where air-to-water heat pumps often proved to be the only achievable solution. The prescription model was established to harmonize the different regions. It applies to building conception as well as authorization procedures, and its full implementation in its latest version (MoPEC 2014) is not yet effective in many parts of the country.

Regarding funding, discrepancies range from no subsidy policy for heat pump retrofits to generous ones including the distribution system replacement. A lack of subsidies either stems from technology reluctance or, in contrast, because they are considered the most profitable option in the long run. Some people push for geothermal heat pumps or apply for electric heating system replacement only. Interestingly, the attractiveness of funding is not always reflected in the number of projects realized. Some regions use heat pumps to a great extent despite a lack of incentives, possibly because they are more aware of and confident in the technology from the installers. Other factors include doubts about the reliability in higher-altitude areas whereas rural zones often face fewer worries with noise issues. The contribution models for heat pump retrofits usually consist of a fixed base subsidy with a variable portion linked to the heating power installed. However, some models index the subsidy to the size of the dismantled heating system or to the energy reference surface of the building in order to discourage oversizing and promote heating reduction through envelope sanitation [1].

The Swiss tenancy law is a barrier. Large buildings are mainly inhabited by tenants who do not contribute financially to heating system renewal even though they would benefit from cheaper resulting energy charges. Owners therefore lack an incentive to opt for a renewable solution. To help carry out projects, a successful energy contracting system has been implemented in Geneva by the local public utility SIG.

Implementing a heat pump often requires constructive adaptations, which triggers a building permit application procedure for these works. This can become an administrative nightmare. Each and every function concerned will be consulted with regard to noise, environment, fire protection, monuments and sites, town and country planning. If one function decides negatively, the entire application is rejected. In Geneva, 14 different forms must be filled in. This heavy administrative burden is detrimental to heat pump retrofits because it blocks projects or involves potentially heavy cost overruns for the owners. Height limitations for buildings and installations on top

Figure 1: Exemplary integration in a historical building realized in the Altmarkt-Galerie in Dresden, Germany (Source: Güntner GmbH)

of them can constitute a major problem and make it difficult to find an installation location for the heat pump. The aesthetics of the machine can increase the acceptance of city-compatible air-to-water heat pumps. Indoor installations are not spared, with possibly large air intake and outlet modifying the façade. Split units could help mitigate these challenges. Cultural heritage laws make it even tougher in old city centers, where patrimonial protection could seal the end of a project. This can, however, be surmounted as shown in Figure 1, where air coolers are ingeniously hidden underneath painted grids.

Technical considerations

More heat pumps were sold in Switzerland in 2019 than fossil-fuel boilers, of which 84% consist of heating power under 20kW (97% < 50kW) [2]. Despite a growing market, it is still a challenge to find standardized and silent heat pumps for large capacities. The two options are either cascading smaller modules or choosing a larger industrial range product which is not designed for residential use (Figure 2). Resorting to tailor-made products provides an alternative.

The maximum sound level allowed depends on the sensitivity of the zone. The threshold value is legislated and must be respected at the hearing points, not at the emission point. A relative noisy heat pump impact can be limited through a wise implantation and additional noise- and vibration-reduction measures. Considering the average distance to neighbors in urban areas, the target value of the acoustic power should be around 50-55 dB(A). The energy efficiency (COP or COPA) of the selected machine is key for a profitable operation. The challenge is to try to reduce the supply temperatures, although high temperatures are achievable.

Various implementation concepts are available for indoor, outdoor and split alternatives (Figure 3). Each solution comes with a different set of issues but can also help to address local constraints. Two main integration modes are possible: monovalent (100% of the production by heat pump) or hybrid with a second heat source. The latter can be a pragmatic and economical solution to secure heating needs throughout the year without oversizing. Heat pumps are ideal as monovalent heat generators for floor heating and radiators operating at less than 50°C (area-specific standard heating load of about < 75 W/m^2).

Hydraulic integration schemes have to be specifically developed with the manufacturer to reliably integrate the heat pumps with the constraint of existing heat and DHW distribution systems.

The dimensions and weight of the heat pump and storage tank are critical since a lack of available space may compromise a project. Height especially is a key consideration to ensure a large and properly stratified heat storage that prevents constant switching on and off. Sufficient space is also needed to access the implementation site. The air intake and outlet of indoor installations requires large sizes to avoid noise generation or aspiration issues (vacuum effect clogging). Linking the machine to the boiler room can be tricky too. Insulated connecting pipes of a non-negligible diameter might have to cross the entire building. One option is to run them outside.

Installing a heavy heat pump in an existing structure requires a preliminary static evaluation by an experienced civil engineer who should take into account the heat pump's weight including water and refrigerant content, stand and hydraulic components. Be aware that structure-borne sound that reverberates through the slabs can occur from compressor-induced vibrations. Another practical consideration not to be overlooked is the electrical introduction of the building. Chances are the existing one will have to be reinforced due to the important absorbed power at start-up, potentially implying significant cost overruns [4].

Figure 2: Two rooftop projects with air-to-water heat pumps realized in Geneva. Right: industrial heat pumps with over 80dB(a) at emission with surrounding noise-reduction walls (Source: SIG/ CSD Ingénieurs SA)

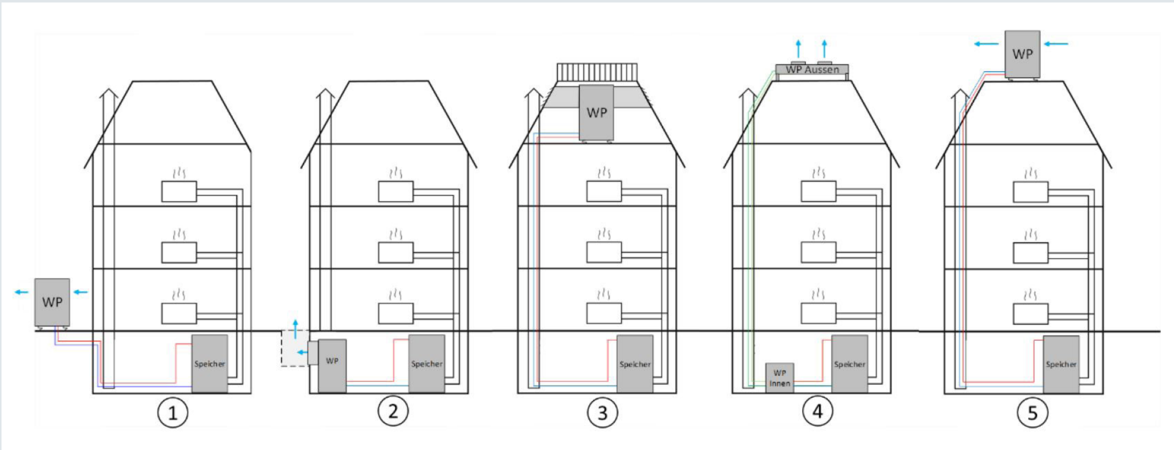

Figure 3: Solutions for heat pump (WP) and storage tank (Speicher) implementation [3]

Large heat pumps contain a substantial refrigerant charge. The same problem is faced by natural ammonia as by new HFO fluids regarding the protection measures requested in a closed room. This particularly implies an important ventilation capacity with possibly high associated costs.

A gap with expected performances may be observed [5]. Experience shows that discrepancies likely originate from the realization phase. A careful follow-up of the installer's work is needed. A monitored running-in period is highly recommended to optimize the installation until results can be considered final.

The complexity of multi-family retrofit projects implies a good management of ancillary works. This is reflected in initial investments that are 3 to 6 times higher for air-to-water heat pumps than for fossil-based heating systems. Nevertheless, the specific annual heating costs including the investment, operation and maintenance do not reflect such differences (Figure 4).

Such projects require technical engineering expertise and a solid understanding of laws and finance. The usual skills needed for small installations are not sufficient. Various professional training courses for installers and engineers are available today as well as energy and incentive consulting. Information dissemination is done at the national, cantonal and municipal levels.

Another line of action lies in demonstrating achieved projects as undertaken by [1] presenting 32 examples of buildings ranging from 13.5kW to 220kW (3 to 77 dwellings), by [3] with eight objects with heating needs from 30kW to 186kW, by HPT TCP Annex 50 displaying case studies from across Europe [6] and others.

Conclusions

Various challenges can stand in the way of large heat pump retrofit projects for multi-family buildings, whether technical, regulatory or financial, or whether due to a lack of knowledge or simply being unsolvable. However, realized examples of a variety of sizes and solutions should inspire and encourage more such projects. Environmental awareness and the desire to maintain property values are already driving owners to choose heat pumps even for larger buildings. The evolution of the regulatory framework following the energy transition strategies and the will to develop adapted tools and training prove that this topic has been identified and is being addressed at different levels. This is encouraging, given the vast application potential and underlying benefits.

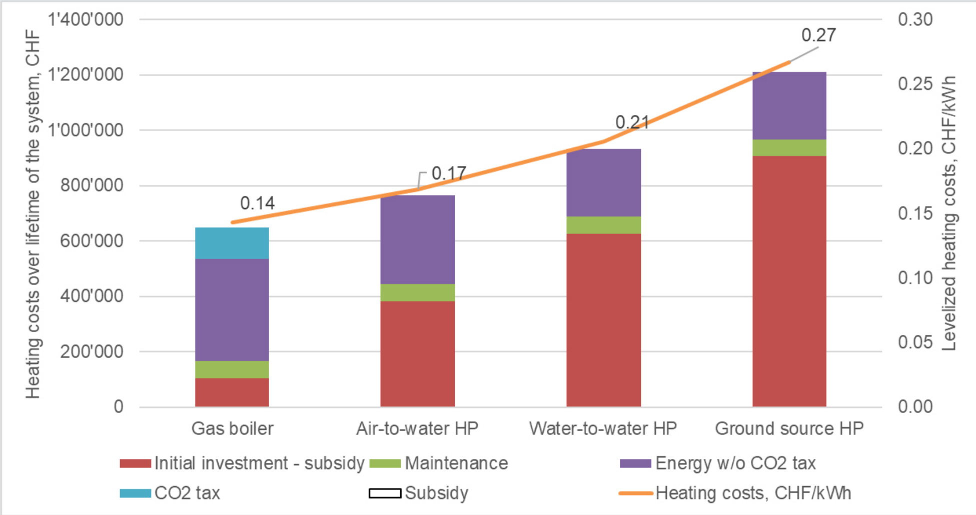

Figure 4 : Heating costs of an average multi-family building (1,700 m2 ERA; 113kW thermal power) according to technology. The bar graph refers to the investments, and the orange line to the heating costs in [CHF/kWh] [5]

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NICOLE CALAME
CSD Ingénieurs SA
Switzerland
n.calame@csd.ch