Heating with Air Conditioners – fast and affordable transition towards carbon neutrality?

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Abstract

There are still many inefficient direct electric heaters in use in Switzerland, as well as other heating systems emitting high amounts of CO_2 and other pollutants all over Europe. In some countries incentive schemes exist for the replacement of heat generators, in many cases also supporting natural gas or other non-renewable energy-based systems.

The installation of a proper hydronic distribution system is often very expensive and not always sustainable. To reach the optimal results in terms of energy, cost and emissions savings, an attentive choice of the right system is always necessary.

This paper will present a number of case studies adopting efficient, effective and comfortable air-to-air heat pumps installation for heating in new and refurbished low energy buildings. The characteristics in terms of energy efficiency and environmental impact of best products, their consumption levels, installation features and the related costs will be presented in more detail for the selected case studies.

Heating: the need for action at EU level

The actual situation in the EU residential sector is rather clear: space heating covers 2/3 of the total final energy consumption, and there is still a high percentage of fossil-fuel based systems. The sector is responsible for about 20% of the CO_2 emissions. Almost 75% of the EU building stock is inefficient, according to current building standards, and 85-95% of the buildings that exist today will still be standing in 2050.

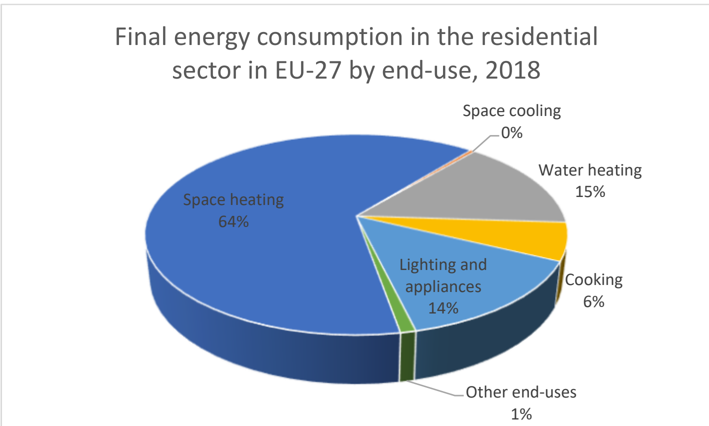

Figure 1: Final energy consumption in the EU residential sector. Source: Eurostat

In December 2021, the European Commission published its proposal for revising the Energy Performance of Buildings Directive (EPBD): the recital 19 is stated that “All new buildings should be zero-emission buildings, and all existing buildings should be transformed into zero-emission buildings by 2050"[1]. The recital 20 mentions in an explicit manner the use of renewable sources, such as the heat pumps - among others - to cover the energy needs of an efficient building.

The slow intervention rate for refurbishing buildings and systems, estimated to be around 1% per year and reaching only 0,2% for deep retrofit, is well below the 3% requested for a reduction of GHG emissions by 55% in 2030, for which the GHG emissions from the buildings sector should decrease by 60% by 2030 compared to 2015.

The policies addressing the buildings' energy performance are in place since decades, but due to the high costs for intervention, the technical limitations and the policy ambiguity on fossil sources, the lack of progress in this field persists.[2] Heat pumps are considered part of the solution in GHG emission reduction since years [1], cost effective [2] and sustainable for the energy system [3].

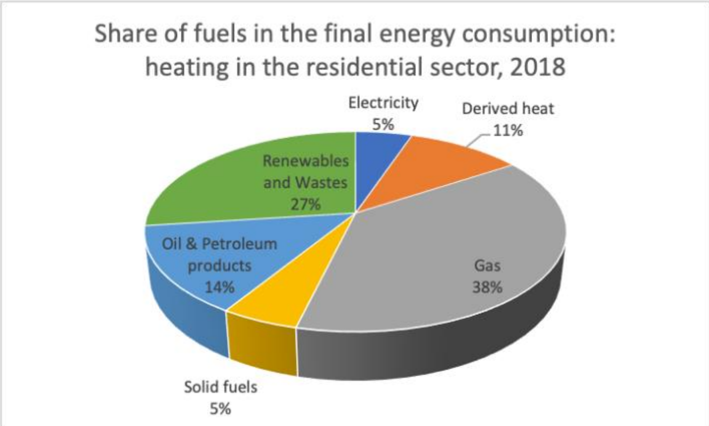

Figure 2: Heating sources for the EU residential sector, 2018. Source: Eurostat.

Swiss energy consumption and GHG emissions

Energy efficiency and renewables are the two main pillars in the swiss long term energy strategy for 2050. A number of policy measures are in place for the building sector: CO_2 levy financing incentive schemes for efficiency, obligation for renewable energy, stricter minimum performance standards for new and refurbished buildings, appliances and systems.

The swiss building sector accounts for more than 45% of the swiss total final energy consumption and the 30% of the CO_2 emissions. The private households' sector consumed in 2019 about 60 TWh, 66% for the space heating needs and 15% for sanitary hot water. The 65% of the space heating needs are satisfied with gas and oil, only 6% with direct electric heaters. With the exclusion of the secondary residences (holiday homes), there are still 23,9 mio. m^2 of heated surface served by direct resistance electric heating systems: in the last 20 years the associated consumption for such systems – climate corrected - decreased only by 11% at around 2,8 TWh. For the sanitary hot water preparation in the residential sector, three quarters of the 9 TWh consumed are covered by gas, oil and direct electric water heaters.

Despite the incentive programmes launched in 2010, the yearly rate of building renovation in Switzerland is lower than 1%, in line with the average numbers in the EU countries. The incentive scheme for buildings rewards with additional incentives the combined interventions on envelope and systems, considering the classification in the building energy certificate or in other voluntary certification schemes.

[1] https://ec.europa.eu/energy/sites/default/files/proposal-recast-energy-performance-buildings-directive.pdf

[2] See e.g. BPIE (Buildings Performance Institute Europe) (2021). Deep Renovation: Shifting from exception to standard practice in EU Policy. https://www.bpie.eu/publication/deep-renovation-shifting-from-exception-to-standard-practice-in-eu-policy/

Heat pump market

Worldwide, nearly 20 million households purchased heat pumps in 2019[3]. Divided by typologies, many are reversible units that only partially cover space and water heating needs, anyway the market growth is significant in the most relevant heating markets: North America, Europe and North Asia.

In newly built homes the heat pump is nowadays the most installed technology in many countries, but they actually meet only 5% of global building heating demand.

For respecting the SDS scenario developed by the IEA their share must triple by 2030: additional policy support and innovation are needed to reduce upfront purchase and installation costs, remove market barriers for renovations, and improve energy performance and refrigeration alternatives.

At European level, more than one and a half million units are sold every year, and the market growth is double digit. The units sold for the preparation of sanitary hot water were around 155k in 2018. In 2020 the air-water heat pumps are the most sold, pushing for the first time the air-air systems in the second place.[4]

In 2020 the stock of heat pump systems in the EU-21 is estimated to be about 15 mio. units. The EU-28 building stock is estimated to be around 120 mio.

The heat pumps sold in 2020 in Switzerland were around 28 000 units: 73% air-water, 25% sole-water, more than 1% water-water systems. The air-air systems sold are negligible, at least for the official statistics provided by the associations.[5]

Building energy policy in Switzerland

Energy efficiency and renewables are two of the pillars of the Swiss Energy Strategy 2050, proposed in 2007, submitted to the parliament in 2013 and approved by the electorate in 2017. The main objective by 2050 is the reduction to zero of the CO_2 emissions.

The main instrument to reduce the energy consumption (and emissions) is the limitation of energy needs for heating. Since the 1977, with the first version of the national swiss standard SIA 180/1, recommendations regarding the insulation level of the components of the building envelope were released by the swiss standardization body. The cantonal legislation adopted the standards between 1977 and 1983. The SIA 380/1 standard, published in 1988, presented for the first time the notions of building energy balance, opening the field to a common cantonal energy policy in Switzerland.

The legislative framework has also defined the obligation for renewable energy since the first version of the joint model cantonal provisions in the energy sector (MuKEn) in 2008, strengthened in the last years with the 2014 proposed model. Depending on the legal framework of each canton, a percentage of renewable energy source for heating is mandatory in new buildings, extensions, or deep renovations. One of the standard solutions defined by the building energy regulation for fulfilling this obligation is the use of heat pumps.

The Model of the Cantonal Energy Regulations (MuKEn)[6] 2014 offers the option of including in the regulations the mandatory substitution of the direct resistance electric heaters and boilers, centralized or not. So far, only few cantons have already included it in their updated local energy regulation.

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[3] IEA (2020), Heat Pumps, IEA, Paris https://www.iea.org/reports/heat-pumps

[4] https://www.rehva.eu/rehva-journal/chapter/european-heat-pump-market

[5] https://www.fws.ch/wp-content/uploads/2021/04/FWS-Statistiken-2020.pdf

[6] The "Model of the Cantonal Energy Regulations" is a set of energy regulations for buildings jointly developed by the cantons, based on their experience in the field of implementation. The Model thus constitutes a kind of "common denominator" of the cantons. https://www.endk.ch/de/energiepolitik-der-kantone/muken

Incentive schemes in Switzerland

In Switzerland, the main policy measure in place for the building sector is the Gebaudeprogramm: the CO2 levy, 2,3 cents per kWh, is actually financing the incentive schemes for increasing the efficiency in the building sector. The actual incentive scheme is based on a common approach for all cantons, with some specificities defined by the single state government.

Since 1991 is active an incentive system for renewable energy (PACER, ENERGIE 2000). In 1994 the canton of Zürich published the Energieplanungsbericht 1994 / Vision 2050, which outlines a scenario for the reduction of CO_2 emissions to 1 ton per person for the year 2050 and estimates its feasibility to be quite realistic, considering current technical knowledge and without a reduction in living standards. In 1995 the first obligation of renewable energy for buildings was set in place in the cantonal energy law of Zürich.

The federal and cantonal building program is a central instrument of Swiss energy and climate policy. Since 2010, the Building Program has provided funding for the following measures:

- Thermal insulation of existing buildings;

- Installation of building systems: heating systems powered by renewable energy (heat pumps, wood-fired boilers, solar collectors), as well as ventilation systems with heat recovery;

- System renovations, i.e. comprehensive building renovations (e.g. Minergie renovations) as well as energy renovations in larger stages, in which the house is considered as a complete system, with measures on the building envelope and building services. (improvement of the GEAK classification[7]);

- Construction and expansion of systems for the centralized heat supply of heat supply of buildings with heat from renewable energies or from renewable energy sources or waste heat (central heating systems and heating and anergy networks);

- High-efficiency new buildings

The *building program* is implemented in accordance with the Harmonized funding model of the cantons (HFM 2015[8]). The cantons align their funding offer with the cantonal goals and framework conditions. In some cantons, for example, not all of the of the building program is funded in some cantons, while other cantons support additional projects and measures to the support additional projects and measures.

The program is financed on the one hand by partially earmarked funds from the CO_2 tax and on the other hand by cantonal credits, which the cantons draw from their regular budgets or - less frequently - from their own energy levies. One third of the revenue from the CO2 tax levied on fossil fuels, up to a maximum of 450 mio. CHF per year, is used in accordance with Article 34 of the CO_2 Act to promote measures in accordance with Articles 47, 48 and 50 of the Energy Act for the long-term reduction of CO2 emissions from buildings. Two thirds are redistributed to the population (via the health insurers) and to the economy (via the AHV compensation funds) - as is what remains from the building program each year. The amount of funds available for the building program depends on the amount of the levy rate. In 2020, the rate was 96 CHF per metric ton of CO_2.[9]

Looking at the period from 2010 to 2020, thanks to the Buildings Program, the Swiss building stock used 2,5 billion kWh less energy and avoided 660 000 t CO2 emissions per year. The subsidy in 2020 will contribute with savings of 230 mio. kWh and 63 000 tons of CO2.

In 2020, around CHF 299 mio. in subsidies were paid out under the building program - despite the Corona pandemic an increase of 13% compared to 2019 - payments were thus higher than at any time since the program was established. The increase was particularly strong for building technology

[7] The GEAK classification is the Energy Performance Building Certificate available in Switzerland. See www.geak.ch

[8] Harmonisiertes Fordermodell der Kantone (HFM 2015) Schlussbericht, INFRAS, Donald Sigrist, Stefan Kessler, 2016

[9] Jahresbericht 2020 des Gebaudeprogramms, Bundesamt für Energie BFE, 2020.

systems projects (+65%) and system renovations (+21%), both of which have a high impact on emissions. The two categories together account for around 45% of the disbursements 2020, while thermal insulation projects still account for just under 40 %.

In 2020 the substitution of fossil fuel based heating or direct electric heaters with heat pumps of any kind, will cause a saving of 926 GWh and 345 000 t of CO_2 emissions, calculated in the whole system lifetime.

In the framework of the actual funding model, only air-water, water-water and sole-water heat pumps are supported. The subsidy is composed by a minimum forfeit depending on the technology installed and a variable amount, proportional with the nominal thermal power of the appliance. In parallel, and with a similar approach, is incentivised also the installation of a new hydronic system in case of substitution of decentralized inefficient or fossil-based heating appliances. In general, the incentive is estimated to cover the 20-30% of the investment cost.

The approval process, managed at cantonal level by specific offices, is subject to several formal controls, mainly regarding the quality of the system: the installer needs to be in a list, the new heat generator and network needs to be certified (product and installation).

Standard and policies about the efficiency of heat pumps

In 1995 the national swiss standard SIA 380/4 set minimum performance standards for electrical appliances and systems. Since 1997 the use of the EU energy label is promoted on voluntary basis and is mandatory since 2002. Nowadays the efficiency level for the vast majority of systems for heating and cooling are covered by the national legislation, that redirects to the EU energy labelling and Ecodesign regulations.

In Switzerland the energy labelling and Ecodesign are entirely included in the legislative framework, using the EU definitions and the regulations are adopted as is, thanks to the Ordinance concerning energy efficiency requirements for series-produced plants, vehicles and appliances[10].

The energy label for air conditioners[11] has been mandatory since 2004, updated in 2013 with EU Regulation 626/2011. On the label is a graduated scale of seven energy efficiency classes (from A to G). The electricity consumption is in 60 minutes at full load of air conditioners in cooling mode is indicated in kilowatt-hours, although the actual energy consumption also depends on how you use the air conditioner and the weather conditions. In addition to energy consumption, the energy label states the electrical efficiency index, which indicates the ratio of cooling (EER/SEER) or heating (COP/SCOP) power to electrical power consumption. The higher the value of the electrical efficiency index, the better the energy efficiency of the appliance.

In parallel to the labelling schemes the EU legislation included MEPS: minimum performance standards. The Commission Regulation (EU) No 206/2012 sets minimum performance standards for all air conditioner appliance types, in heating and/or cooling mode, since 2013.

Moreover, at EU (and Swiss) level, since 2015 all heating and domestic hot water production appliances - including any type of heat pump - must comply with specific minimum performance requirements and, as part of the domestic application, are accompanied by an energy label, to provide the user with information for easy comparison. These appliances also include heat pumps, which on the label show some technical data such as thermal power output and noise, in addition to the efficiency class, from A++ to G. Since September 2019, a stricter classification has been introduced with the elimination of the lowest efficiency energy classes (E to G) and the addition of a new A+++ class to identify the most efficient generators.

[10] https://www.fedlex.admin.ch/eli/cc/2017/765/it

[11] Defined in the Regulation as "Electric mains-operated air conditioners with a rated capacity of ≤ 12 kW for cooling, or heating, if the product has no cooling function. Energy labels do not apply to a) appliances that use non-electric energy sources; b) air conditioners of which the condensor- or evaporator-side, or both, do not use air for heat transfer medium."

All policies presented are supported by different technical standards: the efficiency of products on one side, the efficiency of building and related system on the other, led to a number of different standards for the evaluation of the heat pumps technical features and other characteristics. A better coordination of all actors involved in the legislative and standardisation process is probably needed for covering in a more rational way this important driver for high-efficient and low emission heating (and cooling) systems[12].

Voluntary initiatives such as the best product selection offered by Topten – cited also as reference for cooling appliances below the 12 kW of refrigerant power in the swiss standard SIA 384/2 – are promoting efficiency levels based on the EU energy label. In the portal, for heating purposes, only the first two classes of air-air heat pumps are promoted as efficient. A number of products with such features is available on the market, since years. For a more complete information: the first 2 classes of air conditioners, except double ducts and single ducts, have a seasonal coefficient of performance (SCOP[13]) higher than 4,6. The minimum allowed in the EU market has a SCOP higher than 3,06 or 3,4, depending on the refrigerant GWP lower than 150 or not. The difference between the minimum and the good efficiency is around 50%!

Looking at the bottom of the market, the MEPS for air-air heat pumps are increasing worldwide: better appliances are always available. In the most recent EU study for the revision of the regulation of such products, the proposed MEPS is a SCOP of 4.0[14].

Real efficiency and thermal comfort of air-air heat pumps

Air-air systems are also capable to provide comfort in summer and in winter: the latter depends in many cases on the quality of the envelope, rather than the installed systems. The policy focus is (and should always) primarily address the building shell energy efficiency: the priority in regulations and standards remains an effective reduction of heat loads with good insulation, sufficient thermal mass and effective shading[15].

The studies conducted in Switzerland, such as [4] that considered air-air systems developed during the '90s, were reluctant in suggesting the adoption of such technology for substituting the direct resistance electric heaters. The efficiency, effectiveness and especially the comfort level were evaluated as insufficient. Different and more recent sources [5] and [6], on the contrary are demonstrating that in Nordic climates the air-air systems, especially those of the last generation, are a good solution for heating with good efficiency and comfort. Norway, Sweden and Finland have adopted and supported this technology in the early 2000's and the solution is still proven as valid also for very efficient buildings [7].

An advantage of air-air heat pumps is that can easily provide space heating and domestic hot water and space cooling too. Especially in some regions the increasing thermal comfort demands in summer can cause a cooling demand even in residential buildings. The adoption of one single efficient system for both winter and summer can deliver significant improvements in comfort, and support correct sizing, combining also the measures for reducing the heat loads in the hot season.

Case studies using air-air heat pumps

To understand the potential of the use of air-air heat pumps for heating purposes, after discussions with designers and installers, a number of case studies was researched in the southernmost part of Switzerland, Canton Ticino, for a more detailed analysis.

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[12] See e.g. Heat pumps: lost in standards…; L Socal, REHVA Journal 4/2021

[13] SCOP (Seasonal Coefficient of Performance) defines the annual energy consumption and efficiency in typical day-to-day use. It takes into account temperature fluctuations and standby periods to give a clear and reliable indication of the typical energy efficiency over an entire heating season.

[14] Review of Regulation 206/2012 and 626/2011 on air conditioners and comfort fans. Task 7 report. Final version.

[15] See the requirements set for installing cooling systems in the swiss standard SIA 382/1, legally binding in all cantonal energy regulation

The location is in the alpine or subalpine region, at heights between 200 and 2000 metres above the sea level, in a temperate climate – also with minimum temperatures well below zero for days during the winter.

During the preliminary search of case studies, a local installer provided information on 10 installations, but with very limited documentation. All systems were from a specific manufacturer, using different models, with or without sanitary hot water integrated modules. In 6 of those cases was possible to install a separate heat pump boiler for hot water, to fully respect the Cantonal Energy law. The responsible person for the installer company, stated: "until today, all clients are extremely satisfied in terms of costs and comfort." All the internal units installed are very silent (below 30 dB in night mode). The main problem encountered was during the construction permit request, for respecting the federal law on noise reduction. In some cases, the additional costs for a silencer case for the external unit made the overall investment cost higher than originally expected (from +15 to +30%).

In a second phase were contacted both the Cantonal Energy Office and the Ticinoenergia Association, who suggested to research for well documented cases, e.g. in the list of the Minergie certified buildings. Following the suggestion, extensive research was carried out in 2020-21 for finding fully documented and efficient case studies: 4 SFH certified with the Minergie label[16] (2 new and 2 refurbished) + 1 non-certified refurbished building, but with a good insulation level.

The contact with the architects and the energy consultants was essential, to receive the technical data, the building plans, the contacts with the owners. A survey was made in all buildings selected, for posing direct questions to the occupants and collecting the consumption data from the energy bills.

A preliminary survey with the designer/installer and users was carried out, to collect as many information as possible, especially regarding construction plans and details, systems installed, historical and actual consumption. A survey in place, with tenants, was useful to understand better how the system operates.

Design: envelope efficiency and system sizing

For existing buildings is anyway often necessary an improvement in the insulation of the envelope, in order to reduce the heating power needs. This improvement has also a positive impact in the size of the new equipment, on the investment costs for the system and obviously on the annual consumption for heating. Thanks to the well-insulated building envelop the efficiency level is also higher than expected [8].

Compared to the pre-intervention state, in any case the improvement of the envelope quality (also partial) and the new heating system has increased the comfort considerably. All the occupants interviewed are satisfied, most of them are the building owners.

Another issue to solve, especially in existing buildings, was the space for installation. In many cases, especially in those with a decentralized direct electric heating or single wood stoves, the space for installation is very limited.

Investment costs

The cost for a new air-air heat pump, compared to a similar air-water was in average 30-50% less. It comprises external and internal units and the refrigerant gas distribution system.

For understanding the different investment costs towards a traditional heat pump with water distribution, a new underfloor heating could cost between 40 and 100.-CHF/m^2: for a typical SFH (new or without distribution system): the additional investment could be between 20-50k CHF, depending on the size of the household and the heating power needs.

In 4 cases the sanitary hot water is produced using another appliance: 3 have a hot water heat pump and one with a direct electric system. There is only one case that uses the same air-air heat pump,

[16] Minergie is a Swiss quality label for low-energy buildings. This standard is a guarantee of quality and low energy consumption. See https://www.minergie.com

equipped with a hydronic module for hot water production. The extra cost for such systems is comparable with the production with a dedicate SHW heat pump.

Acoustic comfort

The installation of a new heating system requires, for the cantonal building law, a construction permit. To receive the permission, is necessary to respect primarily the energy regulation[17] and the federal Noise Abatement Ordinance[18].

Heat pumps are considered a standard solution for respecting the minimum share of renewable energy – so they easily respect the energy regulation. The noise pollution is on the opposite a problematic issue, for any new installation of air source heat pump. The noise produced by the appliance must be evaluated considering the hours of functioning, the distance to the rooms sensitive to noise. The result of the determination shall respect the planning values corresponding to the sensitivity level of the building area.

All the installation of the case studies analysed are clearly respecting the legal limits[19], thanks to low noise external units, sound insulation hoods, distance towards the windows of sensitive rooms of any building surrounding the installation.

The indoor noise level is not subject to legal limits but should respect the national standard SIA 181 covering the sound insulation in building construction, that beside external and internal airborne and impact noise, set also limits for the sound produced by the technical equipment installed in buildings. The internal units installed in the case studies are capable to work at reduced speed (silent mode) with a declared sound power level Lw below 25 dB(A), accomplishing the limits suggested by the building standard. In the market are available also units capable to operate with ultra-low noise levels, below 20 dB(A). Despite the values, many system designers are still avoiding air system in the residential sector

Case study analysis

In terms of thermal and acoustic comfort the building occupants are satisfied: the good insulation level of the buildings and the quality of the indoor units can easily ensure good conditions. The energy costs are considered in line with the expectations.

Below is presented the preliminary data collection for the case studies selected. A more detailed analysis, using separate metering systems, is necessary for understanding the overall efficiency of the heating systems installed.

In the table below are presented the main features for the objects surveyed:

- The heated surface (gross heated area, calculated following the national standard SIA 380)
- The system installed for heating and hot water, with the nominal thermal power for heating
- The annual total electrical consumption, as an average of the last years, comprising all electrical end uses (appliances, heating, ventilation where installed, etc.)
- The building characteristics, in order to understand the efficiency level of the envelope
- An indicator of specific electricity consumption per square meter of heated surface

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[17] E.g. in Canton Ticino is legally binding the *Regolamento sull'utilizzazione dell'energia (RUEn)*, 2008.

[18] https://www.fedlex.admin.ch/eli/cc/1987/338_338_338/en

[19] The Federal Act on the Protection of the Environment (Environmental Protection Act, EPA) requires that for the precautionary principle the limit should be respected at least with a margin of 5 dB.

Table 1: Case studies analyzed, main features

Case study #	Heated surface (m2)	Power installed (kW)	System type	Hot water	Consumption (kWh/y)	Building charact.	kWh/m2
1	304	7.0 + 7.2	A/A heat pumps for heating and hot water	-	5500	Refurbished as Minergie in 2016	18,1
2	249	8.6 + 7	A/A heat pumps for heating	Separate A/W heat pump	9000	Minergie new building in 2004	36,1
3	100	7.0	A/A heat pumps for heating	Separate A/W heat pump	4100	Refurbished as Minergie in 2018	41,0
4	184	6.6	A/A heat pumps for heating	Separate A/W heat pump	5000	Minergie-A new building in 2014	27,2
5	85	6.4	A/A heat pumps for heating	Electric Boiler	metering in progress	Wall and roof insulation as new	n.a.

Effects for energy utilities

The reduction in the power installed, especially while substituting direct electric heaters, could be a reduction in the peak load in winter. The peak load energy cost is reduced, the load management is better, in many cases is possible to remove the blocking period[20] and guarantee a better service continuity (especially in the less dense areas).

Due to the lower energy consumption, the programming could also lead to an improvement of the primary energy factor for electricity and also reduce the emission factor. The 2018 energy mix for electricity consumed in Switzerland has a PEF of 2,67, and an emission factor of 128 gCO_2/kWh, while the average renewable electricity is 16 gCO2/kWh[21]. Having a better CO_2 emission factor could also reduce the emission compensation and help in reaching the climate targets.

A generalized better efficiency in heating production can also open the market to new forms of business, such as “heating as a service”, today only restricted in the district heating supply solutions.

A major obstacle (or disincentive) for more efficient heating solutions is the actual price of energy and more in detail the tariff structure, in many cases not consistent with energy saving. In some cases, a strong reduction in energy consumption is not proportional with the cost savings. E.g. reducing the annual consumption from 25 000 to 8 000 kWh could increase the cost per kWh in the range of 15-20%[22]. A better price signal could be introduced for incentivising exemplary interventions.

Conclusions and outlook

In Switzerland the electrification of heating started in the 1970’s with the oil crisis. The building energy efficiency policies started in the ‘90s and are mainly focusing on reducing the energy needs for heating. In order to reach the optimal results in terms of energy, cost and emissions savings, an attentive choice of the right heating system is always necessary.

The high investment costs and low energy prices are considered the main barriers against more efficient heating solutions, despite the level of incentives - that excludes air-air heat pumps. Other obstacles in Switzerland are the low building property rate, in average 38%, and the electrical energy tariffs, slightly regressive in all regions. The cost for the installation of a proper hydronic distribution system is not always economically sustainable despite the additional subsidy for its installation.

The higher efficiency of heat pumps, combined with management and control systems are an opportunity for the energy utilities: reducing the peak power, managing the supply and the demand, reducing the emissions, offering a service without interruption.

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[20] Blocking period (Sperrzeit) is a period in which, due to peak time energy management, the high-power heating systems are disconnected from the network.

[21] Umweltbilanz Strommixe Schweiz 2018, Luana Krebs, Rolf Frischknecht, 2021.

[22] See e.g. the portal https://www.strompreis.elcom.admin.ch

The reduction of the demand for heating is crucial for meeting the decarbonisation targets and the other objectives of the Swiss Energy Strategy 2050[23]. The heating demand density is already low in many regions. With a higher renovation rate for the building envelope, it will decrease even more: the small scale and decentralized heat generation is still the only cost-effective option in many cases.

A quick adoption of highly efficient solutions, typically supported by incentive schemes or obligations, will help in a rapid decrease of the energy consumption and the related CO_2 emissions. Initiatives such as the Horizon 2020 HACKS project will aim the households equipped with old and inefficient devices - boilers, water heaters, air conditioners, certain types of boilers and stoves, etc. - to replace them with new super-efficient equipment.

The quality of the appliances installed, the consumption, installation features and costs were presented for the selected case studies of new and refurbished buildings located in Switzerland. Between the 5 buildings there are new and refurbished existing buildings, almost all are low energy - certified with the Minergie quality label. The cases are located in the alpine or pre-alpine area, and adopt efficient, effective and comfortable air-to-air heat pumps installation for heating. In the next steps will be carried out a detailed analysis for understanding the efficiency and comfort level of the air-air heat pumps installed.

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