Heating with Air Conditioners: Swiss Case Studies

Eric Bush and Steffen Hepp, Topten GmbH, Zurich, Switzerland
Andrea Roscetti, Università della Svizzera italiana, Accademia di architettura
Lorenz Deppeler, EKZ Power Utilities of the Canton of Zurich, Switzerland

Abstract

Direct electric heating systems (in short: electric heating systems) consume a considerable amount of electricity in many countries. The potential for savings by replacing electric heating with heat pump heating systems is huge as electric heating systems consume a good 3 times more electricity than heat pumps.

Electric heaters are often installed as storage heaters in the individual rooms of a building and do not require a central heat supply. When replacing electric heating systems, it is therefore usually necessary to retrofit a central heat distribution system, which is very expensive and therefore unpopular.

The option of air-to-air heat pumps, in which the heat is delivered directly into the various rooms using individual appliances, is still little known in Switzerland (in contrast to other countries). There is already a mass-market proven and cost-effective technology for this: air conditioning units that are operated in heating mode. In this way, the high costs of centralised heat distribution can be saved. This study analysed the possible applications as well as the strengths and weaknesses of air conditioning units for heating.

The analysis of a dozen Swiss case studies showed that all users were satisfied with the heating solution provided by air conditioning units. In particular, the heating output, comfort and low noise emissions were rated favourably.

The option of replacing electric heating with air conditioning units should be presented to a wider public as part of information campaigns. The spread of air-to-air heat pumps could be accelerated particularly effectively with the launch of rebate programmes. In Germany, air conditioning units for heating have been subsidised since the beginning of 2024 as part of the programme «Bundesförderung für effiziente Gebäude».

Keywords: Air conditioners, Heat pumps, market transformation, best available technologies, energy efficiency requirements, energy label, rebates.

Introduction

Thanks to the integrated heat pumps, air conditioning units in heating mode are much more efficient than direct electric heaters (around 3 times more heat per kWh of electricity). Air conditioning units for both cooling and heating are a tried and tested product worldwide on a massive scale.

The use of air conditioning units to replace electric heating systems raises questions about efficiency, heat distribution, comfort, and noise. At present, the discussion in Europe does not seem to be based mainly on facts, but rather on preconceived opinions or traditions. A lot could be done with fact-based studies to tap into large efficiency potentials.

Accordingly, the aim of a Topten project [1] commissioned by the Swiss Federal Office of Energy (SFOE) and the Electrical Utilities of the Canton of Zurich (EKZ) was to analyse the possible uses, strengths, and weaknesses of air conditioning units for heating. This article summarises the findings. In particular, the following questions were addressed:

- What are the possibilities and potentials of heating with air conditioning units?
- Is it possible to replace decentralised electric heating systems with air conditioning units?
- For which building types and under which conditions can air conditioning units be suitable for heating, e.g. second homes, holiday homes, detached houses, low-energy houses, workshops, commercial premises, offices, temporary uses?

The project and especially the case studies focused on Switzerland. However, the results should also be interesting for any countries.

Case studies were analysed regarding the following key aspects:

- Efficiency based on the standardised declarations and product fiches (specification sheets) according to the EU energy label [2]
- Heat distribution in the rooms
- Comfort
- Noise (inside and outside)
- Design solutions for outdoor and indoor units and aesthetics
- Building permit issues, especially as regulations for air conditioning units are designed for cooling and not heating mode
- Opportunity for that air conditioning units, which are installed for cooling anyway, also enable efficient heating (as a replacement for direct electric heaters, oil or gas)

Methods

Two methodological approaches were used in this project, namely product research and the evaluation of case studies.

Product research

- Which products are particularly suitable for heating?
- Interviews with installers and manufacturers
- Creating a product list on Topten.eu with best models

Case studies

- Investigations and interviews
- Focus on diversity in terms of climate and house type: holiday homes, office, commercial, temporary uses
- Evaluation of electricity bills

Product research

Air conditioning units for cooling and air conditioning units for heating are not different product categories, in most cases they are not even different products. In almost every model sold today, the cooling circuit can be reversed and thus used for heating and cooling. The goal is to generate a list of criteria that products must fulfil in order to be classified as particularly suitable for heating applications.

Case studies

The case studies in this report were visited on site and the users were asked about their experiences.

The evaluation of efficiency (ratio of heat output to electricity consumption per year) was deliberately not the subject of the case studies. This value is already shown on the energy label, is measured there under standardised conditions and is monitored by national supervisory authorities. Where available, electricity bills were analysed to see whether the order of magnitude of energy consumption was roughly three times lower than with conventional heating. The results on efficiency of the "Stiftung Warentest" test of 7 air conditioners were also included [3].

Product selection and evaluation

Selection criteria

Air conditioners for heating must fulfil the following selection criteria in order to be considered energy efficient and to be listed on Topten [4] and [5]. Topten is an international online platform, presenting energy efficient products.

Efficiency criteria		
	Type	**Efficiency class Heating / Cooling mode (average climate)**
Wall-mounted devices	Singlesplit-AC < 4.0 kW Cooling power	A+++/A+++
	Singlesplit-AC >= 4.0 kW Cooling power	A++/A++
	Multisplit-AC for multiple rooms	A++/A++
Cabinet appliances	Singlesplit-AC	A++/A++
	Multisplit-AC for multiple rooms	A+/A+
Additional criteria		
Only products with a refrigerant with a GWP value below 700 are permitted (e.g. R32, R290)		

Table 1: Defined selection criteria for air conditioning units for primary use for heating

Energy efficiency and European Energy Label

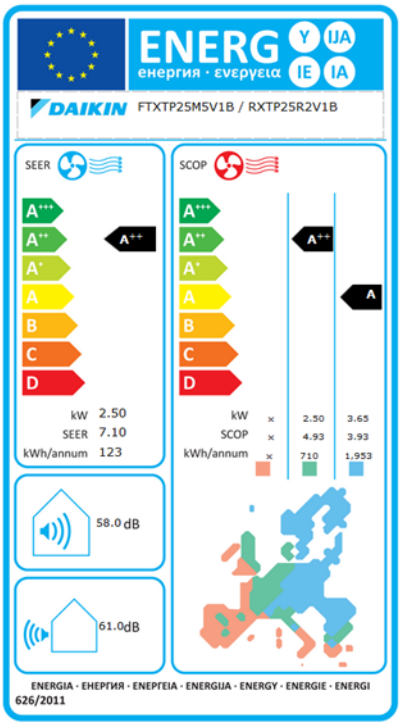

Figure 1: Example energy label [2] of a Daikin model. Source: Daikin [6]

In this example, for an average climate zone heating power is 2.5 kW and the Seasonal Coefficient of Performance (SCOP) is 4.93. This means that with 1 kWh electrical energy 4.93 kWh thermal energy is delivered (on average over the year). In addition to the energy label, there is also the product fiche, which publishes additional specifications (in accordance with standardised EU requirements).

According to the product fiche at an outside temperature of minus 10 degrees Celsius the COP is 3.09 (more than three times as efficient as direct electric heating) and that at minus 22 °C the COP is 1.56, which is still more than 50% more efficient than direct electric heating, details see [1].

The energy label declares the noise level of both the indoor and outdoor part of the air conditioner. The outdoor noise pollution can be reduced by structural measures (distance to neighbours, protection by

stone walls) or by noise protection bonnets. The compressors and fans of today's air conditioning units use inverters, i.e. they no longer operate in on-off mode, but continuously regulate the heating output. This eliminates the annoying starting noises.

“Stiftung Warentest" tested 7 air conditioners [3]. The SCOP of all models was in a range of 3.5 to 4.4. The heating power of all tested models was in a range of 2.9 and 4 kilowatts. Stiftung Warentest thus confirms the high values for energy efficiency (SCOP) and heating output declared on the energy label.

Design of the interior unit of the air conditioner

Wall-mounted units are normally installed at the top under the ceiling. Flaps make it possible to control the direction of air flow, which ensures good air distribution in the room.

Figure 2: Examples of Daikin wall-mounted units

Figure 3: Example of Toshiba Haori wall-mounted unit

Although chest and floor-standing appliances have significant advantages, they are still rarely used. As warm air rises upwards, the air outlet at the bottom is ideal for heating the entire room evenly. In addition, the free-standing appliance can at best utilise the space that was previously used for an electric heater. Chest units have two openings for the air outlet, one at the top and one at the bottom. In cooling mode, the air is only discharged from the top opening.

Figure 4: Chest units (source: Daikin on the left, Topten on the right)

Dimensioning the air conditioning system

At low outside temperatures, the heat requirement of both conventional heat pumps and air conditioning units is very high and at the same time the efficiency of the heat pump is low. Air conditioning systems must be dimensioned so that they function well at the prevailing, even cold, temperatures. Air

conditioning units can also provide high heating outputs. In multi-split systems, up to 5 indoor units can be connected to one outdoor unit.

Manufacturer messages on heating with air conditioning units

Manufacturers of air conditioning systems are increasingly presenting their models for heating applications. The suitability and applicability of air-to-air heat pumps as a heating solution are extensively discussed and described and promoted on the manufacturers' websites. This includes technical adaptations such as frost protection, automatic defrosting or tub heating, but also various programmes and functions, which in the manufacturers' marketing language are: "Heat Boost" (Daikin) [7], "Hyper Heating Technology" (Mitsubishi) [8], "Optimised Heating 4" (Daikin) [9], "Max Heat 3.0" (Samsung) [10], "Fireplace Mode" (Toshiba) [11].

Large differences from country to country

In many countries, such as Switzerland, France or Germany, heating with air conditioning units is largely unknown and is hardly ever used. In contrast, it is very common in many Asian countries or e.g. in Sweden to heat with air conditioning units.

Air conditioners play a crucial role in space heating during winter in China. Over 97% of room air conditioners sold in China now offer both cooling and heating, see report of Clasp [12]. According to this report air conditioners have become one of the most important types of space heating equipment in China, especially in the hot summer and cold winter climate zones.

Rebate programmes

Rebate programmes of air-to-air heat pumps in the German building rebate programmes

In Germany, air conditioning units for heating have been subsidised nationwide since the beginning of 2024. The funding is embedded in the comprehensive programme "Bundesförderung für effiziente Gebäude" [13]. One measure in this programme is the heating subsidy. It subsidises the "installation of efficient heating systems. The aim of the promotion is to accelerate the switch to climate-friendly heating systems. The catalogue of eligible heating technology includes heat pumps. This explicitly includes air-to-air heat pumps, that means air conditioners ([13], page 26).

For a privately owned single-family home, investment costs of up to 30’000 € can be claimed. The maximum subsidy rate is 70% of the investment costs, i.e. up to 21’000 €. The basic subsidy amounts to 30%, i.e. up to 9000 €.

The application process in Germany is time-consuming and complicated. The subsidy is subject to a large number of requirements including a series of supporting documents. That this can hardly be managed by a private individual is reflected in the fact that a listed expert for energy efficiency or a registered specialist contractor must always be commissioned. Over-regulation may result in bureaucratic and planning costs that are not necessary and eat up the applicant's financial incentives. These hurdles should be avoided from the outset when implementing rebate programmes.

Intentions to launch a rebate programme by the Power Utilities of the Canton of Zurich (EKZ)

In the Canton of Zurich, there are still a large number of inefficient electric heaters in use, totalling 10’000, which consume around 140 GWh of electricity per year. Replacing them is often unreasonably expensive if a centralised heat distribution system must be installed. This is where air-to-air heat pumps (air conditioning units in heating mode) are favourable. The EKZ therefore intends to launch a rebate programme for heating solutions using air-to-air heat pumps in its supply area.

The focus of EKZ when designing the rebate programme is to keep the criteria as pragmatic and simple as possible. All unnecessary criteria should be avoided in order to prevent a reduction in impact and to keep the administrative burden low for both the customer and the subsidiser.

The main criteria of EKZ for rebates are:

- One subsidy is possible per apartment

- Flat rate of 2'000 Swiss francs per appliance (approx. 2000 €, 2200 US$), maximum 25% of the investment costs
- Efficiency criterion for operation in heating mode: A++ (exception: multi-split chest appliances: A+)

Case studies

As part of this project, twelve properties were analysed in which air conditioning units were used for heating. In addition, three offers were drawn up to replace existing electric heating systems with air conditioning units. The following table provides an overview of all these cases.

Single family house is abbreviated by SFH.

Cases	**Inst. heating power**	**Operating hours**	**Brief description**
Realised cases			
Bike repair shop, St. Gallen	5.1 kW	Office hours	Suitability for temporary use, fast heating system
SFH, Ticino	22.0 kW	Inhabited year-round	Solution for SFH, high standard, ceiling heating
Tiny House, Berne	4.2 kW	Inhabited year-round	New build, low energy, high standard, underfloor heating
Mobile home (1), Fribourg	5.2 kW	Inhabited year-round	Holiday home, cost-effective replacement of electric heating
Mobile home (2), Fribourg	4.0 kW	Inhabited year-round	Holiday home, cost-effective replacement of electric heating
Art atelier, St. Gallen	6.2 kW	Irregular hours	Fast system and quiet compared to oil heating
Ecocentro Melano, Ticino	13.2 kW	Irregular hours	New build, very low energy, commercial construction
SFH Cerentino, Ticino	8.0 kW	Inhabited year-round	Low energy, retrofitting with central heat distribution not possible
Residential building, Ticino	15.0 kW	Inhabited year-round	Low energy, complete refurbishment
Holiday home, Grisons	5.0 kW	Temporarily inhabited	Holiday home, stone house, frost protection with AC
Alpine restaurant, Grisons	4.0 kW	Tourist season	Heating with air conditioning for 8 years, traditional timber construction
Traditional SFH, Grisons	4.1 kW	Inhabited year-round	Heating replacement realised at short notice, aesthetics of outdoor unit
Offers			
Holiday home, Grisons	5.0 kW	Inhabited year-round	The owners are already at an advanced age, It is still unclear how the heirs will use the house
Holiday home, Grisons	10.5 kW	Temporarily inhabited	High-quality property, complete refurbishment planned
Art atelier, Grisons	4.0 kW	Irregular hours	Future utilisation intensity open

Table 2: Overview of the case studies

All the case studies are described in more detail in [1] and some of them below.

Bike repair shop, St. Gallen

Figure 5: Bike repair shop: Indoor and outdoor units (Daikin). The air conditioning system is programmed the evening before so that the desired interior temperature prevails at the start of work.

Even before the two new buildings were constructed, the owners weighed up the various heating options. The alternatives considered included air conditioning units, underfloor heating and radiant heaters. The decision was made in favour of air conditioning due to its flexibility, low cost and high reactivity. The owners' state: "We don't know whether the buildings will still be standing in 10 years' time." The air conditioning system could be installed quickly and could be dismantled and disposed of or used elsewhere just as quickly.

The investment costs for the air conditioning units are very low compared to the alternative of underfloor heating (air-to-water heat pump). The total investment costs for the air conditioning units were 5000 €. Underfloor heating would have cost around 20'000 €.

Reactivity is particularly important. The air conditioning system allows you to react quickly to external temperature fluctuations. In the event of a sudden cold snap, a pleasant interior temperature of 19 °C can be maintained.

All in all, the owners are very satisfied with their heating solution with air conditioning unit.

Mobile home, Fribourg

Figure 6: This mobile home is heated with an outdoor unit and 3 indoor units by Panasonic.

The investment costs for the air conditioning system were significantly lower than any alternative without a centralised water distribution system. The ability to heat rooms individually (with remote control) reduces power consumption considerably. The noise level of the indoor and outdoor units is not perceived as disturbing. All in all, the owners are very satisfied with their heating solution with air conditioning.

Ecocentro Melano, Ticino

Figure 7: Recycling centre with municipal depot (with high energy efficiency standard). The office, reception, repair workshop, cloakrooms and the sanitary facilities (showers and toilets) for the employees are equipped with a VRF system by Daikin.

The intensity of use of the building varies greatly throughout the week. The facility is open to the public four days a week for around 16 hours. The workshop room is only used irregularly (depending on demand) and is only heated when it is in use. The remaining rooms for the workers are used from Monday to Saturday. This irregular utilisation makes it challenging to find an efficient heating system. In the end, the decision was made in favour of a heating solution with air conditioning units.

The recycling centre is heated by a VRF (Variable Refrigerant Flow) system. A VRF system is an air-to-air heat pump system for commercial buildings which, in contrast to multi-split air conditioning systems from the residential sector, has a central line to the outdoor unit from which the individual indoor units are supplied with a branch line to the main line. Instead of 5-6 indoor units, the outdoor unit on the roof can therefore serve up to 100 indoor units.

Due to the internal insulation in the building (approx. 20 cm), the thermal capacity is barely usable to keep the warmth indoor and a reactive and fast heating system is required. Thanks to the good insulation of the building, heating up is relatively quick. It is possible to heat all rooms to the target temperature in less than an hour.

The investment costs for the VRF system totalled around 32’000 €. The heated area is 86 m^2 and the total electricity consumption is expected to be less than 2000 kWh/year, which corresponds to a total consumption of around 23 kWh/m^2 per year for heating, cooling, ventilation, lighting and building services.

From the outset, the HVAC planner's aim was to create a flexible, fast, and efficient heating system. The most important requirements were:

- Simple control and handling
- High efficiency
- Low investment costs (compared to an air-water system, which is twice as expensive for underfloor heating)
- Fast response in providing comfortable temperatures in the event of short-term activation or after prolonged inactivity (also thanks to good insulation)
- Control of the heating zones with individual setpoint and individual control in each room

For an industrial building of small municipal government in particular, the main requirements were reliability, simple operation, low energy consumption and low maintenance costs. The reactions from users are very positive.

Traditional house, Grisons

The traditional house from the 16th century is located at an altitude of around 1200 metres above sea level and was extensively renovated in 1985.

Figure 8: Outdoor unit on the left on the balcony (without visual impairment of the traditional building)

Figure 9: External unit of the AC

Figure 10: Internal unit of the AC

The traffic zone with stairs used to be heated electrically with underfloor heating throughout the heating period. The heat also warmed the three rooms on the upper floor (bedroom, guest room, bathroom). The floor heating had an output of 1.8 kW and was switched on for 5 hours (4 am to 9 am), which resulted in an electricity consumption of 9 kWh per day. The room temperature achieved was up to approx. 14°C, depending on the weather. A lot of heat was lost to the cellar through the concrete floor.

In December 2023, the electric heating was replaced by an air conditioning unit (Daikin) with a nominal power consumption of 1.6 kW and a nominal heating output of 4.1 kW.

The owners have an overall favourable impression of the equipment:

Although the target temperature was raised from 14 to 19°C, electricity consumption was reduced considerably. The noise level both inside and outside is perceived as very quiet and not disturbing. The chest model heats thanks to radiation, with a controllable air outlet at the top and an air outlet at the bottom of the appliance. The "floor" function, where only the air outlet at the bottom by the feet and convection are used, provides targeted comfort in the home office workstation directly next to the indoor unit while avoiding a draught on the upper body. In "Heat Boost" mode, the room can be heated up in a very short time after switching on. Comfort, cosiness and temperature have improved massively. It was key that the visual impact on the building should be minimised. The outdoor unit directly on the facade would have been a nuisance, so an optimal solution was found by placing it behind the balcony railing.

Residential building in Vacallo (TI)

This house with two flats is located in the southern part of Switzerland with a mild climate 360 metres above sea level. A high energy quality was achieved with an overall refurbishment. The two separate systems for mechanical ventilation with heat recovery ensure good air quality and help to reduce heating energy requirements. The building has a photovoltaic system on the roof.

As part of the refurbishment, various heating solutions were evaluated, and the installation of an air conditioning system was deemed to be the best option. At the same time, a decision was made against radiator heating, primarily because it avoided expensive retrofitting of a central heat distribution system.

Figure 11: Outdoor unit on the balcony

Figure 12: Interior unit in the studio below the roof

In the building, the temperature for each room can be controlled individually by the respective indoor unit of the air conditioning system.

The investment for the air conditioning system, including installations, cost around 25’000 €.

The heating energy requirement for this house is 50 kWh/m2/year. The electrical energy required for this is 16.5 kWh/m2/year. This results in an annual coefficient of performance (SCOP) for the air conditioning system of 3.

The aim of the renovation of the house in Vacallo was to revitalise an existing and outdated building at a reasonable cost while ensuring comfort and environmental sustainability. The figures provided and the interview with the owner show that this objective was achieved at a reasonable price. The feedback from the users in terms of convenience and user-friendliness has been very positive.

The noise from the outdoor unit is certainly audible on cold nights, especially when staying on the terrace. However, this is not at all disturbing, as the terrace is not usually used on cold nights anyway. The indoor units are noiseless and can be programmed to go into a special "sleep mode" at night.

The owner is very convinced by this heating solution and would not be persuaded to use any other solution.

Discussion and recommendations

Large savings potential

As air-to-air heat pumps, air conditioning units have a very high energy efficiency. According to the European energy label, the efficiency values for heating (SCOP) for single-split air conditioners are over 5.1 in the best efficiency class A+++, over 4.6 in class A++, over 4.0 in class A+ and even in class A still over 3.4. The high efficiency values have been confirmed by tests carried out by Stiftung Warentest [3]. As a general rule, air conditioners consume 3 to 5 times less electricity than direct electric heating systems. This results in high savings in electricity costs.

The air conditioning units can generate sufficient heat even at very low outside temperatures. The efficiency at minus 20 °C is still around 50% better than electric direct heating systems. On an annual average basis, the efficiency is around 3 times higher.

Low investment costs

The main cost advantage over conventional heat pumps results from the fact that heating with air conditioning units does not require a centralised heat distribution network with radiators or underfloor heating. In particular, retrofitting a central heat distribution system to existing buildings with electric room heating systems can be very expensive and uneconomical.

Large variety of applications

At the beginning of this project, it was expected that holiday homes and second homes in particular would have great potential for replacing electric heating systems. In practice, it has been shown that the range of applications in which air conditioning units are used for heating is significantly wider. To summarise, it can be said that air conditioning units are already used for heating wherever there is no water distribution network and an alternative to electric heating is required. They are used in holiday homes, low-energy buildings, residential houses, office and commercial buildings, studios, restaurants and doctors' surgeries. They are used in existing buildings following refurbishment but are also often the first choice for new buildings.

The air conditioning units are also often used as an interim solution for temporary use. The advantage lies in the low costs and the quick installation and de-installation. The units can therefore be dismantled and sold at a later date.

Finally, air-to-air heat pumps are also used in modern electric cars because they increase the range by up to 20% compared to electric cars with conventional electric heating. Tesla was therefore one of the first manufacturers to start installing heat pumps in its Model Y in 2021 and is now doing so across its entire model range [14].

Positive feedback from users

There were no cases in which users stated that the air conditioning had not reached the desired temperature and that they were cold, despite having been installed in areas where very low temperatures are common in winter. The performance limit of the appliances was never reached. The appliances were apparently correctly selected and dimensioned in all cases.

It is noticeable, that the issue of noise and draught in the interiors was not proactively addressed in any of the cases. The noise is probably a former problem that has become redundant with the speed-controlled compressors without annoying on-off mode. Obviously, noise levels are low with modern equipment.

Another advantage lies in the fast responsiveness of the air conditioning units. This is particularly important in cases of irregular use or for buildings with low thermal capacity. On top of this air conditioning units can react very quickly to solar gains through large windows.

Overall, the residents and users of the cases analysed expressed a high level of satisfaction with their heating solution and would recommend the heating concept with air conditioning units to others.

Potential for improvement in controls, thermostats, and frost protection

There is the impression that the air conditioning units are strongly designed with a focus on the cooling function and that optimisations for heating operation could still bring considerable benefits.

Recommendations

In this study, a dozen case studies were analysed to investigate the suitability of air conditioning units for heating in a wide range of building types. We recommend investigating the topic of heating with air conditioning units in different climate zones, in several countries and in greater depth. The project has shown that the areas of application are much broader, all applications should be covered, residential houses, low-energy buildings, commercial premises, holiday or leisure homes and temporary uses.

The results of this study show very large potential savings that are still unrealised with air conditioning units for heating. Although the heating solution with air conditioning units is already being used by some specialists, the solution is still largely unknown or underestimated among experts. As part of information campaigns, the concept of using air conditioning units for heating and replacing electric heating should be presented to a wider public. In particular, trade associations, planners, installers and building owners should be addressed and familiarised with the concept.

The launch of rebate programmes could be extremely effective in accelerating the spread of the technology. This generates important incentives for both suppliers and building owners. As in Germany, subsidy programmes can be embedded in large programmes for efficient buildings with large subsidies and a demanding application process or, as with Zurich's planned rebate programme, pragmatically focus on straightforward application criteria and only offer smaller subventions in return.

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