Heat Pumps in Multi Family Buildings
IEA Annex 62

Case Studies
University of Geneva

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Laurana, Geneva – Switzerland

Renovation of a DH heat production plant combining gas boilers with a HP for flue gas heat recovery and geothermal heat production via a borehole field.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	*1960*
DH renovation	*2012*
Type	*Multifamily building*
Heat distribution	*Radiators*
Heated area	*100'000 m²*
Level of insulation	*None/poor*
Heat production	*10 GWh/y (103 kWh/m²/y)*

Heat pump and source

Number of HP	*1*
Installed capacity	*340 kW_{th}*
Operation mode	*Bivalent with 9.8 MW gas boilers*
Heat source	*Flue gas recovery & borehole field (44 probes x 300 m)*

Heating system

SH share, demand	*69%, 70 kWh/m²/y*
Heating temperature	*Max. 60°C at -5°C*

Domestic hot water

DHW share, demand	*31%, 32 kWh/m²/y*
Type of system	*Central per building*
Max. temperature	*60°C*
Circulation system	*Yes*

Other information

HP share	*14%*
SPF	*measured: 3.0*
Gas boilers share	*86%*
Investments costs	*CHF 120.-/m²*
Heat cost (LCOE)	*CHF 22.-/m²/year*
Ventilation	*Single-flow*

Lessons learned

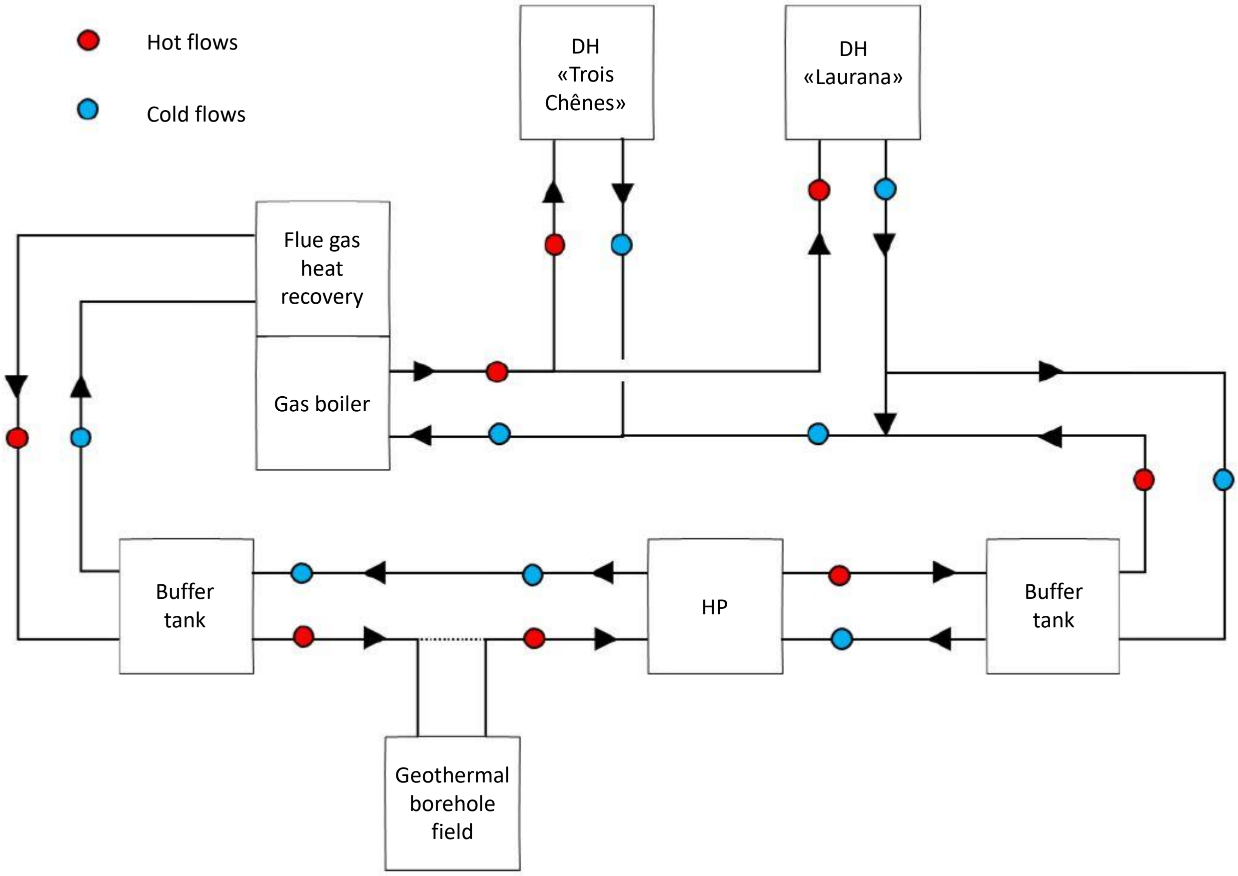
- DH return temperature is a key factor for HP integration on DH network.

This study concerns the renovation in 2011 of an existing DH plant and the extension of its DH, supplying 18 substations. The renovation implied the replacement of three oil boilers (cumulated power of 3.3 MW) by three new gas boilers (cumulated power of 9.8 MW, with a two-stage heat recovery system) and a dual source HP with a thermal power of 0.34 MW. The HP sources are geothermal (borehole field of 44 heat exchangers of 300m) and gas (waste heat recovered from the vapour condensate of the gas boiler).

The extended DH ("Laurana" and "Trois-Chênes" sectors combined) has a high linear density (7.3 MWh/m/year) and is responsible for the heat delivered to approximately 100'000 m² of heated surface, with 2'500 inhabitants, for 7 MW of subscribed power.

This renovation intended to use a borehole field as seasonal storage for flue gas waste heat recovery, which would allow the shutdown of gas boilers in summer. In reality, the gas boilers continue working throughout the summer, limiting energy extraction from the boreholes as well as seasonal storage.

Laurana, Geneva – Switzerland: Technical details



Description of the technical concept

In this system, heat production for both DH ("Trois-Chênes" and "Laurana") is provided by a set of gas boilers (total of 9.8 MW), complemented with a HP (340 kW_{th}). There are two heat sources for the HP: flue gas heat recovery from the gas boilers and a geothermal borehole field (44 probes of 300 m deep).

Heat recovery from flue gas condensation, which takes place at a temperature too low to be used directly on the networks, is routed to a reservoir at tepid temperature. This heat is used either directly as a heat source for the HP, or to recharge the geothermal probes, which constitute the second heat source for the HP.

The HP heat production feeds the return flow of the "Laurana" DH, via a buffer tank, which enables the management of the different flow rates between HP and DH (hydraulic separation). Mixed with that of "Trois-Chênes", the return flow from "Laurana" DH finally goes back to the gas boilers, which supply the additional heat needed to reach the supply temperature needed on these two DH.

DH supply/return temperatures here are typically 75-65°C/55°C.

Final report: FAESSLER, Jérôme et al. (2016). Réseaux thermiques multi-ressources efficients et renouvelables : Retour d'expérience sur la rénovation de la chaufferie de quartier de Laurana-Parc à Thônex (GE).
Url: https://archive-ouverte.unige.ch/unige:93169

Les Vergers, Geneva – Switzerland

An eco-district including 33 high performance buildings heated by a 5 MW_{th} HP on shallow groundwater.

Key facts

Building	
Location	*Geneva, Switzerland*
Construction	*2015-2020*
Type	*Multifamily building*
Heat distribution	*Underfloor heating*
Heated area	*170'000 m²*
Level of insulation	*High performance*
Heat pump and source	
Number of HP	*1*
Installed capacity	*5000 kW_{th}*
Operation mode	*Monovalent*
Heat source	*Ground water & heat recovery*
Backup heat source	*Geneva's main DH (gas boilers & waste incineration)*
Heating system	
SH share, demand	*64%, 46 kWh/m²/y*
Heating temperature	*Max. 35°C at -5°C*
Domestic hot water	
DHW share, demand	*36%, 26 kWh/m²/y*
Type of system	*Central per building*
Max. temperature	*60°C*
Circulation system	*Yes*
Other information	
HP share, SPF	*85%, measured: 3.7*
Backup heat source	*15%*
Heat cost (LCOE)	*CHF 13.-/m²/year*
PV installation	*12'000 m²*
Ventilation	*Double-flow, or Single-flow with decentralized exhaust air HP for heat recovery*

Lessons learned

- High DH return temperature (mainly in mid-season in SH mode, all year round in DHW mode) causes a degradation of the HP SPF, or causes HP shutdowns.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"Les Vergers" is an eco-district composed of 33 high performance buildings, whose main heat source is a low temperature district heating network. This network is mainly supplied by a water-to-water HP using two resources: groundwater from the Rhone River and waste heat from the neighboring industries.

The results show that this eco-district is in line with the cantonal energy master plan, both in terms of building energy efficiency and massive integration of renewable energies.


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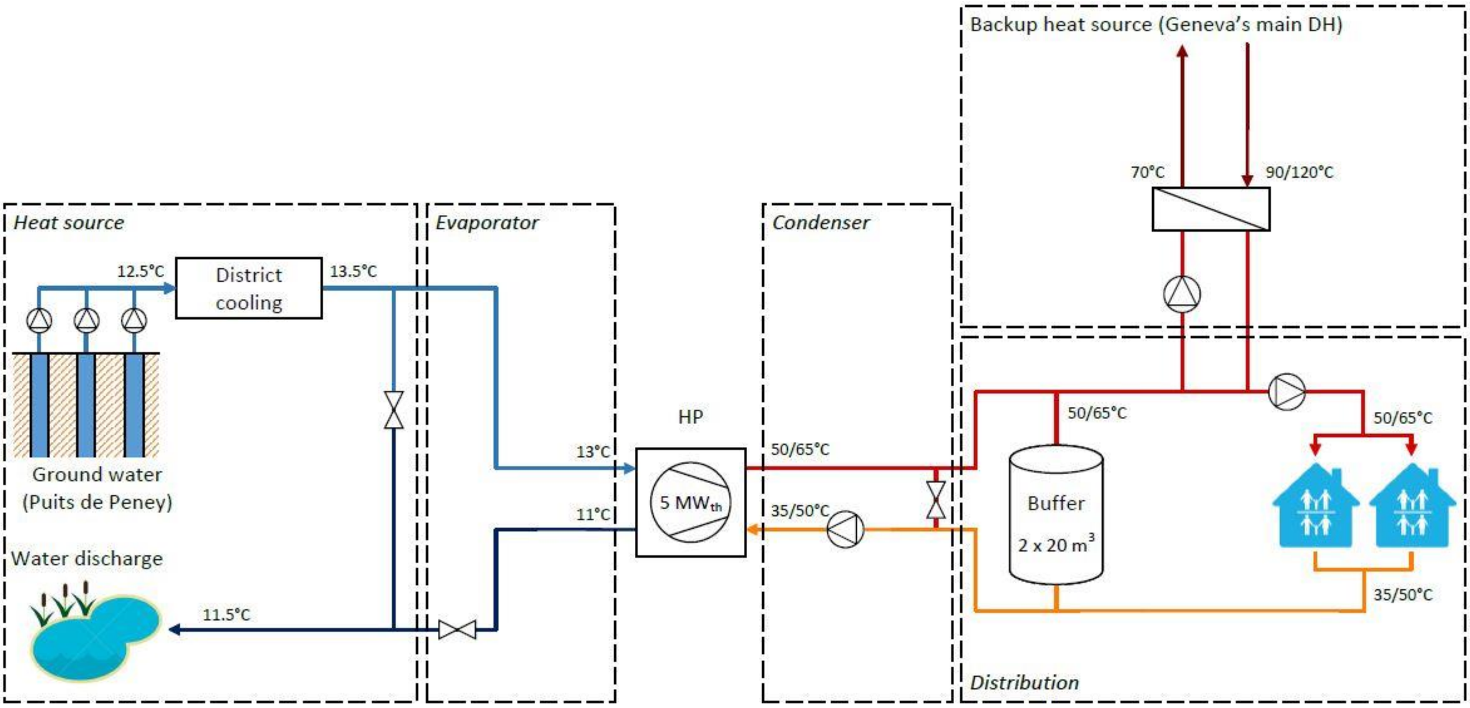
Prefabricated DH substation

Les Vergers, Geneva – Switzerland: Technical details



Description of the technical concept

"Les Vergers" is an eco-district including 33 high performance buildings, with around 1'350 dwellings and various activities, totalizing 170'000 m² of heated area. A local low-temperature district heating network (LTDH) distributes heat to the buildings for SH and DHW. Since all connected buildings meet high energy performance standards, the LTDH supplies heat at a low temperature level (50°C). At fixed time, twice a day, the supply temperature of the network is raised from 50°C to 65°C to heat up DHW tanks located within the buildings over a 2-hour period. Compared to a network with a constant supply temperature of 65°C, this lowers DH heat losses and increases the energy performance of the heat production. The LTDH is supplied by a 5 MW_{th} HP, whose heat source is shallow groundwater. Before reaching the HP, this cold water at approximately 12°C supplies a district cooling network, recovering waste heat from the nearby industries, thereby increasing the resource temperature for the HP and improving its efficiency. As complementary or back-up heat source, the LTDH is connected to Geneva's high-temperature main district heating network, which is supplied by gas boilers and heat recovery from the city's waste incineration plant.

The DH substations consist here of two parallel primary heat exchangers, one for SH distribution and the other for DHW production. Buildings are equipped with ventilation heat recovery, mostly by way of exhaust air HP, producing heat for DHW preheating and/or SH.

The LTDH heat production (July 2019 – June 2020) is covered at 85% by the HP and at 15% by CAD-SIG (due to HP maintenance). The monitored HP SPF is 3.7, the COP reaches 4.3 in SH mode (condenser outlet at 50°C) and 3.3 in DHW mode (condenser outlet at 65°C). The heat source/evaporator inlet varies between 13-16°C.

Final report: SCHNEIDER, Stefan, BRISCHOUX, Pauline, HOLLMULLER, Pierre (2022). Retour d'expérience énergétique sur le quartier des Vergers à Meyrin (Genève). Url: https://archive-ouverte.unige.ch/unige:164877

SolarCity, Geneva – Switzerland

Solar assisted HP in combination with unglazed solar collectors for a new multifamily building complex in Geneva, Switzerland.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	*2010*
Type	*Multifamily building*
Heat distribution	*Underfloor heating*
Heated area	*927 m^2 (one block)*
Level of insulation	*High performance*

Heat pump and source

Number of HP	*1*
Installed capacity	*30 kW_{th}*
Operation mode	*Monovalent*
Heat source	*116 m^2 unglazed solar collectors*
Backup heat source	*Direct electricity*

Space heating

SH share, demand	*28%, 19 $kWh/m^2/y$*
Heating temperature	*Max. 35°C at -5°C*

Domestic hot water

DHW share, demand	*72%, 48 $kWh/m^2/y$*
Type of system	*Decentralized*
Max. temperature	*60°C*
Circulation system	*No*

Other information

HP share, SPF	*80%, measured: 2.7*
Direct solar heat	*19%*
Backup heat source	*1%*
Ventilation	*Double-flow*

Lessons learned

- Excellent system reliability.
- A single heat distribution circuit with decentralized DHW storage which doesn’t allow for solar preheating and thus deteriorates the potential of direct solar heat production.
- A high part of the heat is produced at high temperature (60°C) for DHW production, decreasing the expected SPF.

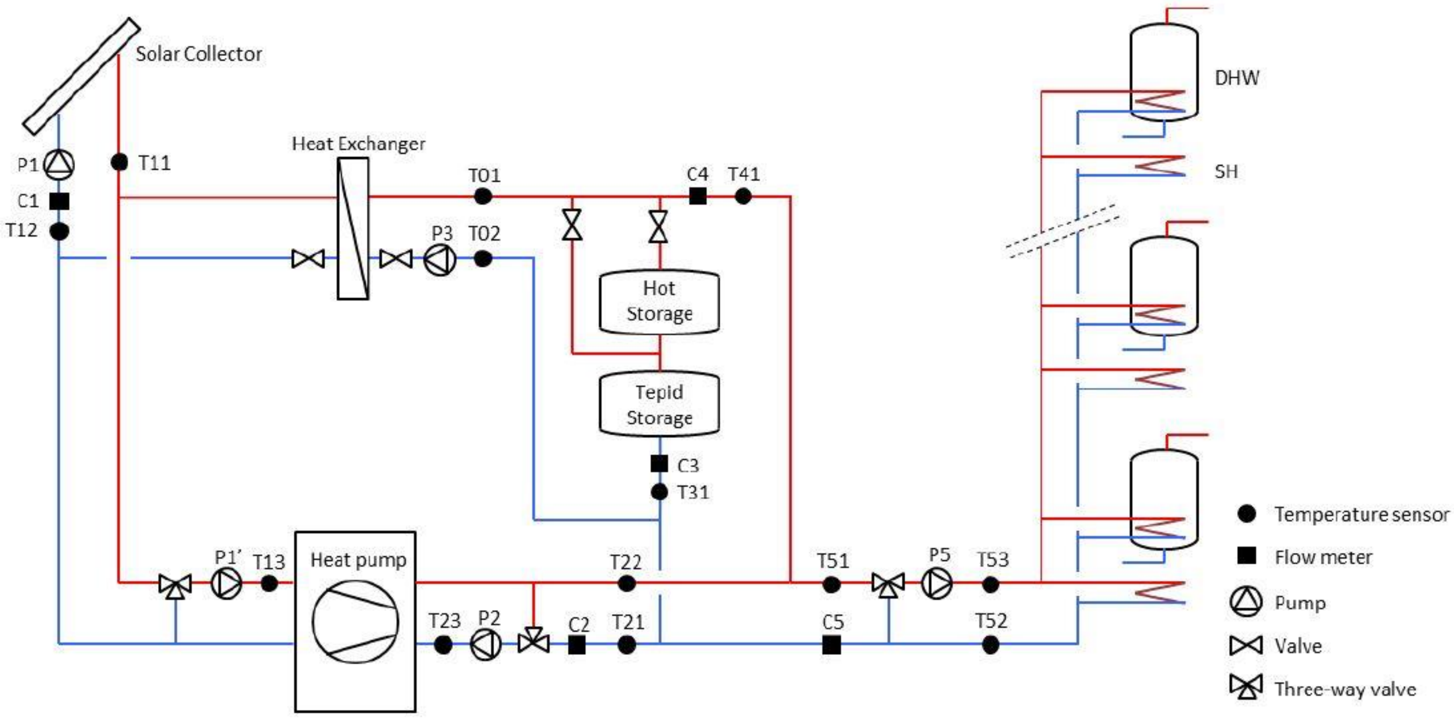
This case study concerns a coupled solar and HP system which was implemented in 2010 in a new housing complex, called SolarCity, located in Geneva (Switzerland).

The complex is composed of 4 buildings, each subdivided in 2 or 3 blocks, for a total of 10 blocks. The buildings present a high thermal performance envelope and a total living surface of 9’552 m².

This case study concern only one of the 10 existing buildings blocks, which are all equipped with their own identical and independent heat production system.

The results show a very low SH demand for Switzerland and an unusually high DHW consumption, which can partly explain the relatively low HP SPF.

SolarCity, Geneva – Switzerland: Technical details



Description of the technical concept

The energy concept consists of solar collectors that can be used for direct solar heat production, via a heat exchanger, but are also the heat source of the HP (they are directly connected to the evaporator). Hence, when there is no solar radiation, the solar collectors work as a heat absorber on ambient air.

For each building block, there is: a 30 kW_{th} heat pump; 116 m^2 of unglazed solar collectors; 2 x 3’000 L of water for centralized heat storage with an electric rod in the storage tank in case of HP failure.

A specificity of the system consists in a single distribution circuit to the flats, so that SH (floor heating) and DHW cannot be supplied simultaneously and therefore are supplied alternatively. Each flat is therefore equipped with a 300 L DHW tank. DHW distribution has priority over SH distribution, which means that when one of the 300 L tanks is at a temperature below 40°C, the system switches automatically to DHW mode and rises the temperature of all the 300 L tanks up to 60°C.

The system has 4 main operating modes, with the following priorities: (i) Direct solar heat production for SH or DHW (bypassing the HP), the surplus being used to charge the heat storage; (ii) Storage discharge, which is activated when the solar production does not reach the required distribution temperature; (iii) Activation of the HP when the storage temperature is below the required distribution temperature, with surplus production used to charge the heat storage; (iv) Direct electric heating, which is activated in case of HP failure (in particular when the evaporator temperature drops below -20°C).

In summer, the system can also be used for night cooling, by activating the floor distribution circuit and dissipating the heat in the solar collectors.

Final report: DE SOUSA FRAGA, Carolina (2017). Heat pump systems for multifamily buildings: which resource for what demand? Thesis, University of Geneva. Url: https://archive-ouverte.unige.ch/unige:94939

Soubeyran, Geneva – Switzerland

Heat pumps on exhaust air for space heating and domestic hot water in a very high performance multifamily building.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	*2017*
Type	*Multifamily building*
Heat distribution	*Underfloor heating*
Heated area	*4'607 m²*
Level of insulation	*High performance*

Heat pump and source

Number of HP	*2*
Installed capacity	*44 kW_{th}*
Operation mode	*Bivalent*
Heat source	*Exhaust air*
Backup heat source	*Gas boiler (125 kW)*

Heating system

SH share, demand	*66%, 35 kWh/m²/y*
Heating temperature	*Max. 35°C at -5°C*

Domestic hot water

DHW share, demand	*34%, 18 kWh/m²/y*
Type of system	*Centralized*
Max. temperature	*60°C*
Circulation system	*Yes*

Other information

HP share, SPF	*38%, measure: 3.28*
Gas boiler share	*62%*
PV installation	*30 kWp*
Ventilation	*Single-flow with heat recovery*

Lessons learned

- Heat recovery in new MFB buildings, especially from ventilation, has the potential to cover a large part of their heat demand.
- While the use of HPs on exhaust air for the preheating of DHW is widespread, their use for combined DHW and SH production is much less known, results in a more complex system, for which standard solutions and hydraulic schemes need to be developed.

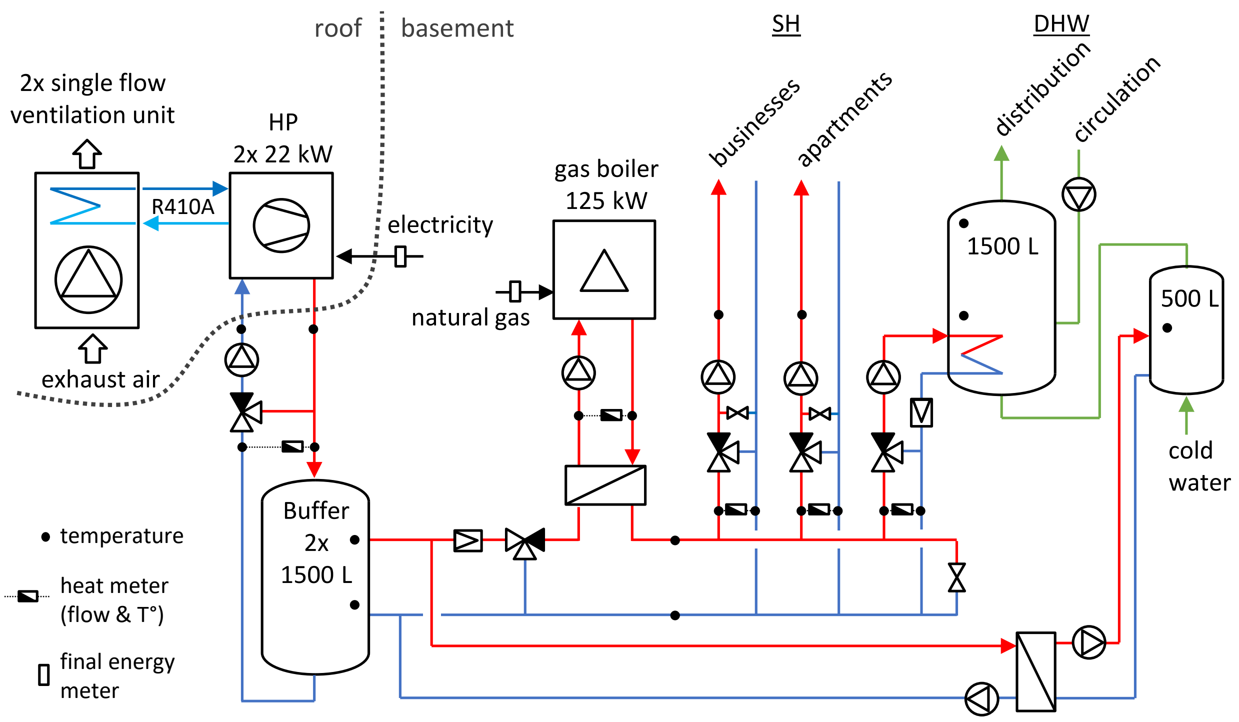
Located in Geneva and built in 2017 by two housing cooperatives, the building under consideration has a 4607 m² heating reference area, which includes business premises on the ground floor and collective housing on the 5 upper floors. Its planned SH demand (18.6 kWh/m²/year) meets the cantonal "very high energy performance" standard.

Despite of the relative difference between planned and effective SH demand, which is a common situation, the SH demand of this building is close to the median of Geneva's multifamily buildings constructed between 2011 and 2020.

In contrast, the DHW production turns out to be at the lower end of a benchmark on existing MFBs in Geneva.

HP on the roof & exhaust air vents in the back

Soubeyran, Geneva – Switzerland: Technical details



Description of the technical concept

The heat production system consists of two exhaust-air HPs (2 x 22 kW_{th}), which supply the underfloor SH system as well as DHW preheating, via common buffers. A condensing gas boiler (125 kW) ensures the complementary SH and DHW production. A 3-way valve allows to send the return flow from SH and DHW production directly to the gas boiler heat exchanger if its temperature is higher than that available in the accumulators, which happens when the gas boiler is in operation.

Heat recovery in new MFB buildings, especially from ventilation, has the potential to cover a large part of their heat demand. While the use of HPs on exhaust air for the preheating of DHW is widespread, their use for combined DHW and SH production is much less known.

In this case study, a HP system on exhaust air covers 38% of the heat production for SH and DHW of a new MFB, against a 61% projected value. Such discrepancy seems to be due to: i) a miss evaluation of the actual HP production / performance, as well as of the intrinsic HP temperature limitations in regard to DHW production; ii) a non-optimized hydraulic system, inducing unnecessary HP temperature degradation along the distribution chain.

While such solutions seem of interest for high energy performance buildings, and a fortiori when the DHW demand is lower than the potential heat recovery on exhaust air, it results in a more complex heat production and distribution system, for which standard solutions and hydraulic schemes need to be developed, and further monitoring in real condition of use needs to be done.

Final report: CALLEGARI, Simon Augustin, HOLLMULLER, Pierre (2023). Soubeyran 7 : pompes à chaleur sur air vicié avec valorisation pour le chauffage et l'eau chaude sanitaire, dans un immeuble d'habitat collectif de très haute performance énergétique à Genève. Url: https://archive-ouverte.unige.ch/unige:169454

St-Julien, Geneva – Switzerland

Two industrial air-to-water HPs for replacement of an old oil boiler, assuring 100% of the heat production for SH and DHW in an existing non-retrofitted multifamily building.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	1972
Type	*Multifamily building*
Heat distribution	*Radiators*
Heated area	*4050 m^2*
Level of insulation	*None, except retrofitted roof*

Heat pump and source

Number of HP	*2 x 156 kW_{th}*
Installed capacity	*312 kW_{th}*
Operation mode	*Monovalent*
Heat source	*Air*

Space heating

SH share, demand	*58%, 77 $kWh/m^2/y$*
Heating temperature	*Max. 55°C at -5°C*

Domestic hot water

DHW share, demand	*42%, 55 $kWh/m^2/y$*
Type of system	*Central*
Max. temperature	*60°C*
Circulation system	*Yes*

Other information

HP share, SPF	*100%, measure: 2.3*
Ventilation	*Single-flow*

Lessons learned

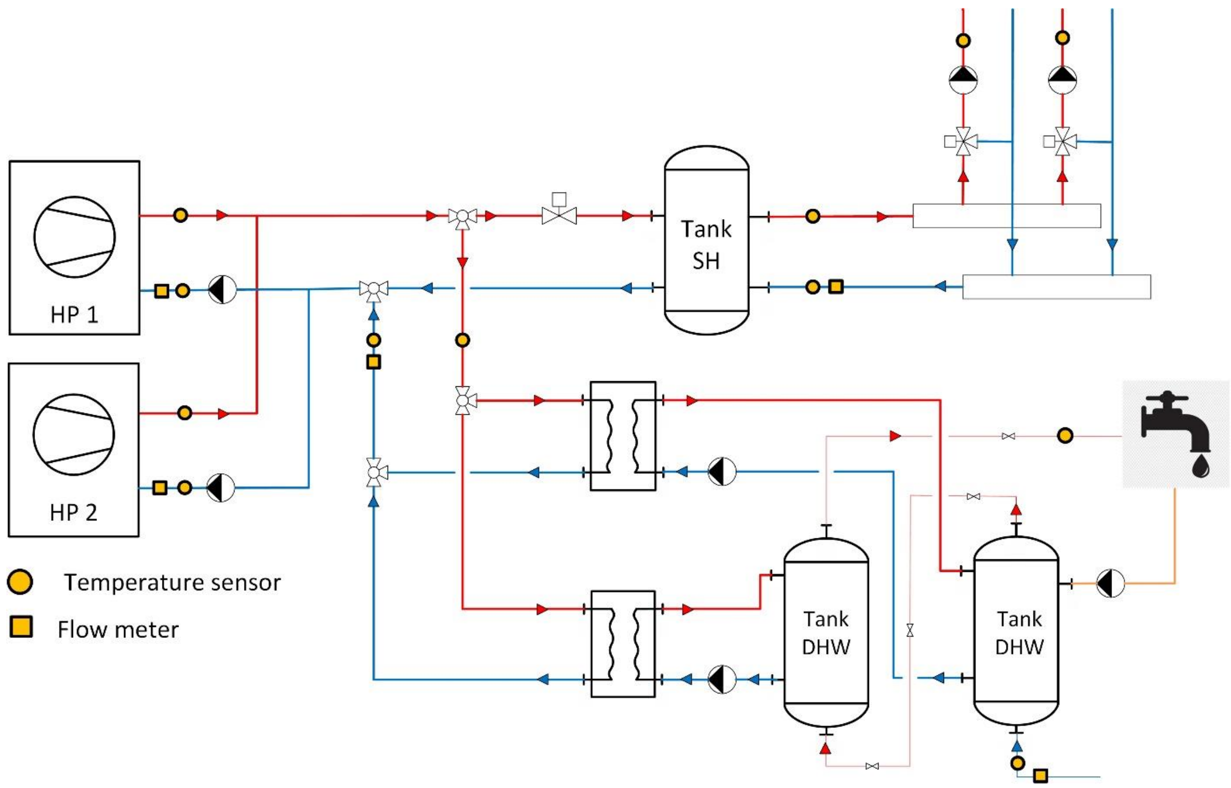
- Electrical auxiliaries (pumps) can greatly reduce system performance if not properly regulated.
- Pay attention to DHW loops as they are sources of significant losses, both in terms of heat and temperature.
- Industrials HPs are cheap but needs consequent noise-reduction installation for proper integration.
- Avoid oversizing: measure the building's demand prior to the project to size the system accordingly, thereby minimizing investment, auxiliary power consumption and short-cycle problems.

This pilot project, formerly heated by an old oil boiler, is now equipped with a monovalent system comprising two industrial-type air-source HPs.

In the last year of monitoring, the annual SPF was 2.3, including auxiliaries, with DHW consumption accounting for almost half of the total heat requirement.

Operating errors were detected during the first year of monitoring, due to incorrect device settings, and were largely rectified by optimizing the control strategy, improving the system's performance since commissioning.

St-Julien, Geneva – Switzerland: Technical details



Description of the technical concept

The heating system comprises a 1 m^3 storage tank and two SH distribution circuits (northwest and southwest). Each SH distribution circuit has its own three-way valve and circulator. On the other hand, the DHW subsystem comprises two 1 m^3 storage tanks connected in series, separated from production by two plate heat exchangers.

The 2 industrial-type HPs supply heat for SH and DHW alternately to maintain the storage tanks at their set temperatures. The heating and DHW setpoints are fixed at the top of each storage tank and verified by a temperature sensor.

A motorized isolation valve directs HPs heat production to the DHW subsystem or to SH circuits. When HPs are in SH mode, the valve remains open to send the heat production to the SH circuits. When in DHW mode, the valve is closed and all the HPs heat production is directed to the DHW plate heat exchangers. In the event of simultaneous demand for DHW and heating, priority is given to DHW.

Final report: CALAME, Nicole et al. (2021). AirBiVal: Développement et optimisation de concepts hybrides de pompes à chaleur sur l'air pour des immeubles résidentiels collectifs. Url: https://archive-ouverte.unige.ch/unige:156969

Versoix-Centre, Geneva – Switzerland

A 4-pipe district heating and cooling network with a 400 kW_{th} HP on lake water, for mixed-use building complex.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	*2011-2015*
Type	*Mixed use: activities, hotel, nursing home, multifamily building*
Heat distribution	*Underfloor heating*
Heated area	*27’300 m²*
Cooling demand area	*24’800 m²*
Level of insulation	*High performance*
Heat production	*1.7 GWh/y (63 kWh/m²/y)*
Cooling demand	*30 kWh/m²/y*

Heat pump and source

Number of HP	*1*
Installed capacity	*400 kW_{th}*
Operation mode	*Bivalent*
Heat source	*Deep lake water*
Backup heat source	*1.4 MW gas boilers*

Heating system

SH share, demand	*68%, 43 kWh/m²/y*
Heating temperature	*Max. 40°C at -5°C*

Domestic hot water

DHW share, demand	*32%, 20 kWh/m²/y*
Type of system	*Decentralized with one booster HP on DH in each building*
Max. temperature	*60°C*
Circulation system	*Yes*

Other information

Heat mix (2018)	*77% HP, 23% boilers*
Cooling mix (2018)	*61% lake, 39% HP*
HP SPF (measured)	*3.24 (annual) 3.21 (winter) 3.90 (summer)*

Lessons learned

- Discrepancy between subscribed capacity and real capacity needs of the customers.

In this study, we investigate the operation of the “Versoix-Centre” thermal network in the canton of Geneva during 2018. The network provides heating and cooling to several new buildings (built after 2010) with a total surface area of around 27’000 m².

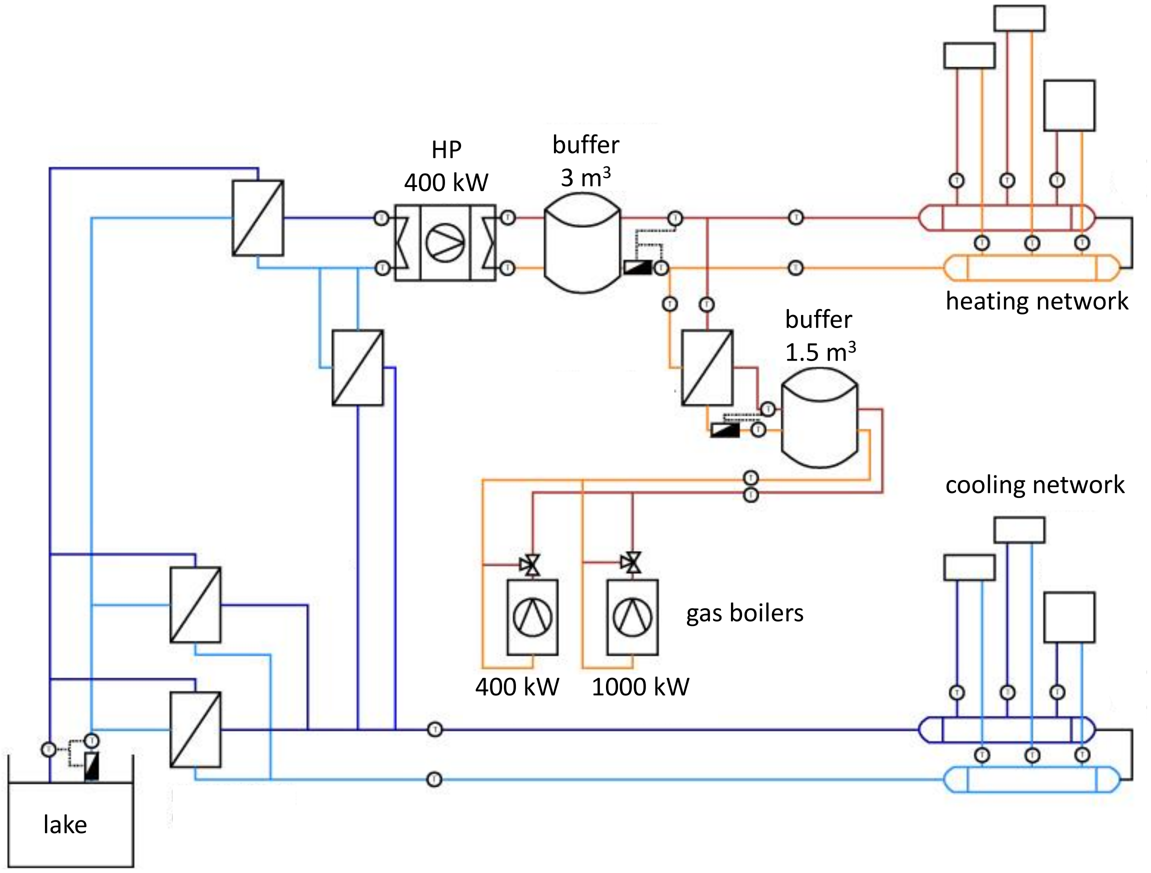
For year 2018, the heat mix is 75% HP & 25% fossil fuel boilers, and the cooling mix is 60% lake & 40% HP. The centralized HP has a SPF of 3.24 (3.21 in winter; 3.90 in summer).

For 2018, a warm year yet with outside temperature range close to normative values:

- The overall DH oversizing is almost 2 times the actual building requirements (contract power/delivered power = 1.8).
- For DC, the oversizing reaches a factor of 3 (contracted power/delivered power = 2.9).

As the real capacity needs of the buildings connected to this DH/DC are close to those estimated for the connected buildings based on normative indications, this oversizing situation could be partly explained by differences between the project and realization phases.

Versoix-Centre, Geneva – Switzerland: Technical details



Description of the technical concept

“Versoix-Centre” is a 4-pipe thermal network in Versoix (Geneva). The network has a single thermal power plant, with two distribution networks: one for heating (DH), and the second for cooling (DC) the buildings connected to the thermal grid. The 7 connected buildings were built between 2011 and 2015 and have an energy reference area of about 27’300 m^2, with mixed use (administrative, home for the elderly, cultural activities, hotel, shopping center, multifamily building). The heating base load is produced by a 400 kW_{th} centralized HP, which heat source is Lake Geneva (at a depth of 45 m, where temperatures vary between 7°C and 10°C). Heating pic load and backup is provided by two boilers: a condensing gas boiler (400 kW) and a second dual-fuel boiler (1 MW) without possibility of heat recovery on flue gases.

The distribution temperatures of the DH network are relatively low, with a supply temperature of 45°C. The production of DHW at higher temperatures is the responsibility of the customers, who use the DH as a cold source for decentralized HP in the substations, after the primary heat exchanger of the DH substation.

Cooling is either done directly with lake water used to cool down the DC network via a heat exchanger, or by the centralized HP transferring heat from the DC network to the DH network. In this second option, the HP covers simultaneously the heating and cooling demands on the two distribution networks (to pool energy needs). The distribution temperatures of the DC network are considerably high, with a supply temperature that can reach 10°C, a temperature compatible with the deep waters of the lake.

Final report: DE OLIVEIRA FILHO, Fleury, HOLLMULLER, Pierre (2020). Réseau thermique Versoix-Centre : Analyse du fonctionnement et bilan énergétique. Url: https://archive-ouverte.unige.ch/unige:145705

Daru, Geneva – Switzerland

Six villa-type air-to-water HPs ensuring 71% of the heat production for SH and DHW in an existing non-retrofitted multifamily building, with a complementary gas boiler.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	1992
Type	*Multifamily building*
Heat distribution	*Radiators*
Heated area	*7560 m²*
Level of insulation	*Low, except retrofitted roof*

Heat pump and source

Number of HP	*6 x 31 kW_{th}*
Installed capacity	*186 kW_{th}*
Operation mode	*Bivalent with a 200 kW gas boiler*
Heat source	*Air*

Space heating

SH share, demand	*71%, 72 kWh/m²/y*
Heating temperature	*Max. 50°C at -5°C*

Domestic hot water

DHW share, demand	*29%, 30 kWh/m²/y*
Type of system	*Central per aisle*
Max. temperature	*60°C*
Circulation system	*Yes*

Other information

HP share, SPF	*67%, measured: 2.3*
Ventilation	*Single-flow*

Lessons learned

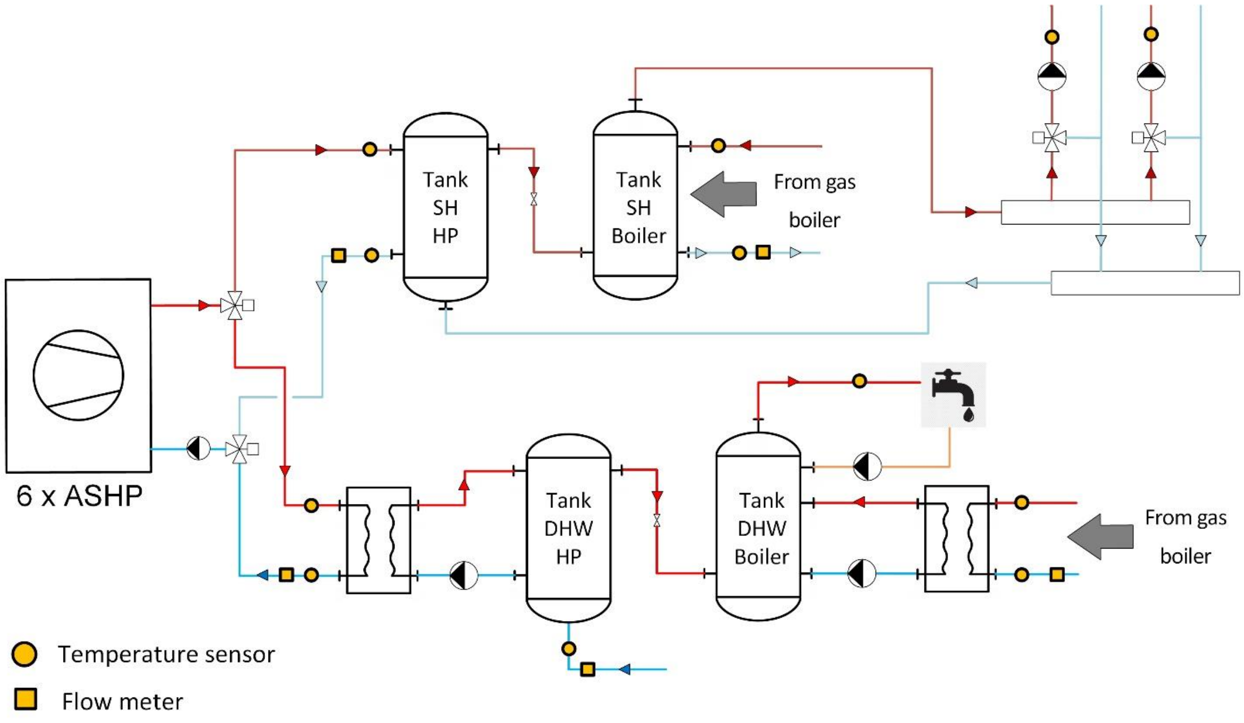
- Combination of HP and fossil fuels needs careful integration.
- Monitoring has enabled us to resolve problems and improve overall performance.
- Optimizing the cascade of HP (and compressors) is a tricky issue.
- Pay attention to DHW loops as they are sources of significant losses, both in terms of heat and temperature.
- Pay attention to heat loss between HP and boiler room, minimize pipe lengths.

In this project, the heat production system of a multifamily building (with business premises on the ground floor) was partially replaced by 6 villa-type air-to-water HPs, installed on the roof, to obtain a bivalent system with parallel boiler operation.

During the last year of monitoring, 67% of production was covered by the HPs, with an annual SPF of 2.3 including auxiliaries.

Before reaching this point, several malfunctions were identified and had to be corrected, for example: high return temperature causing HPs shutdowns, auxiliaries inducing unnecessary electricity consumption, excessive noise emissions from heat pumps.

Daru, Geneva – Switzerland: Technical details



Description of the technical concept

The 6 HPs are residential models typically adapted to individual housing, installed on the roof, each with its own circulator. Three HPs are designed solely to produce heat for SH, while the other three are designed primarily to produce DHW, although they can also supply heat for SH. The gas boiler can provide additional heat for both heating and DHW.

The HPs supply a buffer tank for SH (1 m^3) and an exchanger for DHW production. The heat for SH from the buffer tank passes through the boiler SH buffer tank (1 m^3), whose temperature can be raised by the gas boiler, before being distributed in two SH circuits (apartments and businesses). The return flow from the heating circuits is diverted directly to the boiler when its temperature is incompatible (too high) with the operation of the HPs, which occurs mainly at sub-zero outside temperatures. This hydraulic modification (dark blue line on hydraulic diagram) was made in response to operating problems encountered during the first winter of operation.

Cold drinking water for DHW production is heated in a first tank (1 m^3) by HPs via a heat exchanger, then passes into a second tank (1 m^3), whose temperature can be raised by the gas boiler via another heat exchanger, before being distributed. The return flow from the DHW loop arrives in this tank.

For SH, the HPs are regulated by automatic cascade management (with their own internal software), while for DHW production, the HPs are manually programmed to start up at different temperature levels in the HP DHW storage tank, to better match DHW demand.

Final report: CALAME, Nicole et al. (2021). AirBiVal: Développement et optimisation de concepts hybrides de pompes à chaleur sur l’air pour des immeubles résidentiels collectifs. Url: https://archive-ouverte.unige.ch/unige:156969

La Cigale, Geneva – Switzerland

A solar assisted HP with ice storage ensuring 92% of the heat production for a 19'000 m^2 extensively retrofitted multifamily building complex, in combination with back-up gas boiler.

Key facts

Building	
Location	*Geneva, Switzerland*
Construction	*1952*
Refurbishment	*2013-2014*
Type	*Multifamily building*
Heat distribution	*Radiators*
Heated area	*19’000 m^2*
Level of insulation	*High performance*
Heat pump and source	
Number of HP	*2 (200 + 300 kW$_{th}$)*
Installed capacity	*500 kW$_{th}$*
Operation mode	*Bivalent*
Heat source	*1740 m^2 unglazed solar collectors*
Backup heat source	*130 + 200 kW gas boiler*
Space heating	
SH share, demand	*49%, 35 kWh/m^2/y*
Heating temperature	*Max. 45°C at -5°C*
Domestic hot water	
DHW share, demand	*51%, 34 kWh/m^2/y*
Type of system	*Central per building*
Max. temperature	*55°C*
Circulation system	*Yes*
Other information	
HP share, SPF	*78%, measured: 3.2*
Direct solar heat	*14%*
Backup gas boiler	*8%*
Latent heat storage	*32 m^3 (2’000 kWh)*
Ventilation	*Double-flow*
Total renovation cost	*CHF 1050.-/m^2*
Heating system cost	*CHF 95.-/m^2*

Lessons learned

- Initial issues were largely related to control problems, not to the innovative nature of the technology used.
- It’s essential to check the conformity of the installation before commissioning.
- Ensuring proper energy monitoring leads to overall system improvement.

Located in Geneva, the cooperative housing complex “La Cigale” (2 building blocks, 273 apartments) was built in 1952. The heating oil consumption of these buildings amounted to approximately 150 kWh/m^2/y for SH and DHW production.

The buildings were extensively renovated in 2013-2014 in accordance with the *Minergie-P* standard, which was at that time the most important operation of this type in Switzerland.

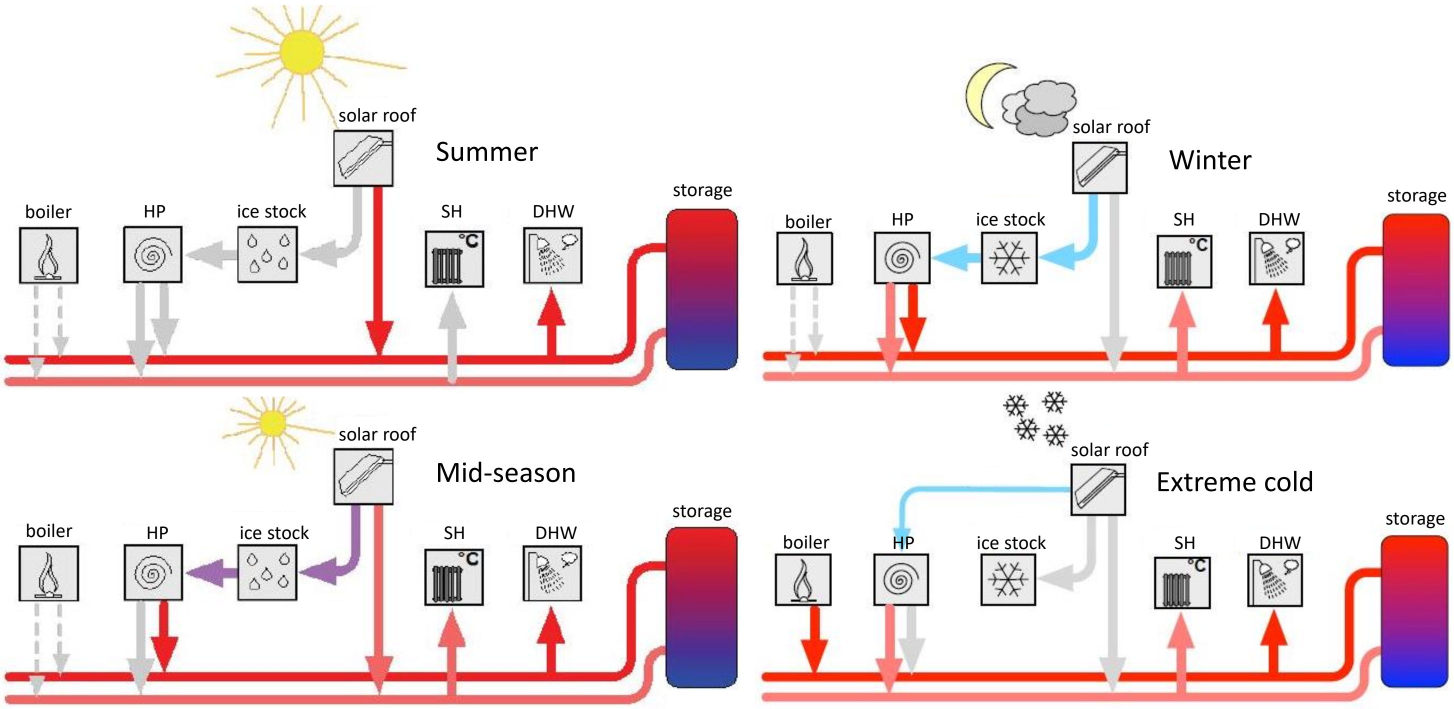
This renovation was performed on an occupied site and required use of prefabricated elements (façades, roof) to achieve quality insulation within short intervention periods; involved transformation of balconies into loggias and installation of a ventilation heat recovery system.

The heat production is mainly provided by unglazed solar collectors covering the south-east and south-west facing roof areas, coupled with a series of HPs using a latent heat storage (water/ice). Each building has its own independent heat production & distribution system (solar roof, ice/water storage, one HP + on backup gas boiler)

Unglazed solar collectors

Latent heat storage (water/ice)

La Cigale, Geneva – Switzerland: Technical details



Description of the technical concept

The architecture of the system comprises a brine-to-water HP whose evaporator-side heat source consists of selective unglazed solar collectors on the roof and a phase-change heat stock (ice/water stock). A heat exchanger also allows direct solar energy use when the solar roof production temperature is high enough (summer & mid-season).

On the condenser side of the heat pump, a hydraulic bus to which all components are connected enables heat exchange between heat producers and consumers, maintaining four temperature levels (note that the 4 tubes system is not shown in the diagram above). A storage tank is connected to the end of the bus, enabling energy storage for semi-instantaneous hot water production in the upper section, while the middle section serves as a buffer tank for the heat pump and the lower section is dedicated to solar energy storage.

To ensure 100% availability of DHW and SH, a backup gas boiler was installed. It was used to produce DHW during the transitional construction period, and

Final report: TORNARE, Guy et al. (2017). Rapport technique et de communication du projet d'assainissement Minergie-P des immeubles « La Cigale » (GE) – Chauffage par pompes à chaleur solaires couplées à des stocks à changement de phase. Url: https://archive-ouverte.unige.ch/unige:92770

Conference paper: HOLLMULLER, Pierre et al. (2017). Solar assisted heat pump with ice storage for a 19'000 m^2 retrofitted multi-family building complex. In: CISBAT 2017 International Conference.
Url: https://archive-ouverte.unige.ch/unige:97185

La Fontenette, Geneva – Switzerland

A centralized wastewater HP with a complementary gas boiler, for a high performance multifamily buildings complex, with heat distribution via a dedicated district heating system.

Key facts

Building

Location	*Geneva, Switzerland*
Construction	*2015-2020*
Type	*Multifamily building*
Heat distribution	*Underfloor heating*
Heated area	*30'440 m²*
Level of insulation	*High performance*
Heat production	*2 GWh/y (67 kWh/m²/y)*

Heat pump and source

Number of HP	*1*
Installed capacity	*200 kW_{th}*
Operation mode	*Bivalent with a 600 kW gas boiler*
Heat source	*Wastewater from the buildings*

Heating system

SH share, demand	*37%, 22 kWh/m²/y*
Heating temperature	*Max. 35°C at -5°C*

Domestic hot water

DHW share, demand	*63%, 43 kWh/m²/y*
Type of system	*Central per building*
Max. temperature	*63°C*
Circulation system	*Yes*

Other information

HP share, SPF	*53%, measured: 3.0*
Investments costs	*CHF 91.-/m²*
Heat cost (LCOE)	*CHF 10.-/m²/year*
PV installation	*210 kWp*
Double-flow vent.	*80% efficiency*

Lessons learned

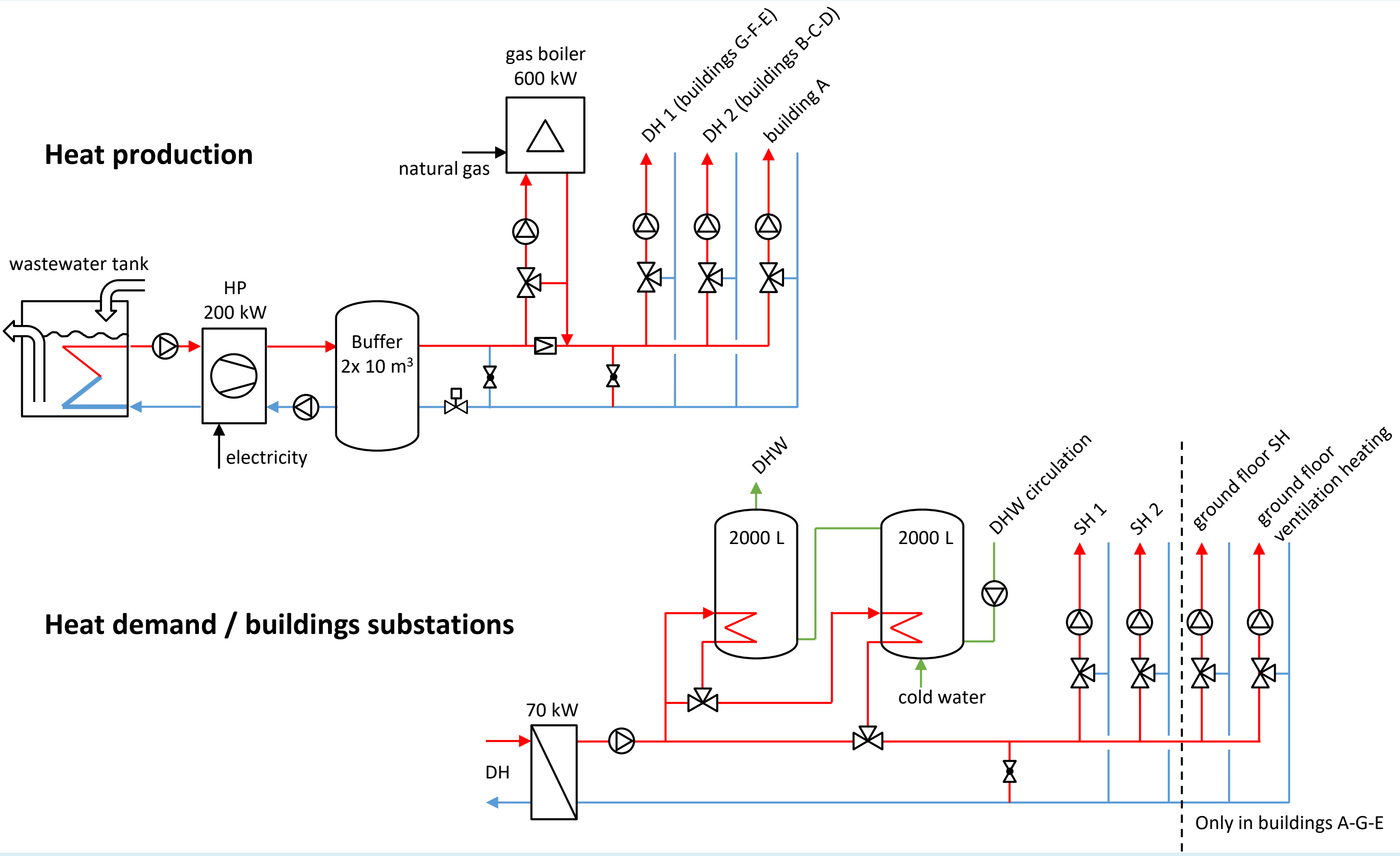
- Use of innovative HP source (wastewater) in combination with fossil fuels needs careful cooperation of stakeholders regarding the system's regulation and its optimization.
- HP covers a high share of the heat production with this local heat source.

While heat pump systems combined with district heating could reduce the CO_2 emissions of Geneva's heating sector, it is crucial to know and control their performance in real condition of use.

We monitored this new low energy multifamily buildings complex for 3 years.

SH demand and DHW supply are higher than planned/normed values. For SH that can be explained by operation conditions which differ from the norm (higher indoor temperatures, window openings), and DHW supply is certainly high, but coherent with a benchmark on other buildings in Geneva.

La Fontenette, Geneva – Switzerland: Technical details



Description of the technical concept

Wastewater from the 7 buildings is collected in a common tank (37 m^3), which contains: a filtration system to retain and remove the solid materials; as well as an immersed heat exchanger (FEKA system). HP evaporator is connected to this submerged heat exchanger via a glycol-water circuit.

The heat produced by the HP is transferred to a buffer stock. Additional heat is provided by a condensing gas boiler located downstream of the buffer stock. A motorized valve regulates the primary flow through the buffer stock (DH return). Heat is produced in a centralized boiler room and is distributed to the buildings via two heating networks.

DH supply temperature is set to meet SH needs (max. 40°C), and raises above 60°C several times a day to enable DHW production and storage in the buildings. This is done to improve heat production performance (mainly for the HP) and limit distribution losses.

Heat production operates according to the following two regimes:

- HP production: this mode is used when the HP and its stock are able to meet the DH demand (in terms of power and temperature).
- Gas boiler production (with HP isolated from distribution): this mode is used when HP and its stock can no longer meet DH demand (in terms of power and temperature). In this case, HP is isolated from the boiler and DH to prevent the boiler from heating the stock via DH return. HP then operates in a closed loop, to recharge the buffer stock, and stops when reaching its maximum setpoint temperature.

Final report: CALLEGARI, Simon Augustin et al. (2021). La Fontenette – « Les Auréa » : Analyse technique et sociale d'un complexe d'immeubles HBM de haut standard énergétique, équipé d'une PAC centralisée sur eaux usées.
Url: https://archive-ouverte.unige.ch/unige:149374