ANNEX 50 : HP IN MULTI-FAMILY-BUILDINGS
TASK 1 : MARKET OVERVIEW

COUNTRY REPORT FOR SWITZERLAND

Fribourg, le 02 octobre 2017
CSD Ingénieurs SA

Contents

1. Swiss Energy Demand

1.1 Global figures

1.1.1 Energy demand in all sectors

Total final energy consumption in Switzerland was of 854’300 TJ in 2016 [1]. Figure 1 shows the relative importance of various energy carriers for households, industries, services and transport.

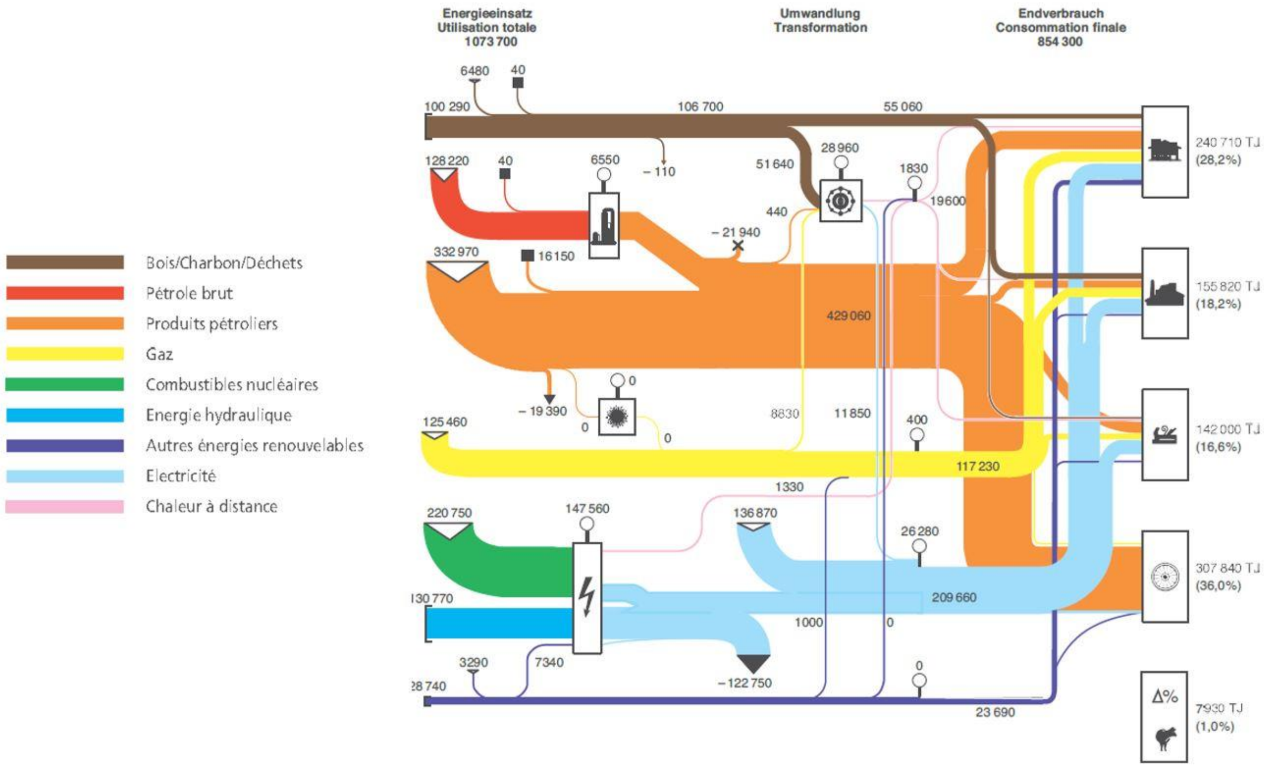

Figure 1 : Detailed energy flow diagram for Switzerland in TJ for 2016 [OFEN]

1.1.2 Buildings sector

In 2016 the housing sector energy needs represent 240’710TJ or 28.2% of the national final energy consumption [1]. The evolution of the household sector shows an increase between 2014 and 2016 as presented in Figure 2.

The national share of renewables in heat supply is about 16% for 2015 (including 11% of wood-based systems, 5% of other renewables) [1, 2]. The share of renewables for heat production reaches 20.2 % in 2016 (without electricity). In 2016, heat pumps make up 28% of the renewable heat in the country [3].

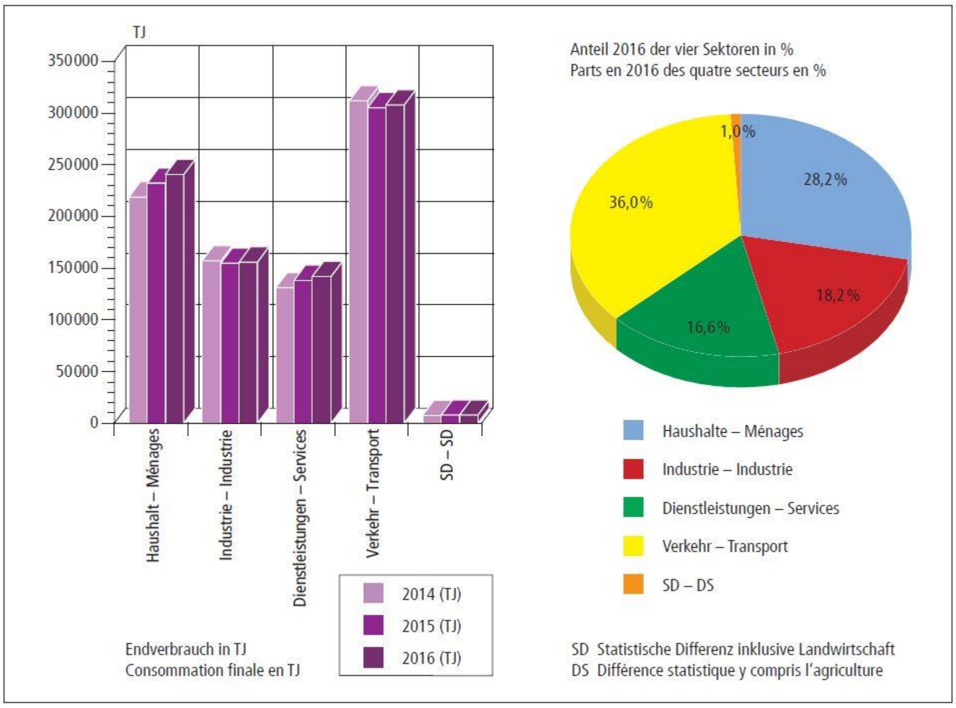

Figure 2 : Distribution of the final energy consumption by sector for 2016 [4]

1.2 Domestic sector

In the domestic sector, the market share of heat pumps grew from near zero in the 1990s to about 50% today. The share reaches 90% in single-family-houses and about 10% in multi-family houses.

Figure 3 illustrates the distribution of heat pumps on the Swiss market for 2013. The HP sales are leading for capacities up to 100kW with more than half of all heat production devices sold. The power range above 100kW on the other hand indicates a marginal share of heat pumps being used for larger capacities like multi-family buildings.

Heat pumps in multi-family houses have a modest share in new buildings and almost zero in retrofitting existing systems.

Thermal energy for space heating and domestic hot water production represents about 40% of the CO2-emissions of Switzerland.

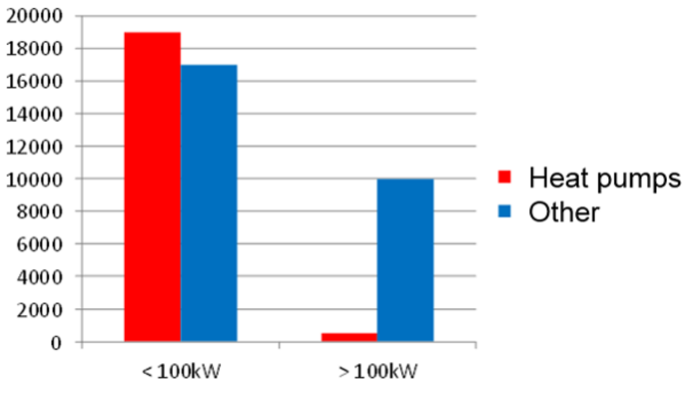

Figure 3 : Swiss heating market for 2013 [5]

2. Policy framework

The majority of Swiss heat supply (75%) is coming from imported fossil fuels, including 40% from heating oil, 33% from natural gas and 2% from coal [1, 2]. The Swiss federal policy targets include 20% decrease in overall carbon emissions and 40% decrease in buildings emissions in 2020 comparted to 1990 level [6-8]. In 2014 overall carbon emissions were reduced by 9% compared to 1990 level [2]. In buildings the emissions were respectively reduced by 30%, about 5.2 million tCO2-eq. are still to be saved by 2020 [2]. A variety of policy instruments has been put into place to achieve carbon emissions reduction and promote renewable heat solutions, including carbon tax and the federal subsidy program *Programme Bâtiment* [6, 7]. However, it was officially recognized that these solutions are not sufficient to achieve the desired level of carbon emissions.
In addition to the federal policy targets and instruments, some cantons undertake actions to promote renewable heat solutions within their geographic jurisdictions. For example in the canton of Geneva, the local public utility *Services Industriels de Genève (SIG)* is mandated by the canton to provide support for renewable heat uptake by final consumers, including single family and multifamily housing sectors. This support is implemented through the energy efficiency program called *éco21* [9-12]. In the case of single housing sector, *éco21* offers subsidies that cover about 10% of initial investment costs (including equipment and installation services). This type of support is not suitable for multifamily houses due to the peculiarities of Swiss housing legislation.

Contrary to the single housing sector, the majority of inhabitants of multifamily houses are tenants [13]. According to the Swiss law the tenants pay the energy and maintenance costs, while the building owner is responsible for the initial investment costs of heating systems and have no right to pass them to the tenants via the energy bills [14]. Currently for existing buildings the investment costs of the renewable heat systems such as heat pumps are from three to five times higher compared to the conventional solutions (fossil fuel-based). The owners therefore have no incentive to opt for renewables. A possibility to overcome this barrier is energy contracting, when an ESCO is investing in renewable heat system and is recovering its costs by selling energy service to the inhabitants of the building. However, this solution is not widely used due to a limited number of ESCOs in Swiss market and a lack of experience in renewable technologies implementation. This is particularly the case of heat pumps integration in the existing buildings, as this solution demands multiple professional services: energy concept development; noise, static and building physics assessment; planning and implementation of heating, electricity and sanitary works; administrative procedures.

There is a real need to rethink the repartition between the cost paid by the building owners and the tenants and no subsidy can cover this gap. The Swiss law provides exception for district heating systems: a possibility to affect all the three parts – initial investment, energy and maintenance cost – to the tenant [14]. The interpretation of the law tends to extend the exception from district heating to more heating solutions types in case when contracting is implemented and the annual heating cost increase does not overpass 10% limit. Still to keep the annual heating cost nearly constant for the tenant we have the opportunity to ask a contribution to the building owner investment which reduces the initial investment. The amount depends on the existing heating system state; if the existing system is old the building owner spends the equivalent amount of a new fossil equipment but if it is new the building owner do not contribute the initial investment.

On the other hand, retrofitting a boiler by the same type of boiler does not require any authorisation or additional procedures. In contrast, authorisation from cantonal energy and building authorities is mandatory when replacing fossil fuel-based system by an air to water heat pump. A number of norms should be satisfied, including with regard to noise level, electrical and fire security. Satisfying these norms often demands significant investment and therefore, increases the costs of renewable heat project. In this view, the current legislation creates more barriers for implementing renewable heat solutions in existing multifamily houses than gives support (for example, federal subsidies). The legal framework is not previewed to give more incentives in the future. Therefore, development of energy contracting by ESCOs and the energy programs such as éco21 can be seen as the major potential instrument for renewable heat promotion in existing multifamily houses building stock.

2.1 Buildings regulations

The “Model of energetic prescriptions in cantons” (MoPEC) prescribe what efficiency new constructions or transformations must comply to and which standard technical solutions are accepted to achieve it. Other solution must be calculated in detail to bring the proof of reaching the energy goal as with a standard one.

The Swiss society of engineers and architects (SIA) norm system gives energy performance targets. The technical file SIA 2040 for a 2000 Watts compatible construction gives objective values by sector [15]. Table 1 shows indicative values for construction, operation as well as mobility that were established to meet national objectives for 2050.

	Énergie primaire non renouvelable MJ/m²		Émissions de gaz à effet de serre kg/m²	
Habitations	Construction nouvelle	Transformation	Construction nouvelle	Transformation
Valeur indicative «construction»	110	60	8,5	5,0
Valeur indicative «exploitation»	200	250	2,5	5,0
Valeur indicative «mobilité»	130	130	5,5	5,5
Valeurs cibles	440		16,5	15,5

Table 1 : Target values for housing sector, in MJ/m2 [15]

As for domestic hot water production, Swiss norm SN546 385/1 "Installation of DHW in buildings" states that for a collective housing with centralized DHW supply, potable water that stayed at a temperature between 25°C and 50°C for more than 24 hours without being used should undergo a thermal disinfection [16]. The latter consists of a heating phase to 60°C for an hour. For collective housing without centralized DHW supply this rule is only a recommendation. Following the same norm, the DWH boiler must be designed to be able to reach a 60°C outlet temperature, 55°C in the hydraulic lines that are maintained at temperature and 50°C at the drawing-off points. [SIA]
In practice, the applied scheme is a once-a-week thermal disinfection by heating the hot water tank at 60°C for an hour.

2.2 High energy performance label

Cantonal building energy certificate (CECB) gives information on efficiency of the building envelope, global energy efficiency (electricity included) and possible refurbishment measures. It is established by accredited experts and isn't mandatory but could be in future. This certificate is however required now in case of a house sale (if not already done before).

The Minergie Standard defines minimal values to reach in different domains in order to certify a building or modules according to Minergie. Is a voluntary approach that offers three options of various degrees of requirement referred to as Minergie, Minergie-P or Minergie-A. Additional "ECO" option for each type are offered. The Minergie standard meets the strict requirements of the "Building Program" described in section 2.3.

2.3 Incentive schemes

The « Buildings Program » gives direct incentives in the form of subsidies. At national level, it encourages energy-related renovation of building envelopes. In most cantons, the program supports the use of renewable energy sources, heat recovery and technical facilities in buildings.

The 26 Swiss cantons have developed a common scheme for subsidies. They share the same criteria for all technologies but the supported technologies may vary from one canton to another. For example, the urban canton of Geneva does not support wood-fired systems.
In most Cantons tax reductions are obtained when investing in renewable energy for heating and domestic hot water.

2.4 Energy savings certificates

Conventions of objectives are passed between the Confederation and companies. They are an instrument used to increase the energy efficiency of the company and simultaneously reduce CO2 emissions. As objective agreements, they are established either on a voluntary basis or as binding instruments targeting to release a company from the CO2 tax.

The objectives are elaborated and discussed in close cooperation between the companies, the Confederation and the organizations mandated by the latter. Details of this can be found in the "Directive on Conceptual Agreements with the Confederation for the Improvement of Energy Efficiency". Two organizations mandated by the Confederation propose models of goal agreements. Thus, large consumers determine for themselves energy efficiency and a level of their CO2 emissions, then they apply these data as objectives to be achieved. SMEs, which use simple production processes, set their energy savings targets. In all cases, the measures and objectives remain adapted to the economic potential of the company.

3. Building stock Characteristics

3.1 Swiss building stock

The Swiss Office for Statistics considers twin, grouped or row houses each having its own access from the outside and separated from the others by a common vertical bearing wall from the ground floor to the roof as being an independent building. All constructions with exclusive or partial housing usage are being considered in the building and housing statistic (StatBL). The total number of buildings with housing application amounts to 1’712’893 in 2015. Most of them (83.7%) are exclusively for accommodation usage.

The single-family homes exclusively used for accommodation represent 57.4% of the Swiss building stock. Almost one out of four families (23%) lives in an individual home.

The multi-family buildings with exclusive housing application add up to 26.3% while they account for 34.9% when considering the whole MFB stock including partial housing use [13].

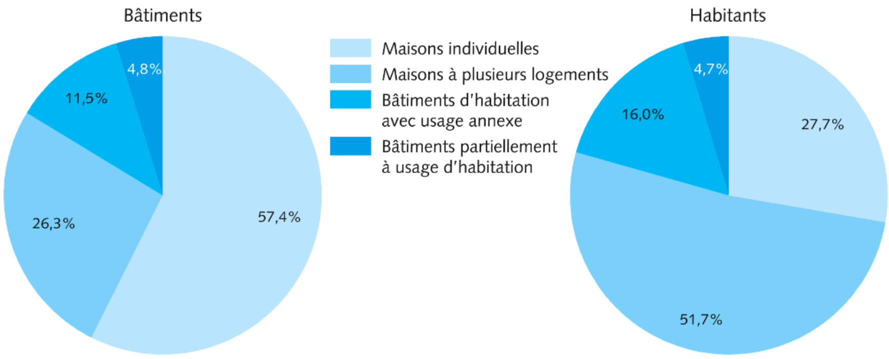

Figure 4 : Distribution of buildings and inhabitants depending on building category [13]

A steady increase in property rate is happening since 1970, which is especially strong in condominium ownership (*PPE*) (+72%) [Panorama OFS 2017]. Large disparities exist between urban cantons showing low ownership rates (Genève 18.2%, Bâle-Villle 16%) and *rural* ones (Appenzell Rhodes-Intérieures 57%, Valais 57.2%, Jura 54.2%).

The distribution of number of housing per building as shown in

Figure 5 indicates the geographical variations that take place throughout the country. In urban areas like downtown Geneva, 79% of the buildings are multi-family houses, for the whole canton the average is around 37%. The national mean value shows 65% of residential buildings are for single-families in 2015 [13].

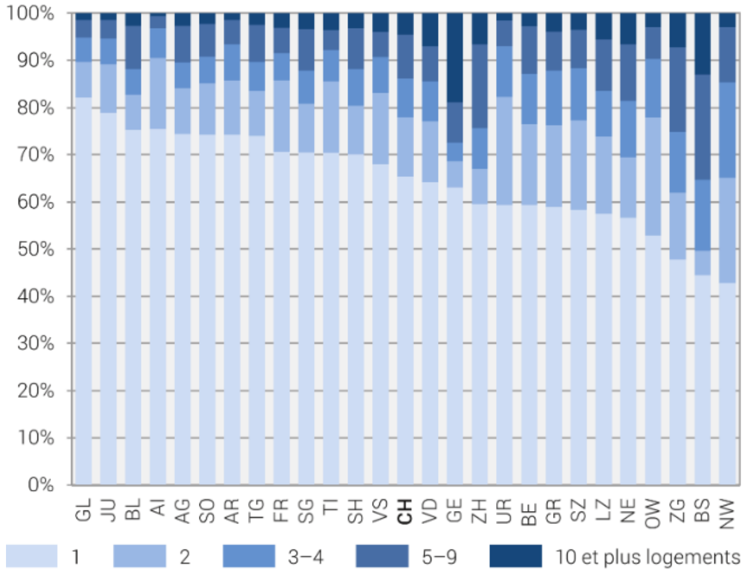

Figure 5 : Building stock given by number of households for each canton and the average Swiss value « CH » for 2015 [13]

3.2 Energy consumption in Swiss buildings

Figure 6 shows the values and trends of energy needs in Swiss households. In 2015 more than two thirds of the energy consumption goes to space heating ("Chauffage" 67.4%, 154.4PJ) [17]. Considering the meteorologically corrected consumption, the share of heating in the total consumption is decreasing over time from 72.6% in 2000 to 70% in 2015. DHW preparation has a significant weight in the global energy consumption as it represents 13.9% ("Eau chaude" 31.9PJ). Other applications show lower impact.

	2000	2010	2011	2012	2013	2014	2015	Δ '00-'15
Chauffage (des locaux)	167.5	192.2	149.0	168.1	185.5	139.7	154.4	-7.8%
Eau chaude	32.3	32.2	31.6	31.9	32.2	31.7	31.9	-1.2%
Climatisation, ventilation, technique du bâtiment	3.6	4.4	3.8	4.2	4.7	3.9	4.4	+21.9%
Médias de divertissement, I&C	5.4	5.5	5.3	5.1	5.0	4.8	4.6	-13.2%
Cuisson, lave-vaisselle	8.8	9.3	9.3	9.3	9.4	9.5	9.6	+8.8%
Eclairage	5.7	5.7	5.4	5.1	4.9	4.5	4.1	-28.9%
Lavage & séchage	2.6	4.9	5.0	5.1	5.1	5.1	5.0	+93.1%
Réfrigération & congélation	7.1	6.9	6.8	6.7	6.6	6.5	6.4	-10.2%
Autres appareils électriques	4.6	7.1	7.3	7.7	8.0	8.3	8.6	+86.8%
Total	**237.7**	**268.2**	**223.4**	**243.4**	**261.3**	**214.2**	**229.1**	**-3.6%**

Figure 6 : Energy consumption in households for various applications in PJ [17]

3.3 Energy for heating & domestic hot water in the building stock

3.3.1 Heating

The share of heat pumps used for heating throughout the country is of 11.9% in 2015.

	2000		2010		2015	
	absolu	en %	absolu	en %	absolu	en %
Mazout	814'827	56,0	841'036	51,3	810'889	47,4
Bois	189'571	13,0	198'624	12,1	206'249	12,1
Pompe à chaleur	60'109	4,1	140'844	8,6	203'169	11,9
Electricité	166'248	11,4	168'098	10,2	163'592	9,6
Gaz	200'187	13,8	248'048	15,1	273'468	16,0
Chaleur à distance	20'593	1,4	29'596	1,8	34'978	2,0
Charbon	1'057	0,1	2'180	0,1	1'126	0,1
Capteur solaire	944	0,1	2'242	0,1	4'851	0,3
Autres agents énergétiques	964	0,1	9'383	0,6	11'298	0,7

Table 2 shows the evolution of the various energy carriers over time since 2000. Heat pumps ("Pompe à chaleur") for heating purpose have seen their usage almost triple from 2000 to 2015. The furnace oil share ("Mazout") is still predominant as it represents 47.4% of the heating established in the Swiss building stock in 2015. Values are shown as number and percentage of buildings equipped with the various technologies [13].

	2000		2010		2015	
	absolu	en %	absolu	en %	absolu	en %
Mazout	814'827	56,0	841'036	51,3	810'889	47,4
Bois	189'571	13,0	198'624	12,1	206'249	12,1
Pompe à chaleur	60'109	4,1	140'844	8,6	203'169	11,9
Electricité	166'248	11,4	168'098	10,2	163'592	9,6
Gaz	200'187	13,8	248'048	15,1	273'468	16,0
Chaleur à distance	20'593	1,4	29'596	1,8	34'978	2,0
Charbon	1'057	0,1	2'180	0,1	1'126	0,1
Capteur solaire	944	0,1	2'242	0,1	4'851	0,3
Autres agents énergétiques	964	0,1	9'383	0,6	11'298	0,7

Table 2 : Energy carrier evolution for heating usage in Swiss building stock in number of buildings and % per year [13]

Statistics show that 7.4% of the global Swiss multi-family building stock uses heat pumps to provide heating [13]. The MFBs account for exclusive housing usage, housing with annex usage as well as buildings with partial housing usage that can accommodate two or more families. Of these 44'257 constructions 88.4% have a HP per building whereas 11.6% have multiple buildings sharing a HP heating station.

3.3.2 Domestic hot water

The share of DHW produced by heat pumps (“Pompe à chaleur”) in Switzerland in 2015 is of 7%. The 2000 value of 1.7% has shown an increase of more than four times over this period as seen in Table 3 [13]. The evolution shows a favourable trend in the decrease of oil use which is still predominant and of electrical water heaters which decline too. The gas share has picked up to compensate for this trend. Use of solar heaters has tripled between 2000 and 2015 but remains marginal. District heating (“Chaleur à distance”) provides 1.8% of DHW in 2015.

	2000		2010		2015	
	absolu	en %	absolu	en %	absolu	en %
Mazout	555'451	38,0	586'041	35,7	570'302	33,3
Gaz	163'050	11,2	204'192	12,4	224'880	13,1
Electricité	590'932	40,4	649'054	39,5	628'473	36,7
Bois	62'461	4,3	75'379	4,6	83'448	4,9
Pompe à chaleur	25'543	1,7	69'388	4,2	119'289	7,0
Capteur solaire	3'190	0,2	16'029	1,0	36'874	2,2
Chaleur à distance	19'920	1,4	24'629	1,5	30'603	1,8
Autre agent énergétique	8'097	0,6	11'611	0,7	10'025	0,6

Table 3 : Energy carrier evolution for DHW usage in Swiss building stock [13]

4. Market of Heating Systems in Multi-Family Buildings

4.1 New built Multi-Family Buildings

According to the Swiss Office for Statistics, the Swiss households are more often tenants than property owners. In the country, 56.2% of accommodations are occupied by tenants in 2015 [13]. Figure 7 illustrates the state of occupied accommodations in Switzerland for 2015. The caption “Locataire” stands for tenant whereas “Propriétaire” means owner.

The ownership rate, defined as the rate of accommodation actually occupied by their owner divided by the total of occupied accommodations shows constant growth since 1970. This rate reaches 38.4% in 2015 at national level but shows great discrepancies from one canton to another (15% - 56%). The problematic behind the lower proportion of building occupied by their owner is that in Switzerland, tenants are responsible for payment of the energy bills, while it is the responsibility of the owners to invest in heating system. Investment costs cannot be transmitted to tenants via heating bills [14]. Currently for existing buildings the investment costs of the renewable heat systems such as heat pumps are from three to five times higher compared to the conventional solutions (fossil fuel-based). The owners therefore have no incentive to opt for renewables.

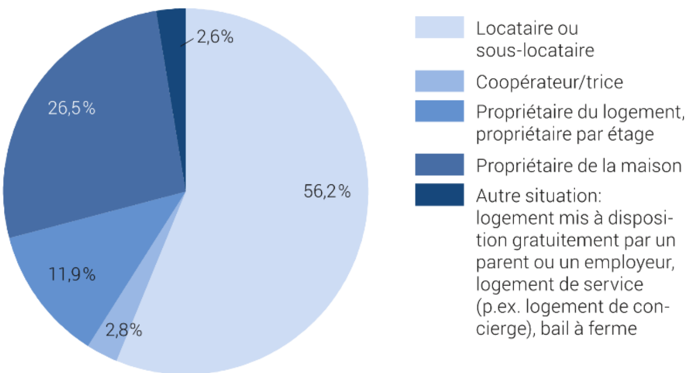

Figure 7: State of occupied accommodations in Switzerland in 2015 [13]

In 2015 0.9% more buildings with housing usage were constructed and there was an increase of +7.4% in newly built accommodations. For that same year, new individual buildings showed a decrease of -0.6%. Figure 8 illustrates the contrasting trends of individual versus collective constructions. The Yellow line shows newly built buildings with housing usage. The rate of new constructions has slowed down since 2004. As illustrated by the green line, households are increasing in number in the new constructions since 2001. This corresponds to more multi-family buildings being built. Finally the red line shows a decrease in the new individual homes since 2004.

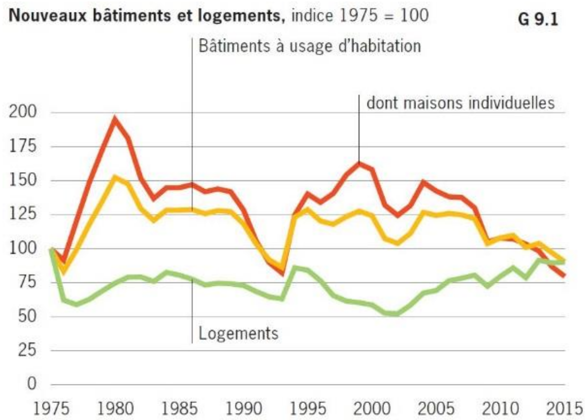

Figure 8 : Evolution of new buildings and accommodation given relatively to the 1975 values as being 100. Yellow line shows buildings with housing usage; green line shows households evolution and red line individual homes [13]

4.2 Market of heating systems in MFB

4.2.1 Space Heating

The Swiss heating market shows that the share of HP sales represents 40.37% in 2016. In comparison, there were 33.58% of gas furnaces, 22.58% of oil boilers and 3.47% of wood fired boilers sold that year [18].

Figure 9 illustrates how heat pumps have increased in sales volume over time and amount to 18’472 units in 2016.

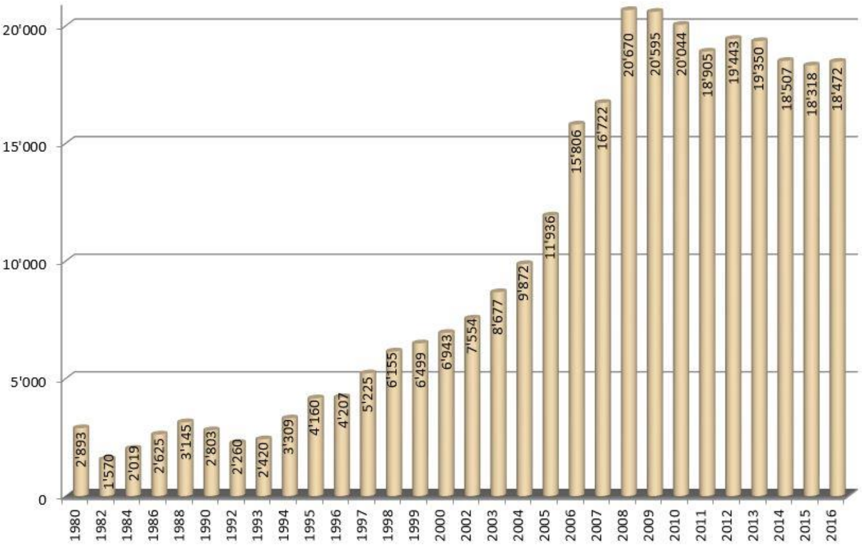

Figure 9 : Evolution of heat pump sales in Switzerland from 1980 to 2016 [18]

Figure 10 shows that a massive portion of the heat pump market in Switzerland lies under 20kW. This share of 81.2% reflects the market for individual housing. Of the 18’472 heat pumps sold in the country in 2016, only 3’465 have capacities above 20kW. The latter are mostly used for multi-family buildings.

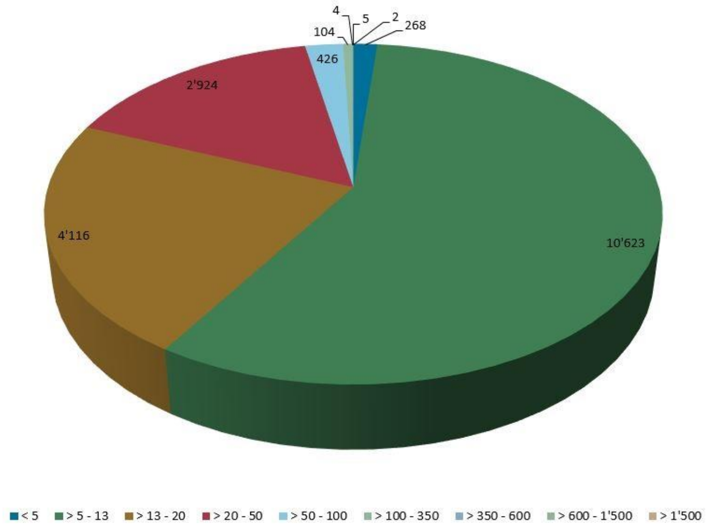

Figure 10 : Number of heat pump sold by power range in kW for 2016 [GSP]

4.2.2 Water heating

In almost all cases, the domestic hot water for multi-family houses is produced by the heating system itself. Heat pump boilers are used for single-family houses. In MFBs there are only few cases where an electrical hot water heater is retrofitted by a heat pump. However, the Cantons strongly push for the production of domestic hot water by solar thermal systems in combination with the heating system.

5. Heat Pumping Products in MFB

5.1 Products for heating

In urban areas, renewable energies are mostly limited or insufficient: no surface water as lake or river, or it is too far away, or restricted (protection of drinking water), no district heating nearby, wood forbidden because of air pollution, solar difficult or impossible (no place on the roof, protected building). The only renewable source which is available anywhere is the outside air. So air to water heat pumps is the technology with the highest potential to retrofit existing heating systems and reduce CO2-emissions [19].

The Swiss heat pump market is summed in Figure 11 [18]. The blue sections correspond to air-to-water HPs which clearly prevail with 66.8%. Brine-to-water installations are shown in yellow and account for almost one third of all sales. Water to water heat pumps represent less than 2% of the market.

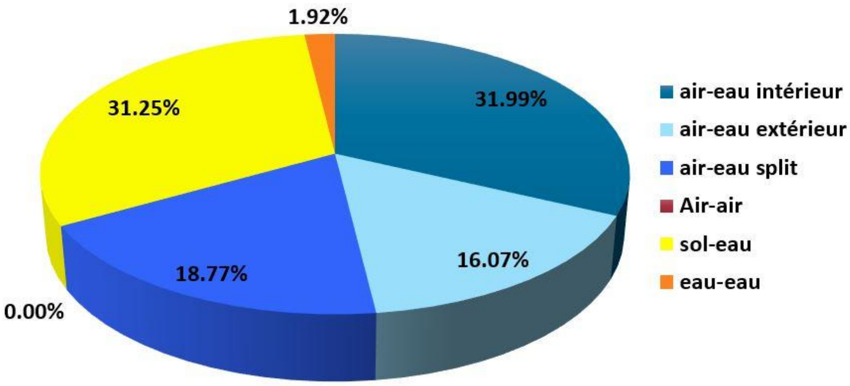

Figure 11 : Detailed distribution of heat pump sales by type for 2016 [18]

5.1.1 Individual air-to-air heat pumps

As illustrated in Figure 11, the amount of individual air-to-air heat pumps sales represent less than 0.01% of all annual heat pump sales for 2016 in Switzerland. This market is negligible.

5.1.2 Collective VRF air-to-air heat pumps

The tendency for collective VRF air-to-air heat pumps follows the same trend than the individual air-to-air products. This type of heat pumps isn't part of the Swiss market at present time. It is due to the fat that the cantonal regulation are very restrictive with heat pump systems which could be operated in a reversible mode. The active cooling mode underlies severe conditions.

5.1.3 Collective geothermal or air-to-water heat pumps

One of the major technical challenges is related to unavailability of air to water heat pumps specially designed for multifamily housing. Most of the residential heat pumps have currently capacity of 3 – 30 kW and are suited for single-family houses. Most of the industrial heat pumps have currently capacity of 30 – 600 kW, but their noise level is high. In order to integrate HP in multi-family buildings, there is a challenge in finding solutions for upsizing traditional heat pumps designed for single family houses or adapting equipment from industrial application onto a rooftop of multifamily houses. Among the other major technical challenges are achieving good efficiency with the outside air as a heat source, addressing noise and static requirements, integrating the heat pump in the existing distribution system in an efficient and reliable way. Among the technical aspects integrated in the feasibility studies are thermal engineering, rooftop static, soundproofing, vibration, electricity capacity and extra height construction limits. Addressing the above-mentioned aspects differs considerably for different types of buildings with respect to the age of construction [19].

5.2 Products for DHW

5.2.1 Exhaust Air Heat Pump Water Heaters

Very few products are on the market and mainly for single-family houses. There are very few products for multi-family houses.

5.2.2 Outside Air Heat Pump Water Heaters

Dedicated HPWH are used for individual homes only. Collective water heaters working with outside air heat pumps found in MFB follow the trend of HP installed in this type of housing.

5.2.3 High Temperature Collective Heat Pumps

Collective HP reach temperatures where it is interesting to supply heating along with DHW from the same unit. Brine-to-water HPs on the Swiss market reach maximum outlet temperatures of 73°C (B0/W35) and even 90°C (B15) with HFO refrigerant [20]. Air-to-water products allow for outlet temperatures up to 70°C-75°C (not guaranteed throughout the year when facing very cold ambient air temperatures). Working fluids for these machines are HFC, HFO or propane. Standard hydronic schemes given by suppliers are included in the appendix.

Given the power needed for DHW in Multi-Family-Buildings, the use of an external heat exchanger is often dictated by the exchange surface required to meet the needs as being too large to fit in the water heater. Where applicable, a plunging coil is recommended for enhanced efficiency and less regulation, temperature and load losses.

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ANNEXE A STANDARD HYDRONIC SCHEMES

Figure 12: Air-to-water HP with DHW in a multi-familial building [21]

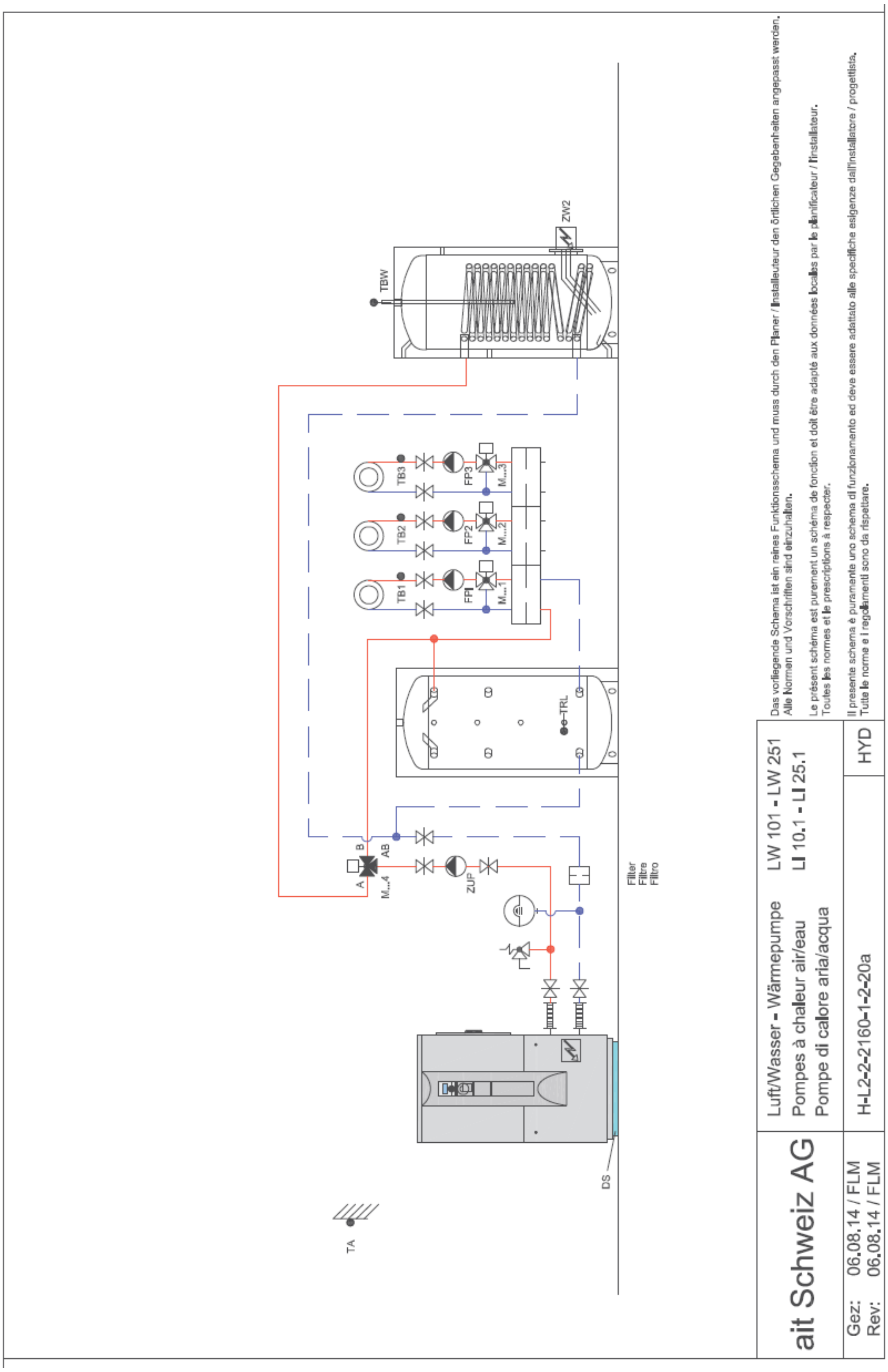

Figure 13: Brine-to-water HP with DHW in a multi-familial-building, part 1&2 [22]