



# HPT Annex 46

## Domestic Hot Water Heat Pumps

### Task 1 Market Overview Country Report *Switzerland*

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## Summary

**Hot water supply** is beside space heating the second most important energy portion in Swiss private households. The share of the **final energy consumption** on providing hot water accounts for 14.9% (31.7 PJ of totally 212.5 PJ in 2014) compared to 65.0% for space heating. The **energy consumption for hot water** is still dominated by the installed base of heating systems running on oil (36.6%), electricity (24.7%) and gas (22.4%). The share of renewable energy such as wood, solar and ambient heat accounts for 10.8%. Just 2.1% of the heating systems is based on heat pump technology. In 2014, nearly 35% of the Swiss population received their hot water from electricity-based heating systems, including electrical resistance systems (26.7% of the population), heat pumps (7.9%), and solar thermal heating systems (5.2%).

The **average hot water consumption per person** at 60°C varies between central systems and individual systems. In central systems it is about 45 to 50 liters per person per day, for individual systems about 35 liters. **Field measurements** in multiple family houses reveal average hot water consumptions of 36 to 44 litres per day and person. For ten households monitored over a periode of one year the mean value was 33.6 liters per day and person which is close to the 35 liters per day and person described in the standard SIA 385/2.

The **building stock** accounts for about 1.7 million buildings in 2014, of which 57% are single and 26% multiple family houses. The trend towards single family houses is unbroken. Overall, 70% of all buildings constructed since 2000 are single family houses. The **average living space per person** increased gradually from 38 m<sup>2</sup> in 1990 to 45 m<sup>2</sup> in 2014. With the high-quality building standards of **MINERGIE** and strong insulation, the **energy demand for space heating** is continually being reduced and hot water became the largest portion in those buildings. Therefore, it is important to develop highly efficient heating systems for domestic hot water.

Like in other countries, the **hot water consumption profiles** in Swiss **single family households** show a great variety depending upon the **human behaviour** and vary greatly from 8 to 65 litres per day and person. The central systems in multiple family houses do not experience this much fluctuation since there is an averaging effect of the individual human behaviours on the cumulated profile. There is a trend to install **water saving armatures** to limit the water consumption which is contrasted by the trend towards more comfort and wellness, which increases the water consumption. Intelligent **real-time display for the shower** are available which promote a more conscious handling of hot water and leads to energy savings. The **environmental awareness** is forseen to increase in the Swiss population and the use of heat pumps in particular has become part of the solution to our global environment.

The most popular systems for domestic hot water using heat pumps in **single family households** are heat pumps generating space heating and hot water simultaneously, followed by combined solar thermal and heat pump systems, and DHW heat pumps (heat pump boilers). Heat pumps for DHW are applied in about 8% in single and 5% in multiple family houses. The **sales numbers of DHW heat pumps** have increased from 364 units in 2009 to 4'919 units in 2015. DHW heat pumps are of great importance in the **retrofitting market** as they are cost-competitive and cut energy consumption significantly. Measurements in the field and at the heat pump test center (WPZ) show that heat pump boilers are about 3x as efficient as equivalent electric water heaters. The **energy efficiency of DHW heat pumps** has steadily improved. In 2012, two out of three DHW heat pumps achieved a COP of 2.60 (A15/W10-55), in 2014 about 90%.

The website [www.topten.ch](http://www.topten.ch) provides data of commercially available DHW heat pumps (heat pump boilers) in Switzerland from **31 suppliers and 78 models**. The typical **storage tank volumes** are between 80 and 500 liters. Particularly suitable is the installation in rooms with waste heat from a technical, workshop or laundry room. Such a system can also be combined with photovoltaics for the electrical supply of the DHW heat pump. In practice, the heat pump boiler is delivered as a plug-in system and it is a simple substitute for an electrically heated boiler. DHW heat pumps are also

available as a **split system** with outside air as energy. Split systems are gaining importance in single family houses as such systems can be used both for space heating and water heating.

In **multiple family houses** the hot water is generated **centralized** (central heat pump with storage tank and recirculation loop or trace heating) or **decentralized**. In centralized hot water heat pumps with storage tank, the water is heated in one large boiler and from there distributed to the different extraction points in each building. Due to long tubing runs, this installation often results in large heat losses. These losses need to be compensated by a heat tracing method. Using a **recirculation loop** for this purpose, the hot water circulates continuously from the top of the storage tank through the entire network and reaches every residential connection before it is fed into the storage in a separate circulation line. Alternatively, self-regulating electrical **heating cables** can be installed on all hot water pipes to keep the stagnant water warm. In large building complexes a **combination of space heating and hot water system** is often applied using a heating network with decentralized hot water storage tanks. Here, a central heat pump provides the heat for space heating and domestic hot water. Efficiencies of these systems are lower compared to recirculating loops or heating cables.

Typical **heat sources** in multiple family houses are ground heat, ground water or sewage water. More and more often, return water from the heating system is used in decentralized DHW heat pumps as heat source. In new multiple family houses, the heat distribution through the hot water pipe network is about half-half divided between recirculation loops and heating cable. However, there is a trend towards recirculation loop systems due to the unfavourable rating of electrical heating in MINERGIE buildings. **Legionella prevention** is typically done by at least one daily charge to 60°C for one hour.

**Research projects on new systems** are being carried out to optimally generate hot water with heat pump systems. These include e.g. waste air heat recovery of the ventilation system in multiple family buildings (HEXModul All-In-One), the combination of heat pump systems with solar technology, e.g. solar thermal and photovoltaic (SOFOWA and AquaPacSol), or a compact decentralized domestic hot water supply system for front-wall installations of bathrooms (KoDeWa).

The most important **associations and organizations** in Switzerland active in the heat pump sector are the FWS, GebäudeKlima Schweiz, Suissetec, SVK, ProKlima, SHKT, EnergySchweiz, and of course, the SFOE. The **FWS** is the Association for Heat Pumps in Switzerland and the responsible authority recognized by the Swiss Confederation and the cantons for the approval of the heat pump quality label. **GebäudeKlima Schweiz** is the leading association of Swiss manufacturers and suppliers of heating, ventilation and air-conditioning technology. The **Suissetec** is an industry and employers' association for the interests of building technicians. The **SVK** is the Swiss association for industrial refrigeration, air conditioning and heat pump technology. **ProKlima** is the platform for information exchange among manufacturers and suppliers of products or systems for the air-conditioning and ventilation industry. The **SHKT** comprises the Swiss heating and air conditioning technicians. **EnergySchweiz** promotes, above all, the training and further education of installers and planners, the information and advice association of plant operators and the quality assurance of new and existing buildings. The **SFOE** is the Swiss Federal Office of Energy and the competence center for energy supply and energy use in the Federal Department of Environment, Transport, Energy and Communications.

**Heat pumps** are expected to give an important contribution to meet the goals of the **energy strategy 2050**. The future **cantonal energy laws** based on the **MuKE**n offer a good chance for a higher market share of heat pumps. The increase in taxes on CO<sub>2</sub> emissions will increase the use of renewable energies in heat generation.

The SFOE is promoting the **replacement of electric water heaters** by heat pump boilers. A prerequisite is the **quality label** of the DHW heat pump for its energy efficiency awarded by the FWS. **Promotional and incentive programs** are bound to this quality label. Banks grant **reduced mortgage loans** for energetically renovated buildings, **tax deductions** are possible in different cantons which have an effect on the energy investments.

The **qualification of heat pumps** is performed at the accredited **heat pump test center WPZ in Buchs**, at the **NTB University of Applied Sciences of Technology**. DHW heat pump are tested according to EN 16147 and the new European ErP directive. Starting 2016, the FWS increased the

minimum requirements for the quality label of DHW heat pumps to a **COP of 3.20 at A20/W10-55** and 2.90 at A15/W10-55. For the EHPA quality label a minimum COP of 2.60 (A15/W10-55) is needed. As a joint venture, industry, SwissEnergy and the FWS have developed the "**Heat Pump System Module**", which is a new quality standard for the planning and construction of heat pump systems.

For designing domestic hot water systems, the building industry is following the standards **SIA 385/1 and SIA 385/2**. Major topics are legionella prevention, reduced heat losses of tubes and storage tank, hot water demand, tapping time, and heat tracing. The legal basis for **refrigerants** is regulated in the Chemical Risk Reduction Ordinance (**ChemRRV**). A special licence is required for handling refrigerants.

The **Swiss Federal Office of Energy (SFOE)** supports and coordinates energy research and innovation and ensures the access of Swiss researchers to the **R&D programs** of the **International Energy Agency (IEA)** and the **EU** (Research Framework Programme, Strategic Energy Technology Plan (SET-Plan)). The **funding** is based on the Federal Government's Energy Research Master Plan, which is revised every 4 years by the Swiss Federal Energy Research Commission (CORE). The energy research conducts **24 research programs** with focus on energy efficiency, renewable energies, nuclear energy and socio-economics. In 2014, the total investment was 305.9 million CHF. The research program of **Heat Pumping Technologies and Refrigeration** has been funded by 3.3 million CHF in 2014. The main focus is on improvement of components, efficiency, and system optimization. It is estimated that about 5% is spent on heat pumps for DHW. The SFOE's **pilot and demonstration program** contributes another 150'000 to 350'000 CHF on projects related to heat pumps and refrigeration.

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# 1. Policy framework

## a. Swiss Energy Policy on Renewable Energy and Energy Conservation

This part describes the Energy Policy and its Instruments and the consequences for hot water in the residential market. Are there:

- Subsidy scheme on investments?
- Tax reduction scheme for investments or R&D?
- Policy on Energy Tariffs through taxes or tax reductions?
- Supporting program on information, training and certification?

**Question:** Is there a policy on renewable heating and cooling and what is the position for heat pumps in general and hot water in this policy framework?

### i. Energy strategy 2050

In Switzerland, there are the following main energy policy regulations in place:

- the CO<sub>2</sub> tax on fuels<sup>1</sup>,
- the regulations of the cantons in the energy sector MuKEN<sup>2</sup> (EnDK 2014)),
- the cost-covering compensation for electricity fed into the grid (KEV<sup>3</sup>), and
- the building program<sup>4</sup> (Das Gebäudeprogramm 2016, 2015).

With the energy strategy 2050<sup>5</sup>, Switzerland ensures the energy supply in the long term. The aim is to reduce the end-energy and electricity consumption, increase the share of renewable energies and reduce energy-related CO<sub>2</sub> emissions. This, without jeopardizing the energy supply security and low-cost energy supply in Switzerland. A first package of measures of the energy strategy 2050 defines the following goals in terms of energy efficiency (BFE 2016b; BFE 2016a):

- Reduction of average energy consumption per person in Switzerland compared to 2000:
  - - 16% in 2020
  - - 43% in 2035
- Reduction of average electricity consumption per person compared to 2000:
  - - 3% in 2020
  - - 13% in 2035
- Average domestic production of renewable energy without hydropower:
  - 4'400 GWh in 2020
  - 11'400 GWh in 2035
- Hydro power: 37,400 KWh in 2035

Heat pumps are expected to provide an important contribution to achieve the goals of the energy strategy 2050 and the future cantonal energy laws offer the heat pumps a good chance of a higher market share in the heat market (BFE 2015a). The increase in CO<sub>2</sub> emissions will increase the use of renewable energies in heat generation. This will have a positive effect on the heat pump market.

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<sup>1</sup> <http://www.bafu.admin.ch/klima/13877/14510/14748/index.html?lang=de>

<sup>2</sup> <http://www.endk.ch/de/dokumentation/MuKEN>

<sup>3</sup> <http://www.bfe.admin.ch/themen/00612/02073/index.html?lang=en>

<sup>4</sup> <http://www.dasgebaeudeprogramm.ch>

<sup>5</sup> <http://www.bfe.admin.ch/energiestrategie2050>



## ii. Competences and impact matrix for the energy policy in Switzerland

Figure 1 gives an overview of the competences and impact matrix for the energy policy in Switzerland (EnDK 2012). The role of the Swiss Confederation and cantons is defined by the competences in the different policy areas that shape the energy policy.

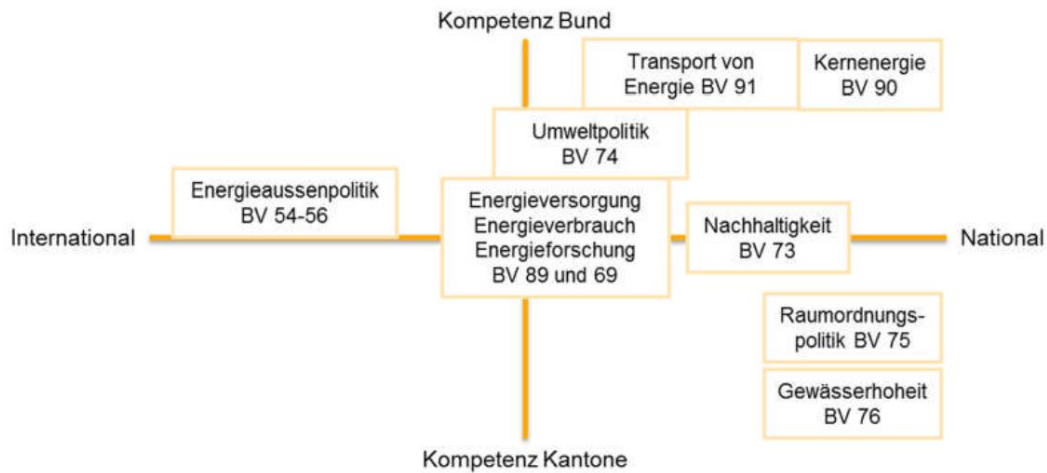


Figure 1: Competences and impact matrix for the energy policy, source: Federal Constitution (EnDK 2012).

The competences of the Swiss Confederation are:

- regulation of nuclear energy,
- transport of energy,
- environmental protection,
- consumption of energy from plants, vehicles and equipment.

Moreover, the Confederation is responsible for the protection of moorlands, and it can make inventories for objects worthy of protection from all over Switzerland.

The cantons:

- are the owners of the water resources,
- regulate the energy consumption of buildings,
- protect nature and the environment
- are responsible for spatial development within the framework of federal legislation.

## iii. EnDK

In the building sector, the cantons are primarily responsible for the regulation and limitation of the energy consumption in buildings (Article 89 (4) BV)<sup>6</sup>. Since 1979, the conference of cantonal energy directors EnDK<sup>7</sup> is the joint energy competence centre of the cantons. It promotes and coordinates cantonal cooperation in energy topics and represents the common interests of the cantons. The guidelines of the EnDK indicate the direction in which the energy policy of the cantons wants to move (EnDK 2012). Affiliated to the EnDK is the EnFK<sup>8</sup>, which is handling the technical questions. The goals of the EnDK are to:

- reduce the energy demand in the building sector, in particular in existing buildings,
- cover the remaining energy needs by means of waste heat and renewable energies, and
- pursue a federal energy policy with high acceptance.

<sup>6</sup> <https://www.admin.ch/opc/de/classified-compilation/19995395/index.html#a89>

<sup>7</sup> Energiedirektorenkonferenz der Kantone, [www.endk.ch](http://www.endk.ch)

<sup>8</sup> Energiefachstellenkonferenz

#### iv. MuKE

The EnDK has approved the revision of the cantonal MuKE<sup>9</sup> regulations (EnDK 2014) in the energy sector. By 2020, the MuKE regulations have to be incorporated into the cantonal energy legislation. The objective of the MuKE regulations is to achieve a high degree of harmonization in the field of cantonal energy regulations in order to simplify the construction planning and the licensing procedures for builders and professionals working in several cantons (BFE 2015a). This way, the MuKE regulations will influence the energy consumption development in Switzerland. The set goals are (EnDK 2011):

- from 2015 on, for buildings built before 1990, the use of electricity for resistance heating and hot water treatment will be prohibited, with a retrofit obligation within 10 years
- In the case of major refurbishments from 2020 onwards, the most important part of the hot water treatment must be renewable energy.

Furthermore, the MuKE article 1.16, no. 2, (EnDK 2014) declares that the new installation or replacement of a direct-electrical heating (by a direct-electrical heating system) of hot water is only allowed in residential buildings if the hot water is:

- heated or preheated during the heating period with the heat generator for the space heating; or
- heated to at least 50% by means of renewable energy or waste heat.

Art. 1.29 (EnDK 2014) defines the replacement of heat generators by renewable heat. When replacing the heat generator in existing residential buildings, they must be equipped in such a way that the proportion of non-renewable energy does not exceed 90% of the relevant demand. 100 kWh/m<sup>2</sup> and year applies as standard energy solution for heating and hot water (EnDK 2014).

The following standards solutions (SL's) with heat pumps and hot water comply with the requirements of the MuKE (Art. 1.31, (EnDK 2014)):

- SL 3: heat pump with ground source, water or ambient air, electrically driven heat pump for heating and hot water all year
- SL 4: natural gas-powered heat pump for heating and hot water all year
- SL 7: Hot water heat pump with photovoltaic system, heat pump boilers and photovoltaic system with at least 5 W/m<sup>2</sup> energy reference area

For new buildings the concept of the "near zero energy building" has been introduced (BFE 2015a). The goal is to achieve a standard that lies between today's Minergie and Minergie P requirements. This means that as little as possible energy is supplied to the building on a certain property. The required energy is produced as far as possible on the property or in and on the building. In addition, each new building will have to cover a portion of its electricity needs in the future.

In the case of old buildings, CO<sub>2</sub> emissions are to be gradually reduced. Thus, in the replacement of fossil heating systems, 10% of the energy consumed will have to be compensated by the use of renewable energies or by efficiency measures.

#### v. Replacement of electroboilers

The general prerequisites for the replacement of electroboilers are defined in the regulation „Verordnung über Förderungsbeiträge nach dem Energiegesetz (EnFöV) (sGS 741.12)<sup>10</sup>. In the coming years when replacing electric water heaters (electroboilers), heat pumps and heat pump boilers are

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<sup>9</sup> Mustervorschriften MuKE

<sup>10</sup> [www.gesetzessammlung.sg.ch/frontend/versions/1940](http://www.gesetzessammlung.sg.ch/frontend/versions/1940), sGS 741.12 - Verordnung über Förderungsbeiträge nach dem Energiegesetz (EnFöV)

expected to be increasingly installed (BFE 2015a). A prerequisite is the product quality approval (FWS quality label).

For example, the canton St. Gallen defined the following conditions (Energieagentur St. Gallen 2015) for replacement of electroboilers by thermal solar collectors or heat pump boilers or for integration into an existing heating system powered by wood, district heating, or a heat pump<sup>11</sup>:

- The heat pump boiler needs to fulfil the requirements of the quality label regarding energy efficiency according to the standards EN 16147:2011 and EN 14511-1 to EN 14511-4
- The heat pump is installed in an unheated room.
- The heat pump is not installed adjacent to bedrooms. In addition, in a multiple family house the heat pump is not installed on a building level used for residential purposes.
- Only one electro boiler replacement is promoted for each housing unit.
- Promoted is the replacement of pure electric boilers.

The MuKE regulations (Zu Art. 1.16 Abs. 2, (EnDK 2014) further defined that the term “new installation” also includes installations in existing buildings with a different hot water system. On the other hand, it is permitted to replace a single faulty electric water heater in a multiple family building. The replacement of a complete set of the hot water system in a multiple family house is equivalent to a new installation.

In 2009, the Swiss Federal Office of Energy (SFOE) started a “stabilization program 2” promoting the replacement of electric storage heaters, also by heat pumps. A total of 1183 electric storage systems have been replaced with heat pumps of which 390 are air/water, 721 brine/water and 82 water/water, which was declared as a success story (Egli et al. 2011). To qualify for the grant only heat pumps with the quality label of the FWS were accepted. The most important result was the reduction in electricity use of 57% representing an annual average saving per inspected installation (Egli et al. 2011).

The EFFIBOILER<sup>12</sup> program of Energie Zukunft Schweiz promotes the replacement of old electroboilers to new heat pump boilers with a contribution of 450 CHF. Today, the program still has funding support for more than 1'000 devices. The program is supported by the promotional program ProKilowatt under the direction of the Swiss Federal Office of Energy.

*Table 1: Energy and cost comparison of an electric storage water heater and a hot water heat pump (GebäudeKlima Schweiz 2012).*

Hot water temperature 55°C	Unit	Electrical boiler (300 L)	Heat pump water heater
Annual energy consumption	kWh/a	4'500	1'500
Investment costs	CHF	2'000	4'500
Amortization (15 years)	CHF	133	300
Interest, 4%	CHF	40	90
Operating costs (0.14 CHF/kWh)	CHF	630	210
Annual costs	CHF	803	600

Table 1 compares the energy and costs of an electric storage water heater and a hot water heat pump (GebäudeKlima Schweiz 2012). The domestic hot water heat pump requires approx. 2/3 less electrical energy (GebäudeKlima Schweiz 2012). The use of the DHWHP is practically CO<sub>2</sub>-neutral (depending on the electricity generation) and cost-effective. Heat pump boilers cost more than electroboilers, but the additional costs pay back over the lifetime due to electricity cost savings (Warthmann 2012).

<sup>11</sup> <http://efoerderportal.sg.ch/Documents/Static/Wegleitung/EE/de-CH/Wegleitung.pdf>

<sup>12</sup> [www.energiezukunftschweiz.ch/de/wpj-jetzt](http://www.energiezukunftschweiz.ch/de/wpj-jetzt) or [www.wpb-jetzt.ch](http://www.wpb-jetzt.ch)

## vi. Funding programs

The promotion of energy projects in the building sector is a central aspect of the Swiss Federal Government's energy strategy 2050. On the basis of the federal legislation, the cantons are responsible for funding in the building sector. The webpage of the Federal Office of Energy provides an overview of the various funding possibilities of the cantons<sup>13</sup>.

The most important funding program in this area is the building program ("Das Gebäudeprogramm"). The building program was developed by the conference of the cantonal energy directors (EnDK) together with the Federal Office of Energy (BFE) and the Federal Office for the Environment (BAFU). The main objective of the building program is to significantly reduce the CO<sub>2</sub> emissions of Swiss buildings. The use of fossil fuels has to be reduced. It supports the improvement of thermal insulation of single-family houses, multiple family houses or public service buildings throughout Switzerland. The main topics of the program are the building refurbishment, energy efficiency, renewable energies and climate protection.

In Switzerland, there is no general funding institution for heat pumps (Banach & Fahrni 2014). In the area of the heat pump only remediation cases are financially supported. In addition, there are cantonal subsidies for a system change in a heating system, e.g. change to a heat pump system. Likewise, boiler heat pumps are supported through various electrical power stations. For example, the BKW<sup>14</sup> (Bernische Kraftwerke) supports the replacement of a "normal" electric boiler with a DHW heat pump with 600 Swiss francs.

The "EnergieSchweiz" program plays an important role in funding. It is not directly focussed on heat pumps. However, some points allow refinancing in this area. For example, when it comes to increasing the share of renewable energies.

In the case of indirect subsidies, the Federal Office for Energy SFOE and the Association of Heat Pumps Switzerland FWS play the most important roles. They support above all the suppliers and manufacturers in the research, the education and training, the marketing and the quality assurance, as soon as their heat pump has received the quality label (Banach & Fahrni 2014).

## vii. Das Gebäudeprogramm

The Swiss federal government and the cantons want to significantly cut the energy consumption of the Swiss buildings with the building program and reduce CO<sub>2</sub> emissions (Das Gebäudeprogramm 2016; Prognos AG 2015). The Federal Act on the Reduction of CO<sub>2</sub> Emissions (CO<sub>2</sub> Act) of 23 December 2011 (Art. 34, Abs. 1) states that 1/3 of the CO<sub>2</sub> tax on fuels, but a maximum of 300 million CHF per year, are used for measures to reduce CO<sub>2</sub> emissions in buildings (Das Gebäudeprogramm 2015). Within this framework of the "Gebäudeprogramm" (Das Gebäudeprogramm 2016, 2015) the Confederation gives the cantons financial grants to:

- part A: energy-related renovations of the building envelope of existing heated buildings, i.e. better insulated roofs, walls, floors, ceilings and windows.
- Part B: promotion of the use of renewable energies, complete renovations of the heating system, the use of optimized building technology, and the use of waste heat.

The CO<sub>2</sub> tax on fuels was introduced in 2008 at an initial rate of 12 CHF / t CO<sub>2</sub> (BAFU 2008<sup>15</sup>). As the reduction target for fuels has not been achieved by 2014, the CO<sub>2</sub> tax has gradually increased to 60 CHF / t CO<sub>2</sub> in 2014 (about 0.16 CHF per litre of fuel oil) and to 84 CHF / t CO<sub>2</sub> in 2016 (Prognos AG 2015; Das Gebäudeprogramm 2015).

For part A, which is uniform throughout Switzerland, the Confederation allocates a maximum of 133 million CHF per year for energetic building renovation of roofs, walls, floors, ceilings and windows.

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<sup>13</sup> <http://www.bfe.admin.ch/dienstleistungen/05822/index.html?lang=de>

<sup>14</sup> [www.bkw.ch/warmwasser](http://www.bkw.ch/warmwasser)

<sup>15</sup> <http://www.bafu.admin.ch/klima/13877/14510/14748/index.html?lang=en>

The improved insulation of the building envelope lowers the heating costs and helps to reduce CO<sub>2</sub> emissions.

In part B, the cantons paid around CHF 79 million CHF subsidies in 2015 to house owners for the implemented measures in the fields of renewable energies, building technology and waste heat use (Das Gebäudeprogramm 2015). This replaces fossil fuels, which also reduces CO<sub>2</sub> emissions. In most cantons, the conversion to heating systems operated with renewable energy sources, such as heat pumps, solar or wood systems, is financially supported by the “Gebäudeprogramm”.

Since 2010 (over the last 5 years), 468 million CHF were funded in energy efficiency and renewable energies in the building sector by the “Gebäudeprogramm” (Das Gebäudeprogramm 2015), which lead to a total reduction of about 9.0 million tonnes of CO<sub>2</sub>. Thanks to this support, the annual CO<sub>2</sub> emissions in the building sector are to be reduced by 1.5 to 2.2 million tonnes of CO<sub>2</sub> by 2020.

### viii. Energiefranken

The Swiss Federal Confederation, cantons, cities and municipalities, as well as campaigns from regional energy suppliers and private institutions are supporting the promotion of renewable energies and increasing energy efficiency. Today, many funding programs are offered at various levels in Switzerland. The webpage “Energiefranken”<sup>16</sup> provides a list of the different types of funding programs of energy promotion in Switzerland. The programs are subdivided into several areas. After entering the postcode of the building location a list of all energy promotion programs are shown (Figure 2). The search includes funding programs for the cantons, cities and municipalities as well as campaigns from regional energy supply companies.

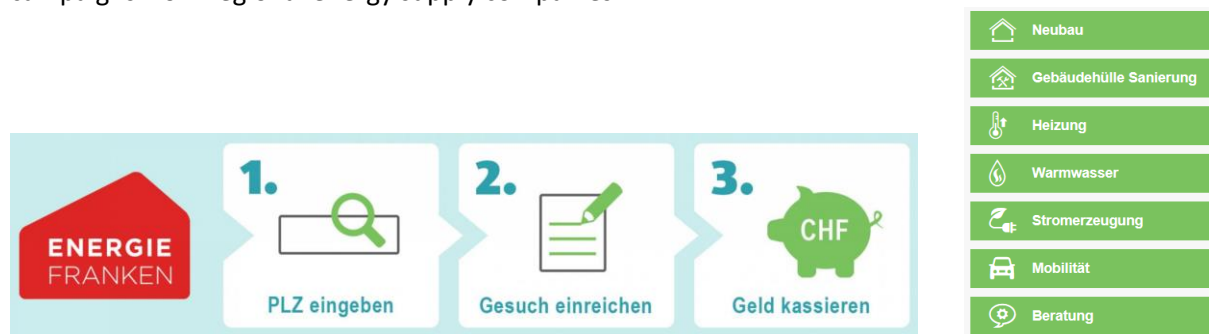


Figure 2: Left: Energiefranken<sup>17</sup> shows the procedure to get financial funding for renewable energies and energy efficiency (1. Enter the postcode of the building location, 2. Submit the application for funding, 3. Receive funding), Right: Example list of energy promotion programs.

In the category of “buildings and living” there are specific funding programs related to hot water. For hot water, the cantons can grant subsidies for the following systems:

- solar thermal systems
- heat pump boilers, and
- combined heat supply system (> 70 kW heat capacity, “Wärmeverbünde”)

Moreover, many banks grant reduced mortgage loans, so-called eco, sustainability or MINERGIE mortgages for buildings and renovations, which are energetically renovated. The most common option is an interest rate subsidy. Over a fixed term, a rate reduction of around 0.4 to 1% is granted at a maximum amount defined by the bank<sup>18</sup>. In addition, there are tax deductions that are possible in different cantons which have an effect on energy investments, in favour of existing buildings.

<sup>16</sup> [www.energie-experten.ch/de/energiefranken.html](http://www.energie-experten.ch/de/energiefranken.html)

<sup>17</sup> [www.energie-experten.ch/de/energiefranken.html](http://www.energie-experten.ch/de/energiefranken.html)

<sup>18</sup> <https://www.energie-experten.ch/de/energiefranken.html>

## b. Building standards/code with calculation and design models

This part describes the policy conditions for Energy performance of buildings and technical systems for Nearly Zero Energy Buildings for New Buildings and renovation.

- Like the EPBD – labelling in Europe
- Product labels for Heat Pumping Technologies, like ECO-label or minimum requirements for efficiency of residential water heaters like in USA
- Test and rating procedures

**Question:** Is there a procedure in the building standards for rating domestic hot water, based upon facts and is it possible to rate innovative technologies?

### i. EU energy label

Within the framework of the European ErP Directive 2009/125/EC (Energy-related Products Directive), also known as the Ecodesign Directive<sup>19</sup> (EU 2013b), the EU adopted new requirements for the ecological design and labeling of energy-related products. Boilers and combined heaters (including heat pumps) and hot water heaters (including domestic hot water heat pumps) are affected. As of September 2015, all manufacturers are obliged to comply with the minimum requirements contained in the Ecodesign Directive. New equipment placed on the European market must meet these requirements.

Figure 3 shows a version of the energy label<sup>20</sup> for domestic hot water heat pumps. The symbol in the upper left corner of the energy label indicates whether it is a hot water heater or hot water storage. The water tap symbol stands for the water heater, a container with wave lines symbolizes the hot water storage tank.

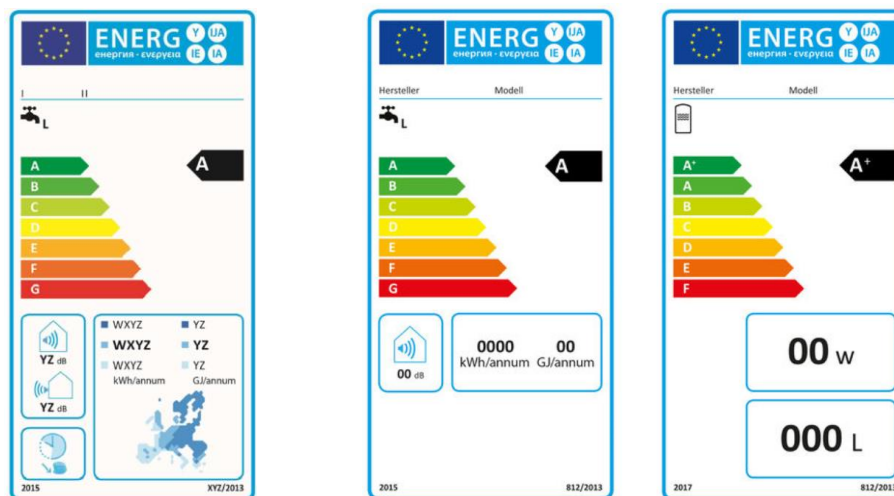


Figure 3: Energy label of a hot water heater and hot water storage (source: (EU 2013a) (WPZ 2013), [www.gebaeudeklimate-energieetikette.ch](http://www.gebaeudeklimate-energieetikette.ch)).

The hot water heater label includes the energy class on a scale of A to G, or A+ to F. This indicates the “water heating efficiency class” at a specific tapping cycle (draw-off profile, e.g. “L” symbol). The larger the tapping profile, the higher the required energy factor a model must meet to attain a given rating. In the case of hot water storage, the storage volume in liters (L) and the heat retention losses

<sup>19</sup> [EU Ecodesign-Richtlinien Boiler: Commission regulation \(EU\) No. 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks](http://eur-lex.europa.eu/legal-content/EN/REGULATIONS/?uri=CELEX:32013R0814). Valid since September 26, 2015.

<sup>20</sup> [www.gebaeudeklimate-energieetikette.ch/typo3/index.php?id=11](http://www.gebaeudeklimate-energieetikette.ch/typo3/index.php?id=11)



in watts (W) at a certain water and ambient temperature are also declared, i.e. the energy lost to keep the water warm. Table 2 shows the efficiency classes for heat pump water heaters (SEAD 2013; EN 16147 2011; EU 2013a).

Table 2: European water heating efficiency classes for heat pump water heaters (SEAD 2013; EN 16147 2011; EU 2013a).

Draw-off profile	Efficiency required to achieve this rating									
	G	F	E	D	C	B	A	A+	A++	A+++
M	<27%	≥27%	≥30%	≥33%	≥36%	≥39%	≥65%	≥100%	≥130%	≥163%
L	<27%	≥27%	≥30%	≥34%	≥37%	≥50%	≥75%	≥115%	≥150%	≥188%
XL	<27%	≥27%	≥30%	≥35%	≥38%	≥55%	≥80%	≥123%	≥160%	≥200%
XXL	<28%	≥28%	≥32%	≥36%	≥40%	≥60%	≥85%	≥131%	≥170%	≥213%

Source : EC (2013) Applies to packaged water heaters under average EN 16147 climate conditions (Table 8)

The A+ to A+++ classes can only be reached by water heaters using renewable energy sources, i.e. either heat pump water heaters or solar water heaters. The energy efficiency classes above A are defined such that the classes A+/A++/A+++ correspond to a contribution of 35%/50%/60% of renewable energy sources to energy consumption, compared to the efficiency class A (SEAD 2013). In addition, the climate conditions (Switzerland belongs to the average climate zone) and the noise levels (in dB) from internal and external components of the heat pump are shown (SEAD 2013). A pictogram shows the tapping profile on which the HPWH was tested (e.g. a single tap for a low load, a series of taps, showers and a bath for a large load). The annual electricity consumption (in kWh/annum and GJ/annum) for the average, warmer and colder climate conditions is also stated together with the map of Europe. An indication is given whether the HPWH is suited to operate with off-peak tariffs.

In order to estimate the ecodesign suitability of domestic hot water heat pumps on the Swiss market, their energy efficiency was determined at the heat pump test center WPZ in Buchs (WPZ 2013) according to the ecodesign rules and compared with the requirements for market approval.

The test conditions of the ErP guideline differ slightly from the EN 16147 measurement. In particular, the air source temperature is 20°C for indoor installations instead of 15°C. The measurements of the WPZ showed that the increase in the source temperature from A15 to A20 results in about 10% higher COP values (Eschmann 2015b). The average measured COP values were 3.36 (at 20°C) and 2.89 (15°C) during the reporting year 2015 measured according to EN 16147. A total of 16 heat pumps were measured. As noted by (Eschmann 2015b) the Ecodesign requirements as a whole do not pose a real obstacle to the market approval in Switzerland concerning hot water heat pumps. Figure 4 shows the required COP values of hot water heat pumps to meet the EU energy label (Eschmann 2014). The energy efficiency classes refer to the complete efficiency of the heat pump device (electricity production is assumed to have 40% efficiency, EU mix).

Zapfprofil	S	M	L	XL	XXL
Entnahmemenge	2.1 kWh	5.8 kWh	11.7 kWh	19.1 kWh	24.5 kWh
Speichervolumen	-	<150 Liter	150 – 249 Liter	250 – 400 Liter	>400 Liter
COP für Gütesiegel	-	2.60	2.60	2.60	2.60
A+++ (ab 2017)	90% (2.25)	163% (4.08)	188% (4.70)	200% (5.00)	213% (5.33)
A++ (ab 2017)	72% (1.80)	130% (3.25)	150% (3.75)	160% (4.00)	170% (4.25)
A+ (ab 2017)	55% (1.38)	100% (2.50)	115% (2.88)	123% (3.08)	131% (3.28)
A	38% (0.95)	65% (1.63)	75% (1.88)	80% (2.00)	85% (2.13)
B	35% (0.88)	39% (0.98)	50% (1.25)	55% (1.38)	60% (1.50)

Figure 4: Required COP values of hot water heat pumps to achieve the EU energy label (Eschmann 2014).

## ii. EHPA quality label

In order to apply for an EHPA quality label (Figure 5) in Switzerland, measurements according to EN 16147 at A15/W10-55 are needed with a minimum COP of 2.60 (independent of the tapping cycle). Measurements of the WPZ (WPZ 2013) show that the efficiency of commercially available domestic hot water heat pumps is about 10% higher at an ambient temperature of 20°C than at 15°C (Table 3). The Swiss national quality label is awarded by a simplified procedure with shorter tests. Quality labels with short-term tests are only awarded if there are bottlenecks in the test centre<sup>21</sup>. The list of heat pumps awarded the international EHPA quality label are listed in the online EHPA database<sup>22</sup> structured by country.

Table 3: Comparison of the COP and volume of hot water heat pumps measured according to the EN 16147 (EHPA quality label) and ErP (WPZ 2013).

	Zapfprofil XL nach EN 16147 Tapping cycle XL according to the EN 16147	Zapfprofil XL nach ErP Tapping cycle XL according to the ErP	Differenz Difference
COP	2.95	3.22	+ 0.27 (+ 9.2%)
V [dm <sup>3</sup> ]	425	421	- 4 (- 1.0%)
Prüfbedingung Test condition	A15 / W10-55	A20 / W10-55	



Figure 5: European Quality Label for Heat Pumps (<http://www.fws.ch/waermepumpen-mit-zertifikat.html>).

## iii. FWS quality label

In Switzerland, the Association Heat Pumps Switzerland (FWS<sup>23</sup>) awards quality labels in the field of heat pumps (Born 2016; EnergieSchweiz 2015). The following quality labels are relevant:

- 1) the quality label for heat pumps,
- 2) the quality label for geothermal probe drilling companies, and
- 3) the quality label for hot water heat pumps (heat pump boilers) with FWS certificate.



Figure 6: Quality labels of the accredited heat pump test centre in Buchs SG relevant in the field of heat pumps (source: (EnergieSchweiz 2015, <http://www.fws.ch/waermepumpen-mit-zertifikat.html>)).

<sup>21</sup> <http://www.fws.ch/waermepumpen-mit-zertifikat.html#inhaber-des-guetesiegels>

<sup>22</sup> [http://www.ehpa.org/?id=757&L=1&tx\\_ehpaqualitylabel\\_pi2\[country\]=CH](http://www.ehpa.org/?id=757&L=1&tx_ehpaqualitylabel_pi2[country]=CH)

<sup>23</sup> [www.fws.ch](http://www.fws.ch)



The quality labels are part of the quality assurance measures of the FWS and the Federal Office for energy. Promotional and incentive programs of the Federation, the Cantons and the energy supply companies are generally bound to these quality labels.

The quality label for hot water heat pumps requires minimum COP values (FWS 2015a). These minimum COP values are measured by the heat pump test centre WPZ in Buchs, Switzerland. Until the end of 2014, the measurements were exclusively performed at an air source temperature of 15°C (A15) according to the test standard EN16147:2011 (EN 16147 2011). Since the beginning of 2015, measurements at the heat pump test centre in Buchs (WPZ) have been carried out according to the ErP directive with an air source temperature of 20°C (A20) (FWS 2015a; Eschmann 2015b).

Based on this new ErP directive the quality label regulations were revised, as shown in Table 4. The FWS has corrected the COP requirement values measured at A20 by 10% downwards and used this corrected value for the assessment and entered into force on January 1, 2016.

Table 4: Minimum COP requirements to receive the FWS quality label for hot water heat pumps (FWS 2015a). underlined = valid requirement, *italic* = equivalent value according to conversion, ProKilowatt<sup>24</sup> supports programs that contribute to a more economical use of energy.

	COP at <u>A15/W10-55</u>	COP at <u>A20/W10-55</u>
Minimum requirements according to the FWS quality label regulations for DHW heat pumps until 31/12/2015	<u>2.6</u>	2.9
Requirements of the competitive tenders from ProKilowatt, the Swiss Federal Office of Energy SFOE	<u>2.9</u>	3.2
New minimum requirements according to the FWS quality label regulations for DHW heat pumps from 01/01/2016 on	2.9	<u>3.2</u>

Until the end of 2015, in order to apply for the quality label for the domestic hot water heat pump in Switzerland, a minimum COP value of 2.60 at A15/W10-55 or 2.90 at A20/W10-55 were required (Eschmann 2015b). Since nearly all heat pumps tested have reached this required level in 2015, the minimum value was raised to 3.20 at A20 / W10-55 (2.90 at A15 / W10-55) from 2016 on (FWS 2015a; Eschmann 2015b).

As in other European countries the domestic hot water heat pumps are promoted if they reach a defined minimum value at A7/W10-55, the same test conditions are also offered at the WPZ. The test points at A7 and A20 are particularly interesting regarding the ErP-directive. As the measurement at A15 is not mentioned in the ErP-regulations, it is expected that hardly any heat pump will be measured at 15°C in the future (Eschmann 2015b).

The required COP values according to EN 16147 depend on the storage volume, the tap profile and the heat source condition (FWS 2016c). In order to obtain a quality label for a hot water heat pump with FWS certificate, the COP values according to Table 5 must be fulfilled, according to EN 16147 (EU regulation 814/2013).

Table 5: Required COP values according to EN 16147 depending on the storage volume, the tap profile and the air source temperatures (A20, A7). The hot water temperature is  $\geq 52^{\circ}\text{C}$ . The actual storage volume may not exceed the nominal content by max. 5% difference (FWS 2016c). The tap profiles are described in EN 16147 (EN 16147 2011).

Storage volum in litres	Tapping profile	Minimal COP at source conditions	
		A20	A7
< 150	M	3.2	2.3
150 to 249	L	3.2	2.3
250 to 349	XL	3.2	2.3
> 350	XXL	3.2	2.3

<sup>24</sup> [www.bfe.admin.ch/prokilowatt](http://www.bfe.admin.ch/prokilowatt)

The following documents must be submitted to apply for the quality label (FWS 2016b):

- Test report with test according to EN 16147 issued by the testing institute
- Test report standstill loss measurements storage acc. To EnV (alternatively authorization certificate SVGW)
- Component list
- EG-Declaration of conformity
- Confirmation of equality in model range, if the model designation deviates from that of the manufacturer
- Installation instructions for the installer
- User manual for the end users
- Description of the customer service organization on how the end-user is supported in the event of a failure

#### iv. Test procedures and results

The measurements of domestic hot water are carried out at the test centre WPZ according to EN 16147. The DHW heat pumps are mostly measured at 7°, 15°C or 20°C. The entire test procedure takes about 5 to 8 days to determine the efficiency of a domestic hot water heat pump (Eschmann 2014).

Figure 7 shows the different test procedures of domestic hot water heat pumps according to EN Testing procedure of domestic hot water heat pumps according to the EN 16147 standard and the ErP directive (right). The illustrated measurement periods are:

- A: Heating period
- B: Determination of the standby loss (at least 48 hours)
- C: COP measurement (defined extraction amounts per day) (extraction types: e.g. hand washing, bathing, dish washing, etc.)
- D: Determination of the hot water temperature and quantity

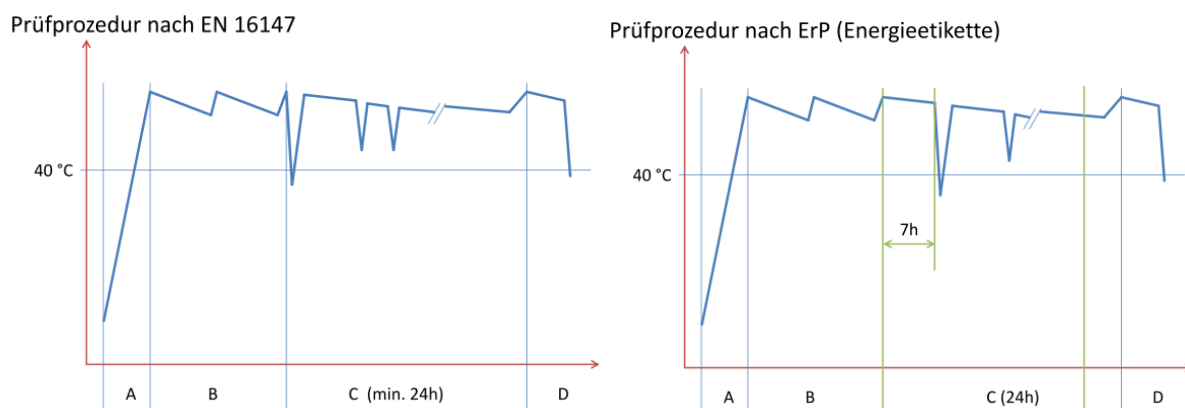


Figure 7: Testing procedure of domestic hot water heat pumps according to EN 16147 (left) and ErP directive (right) (Eschmann 2014).

In 2015, a total of 10 domestic hot water heat pumps were tested at A20/W10-55, 8 units at A15/W10-55 and 8 units at A7/W10-55 (Eschmann 2015b). The brine/water heat pumps with integrated storage tanks were measured at B0/W10-55. A total of 81 heat pump devices have already been measured at one of these test conditions. 25 heat pump boilers were measured according to the ErP Directive, 7 of which were brine / water heat pumps with integrated storage. Figure 8 shows the cumulative frequencies of the achieved COP values for A15/W10-55 and A7/W10-55. The median is 2.84 (A15) and 2.62 (A7), respectively, for the tested domestic hot water heat pumps.

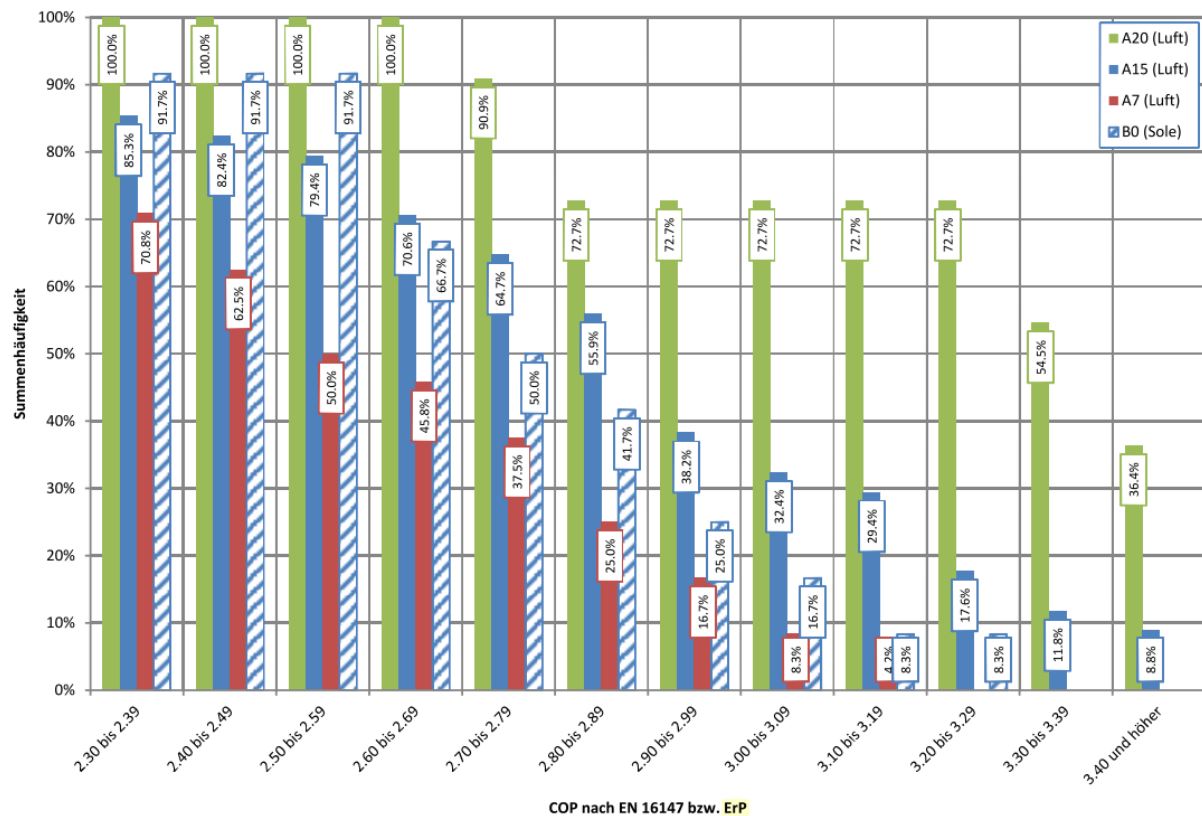


Figure 8: COP distribution of tested domestic hot water heat pumps according to EN 16147 (Eschmann 2015b).

#### v. WP System Modul

Tests on heat pump systems in the field show that the energy efficiency can be increased by at least 15% on average (WPSYSTEMMODUL 2016; Hubacher 2016). (Hubacher & Bernal 2015) showed that the storage tanks of DHWHP were too large and that the small pump volumes influenced the efficiency due to the heat losses. A lack in planning, capacity calculation and operation was identified as feedback from the field tests.

To increase the quality and efficiency of heat pump systems the heat pump system module (WP system module<sup>25</sup>) has been developed as a joint venture of the most important industry operators, SwissEnergy and the Swiss Heat Pumps Association (FWS). For further information see [www.wp-systemmodul.ch](http://www.wp-systemmodul.ch).

The heat pump system module is a new quality standard for the planning and construction of heat pump systems up to approx. 15 kW heating capacity based on the existing international quality label for heat pumps (WPSYSTEMMODUL 2016). The system module can be used both in new buildings and in refurbishment. It integrates the main components of the coordinated overall system of heat production: heat source, heat pump, circulation pumps, storage, hydraulics, heat delivery system, water heating, control, and commissioning – an overall system of heat production. Also the installation is standardized. The house owner receives a complete documentation of the heat pump system (Born 2016).

The heat pump system module ensures that the heat pump system operates with high energy efficiency. The module regulates the procedures and responsibilities during the planning, installation and commissioning of the plant between the heat pump supplier and the installer. This increases the quality of the system. The Association for Heat Pumps in Switzerland (FWS) tests and certifies the heat pump system module developed by the suppliers (EnergieSchweiz 2014).

<sup>25</sup> [www.wp-systemmodul.ch](http://www.wp-systemmodul.ch)

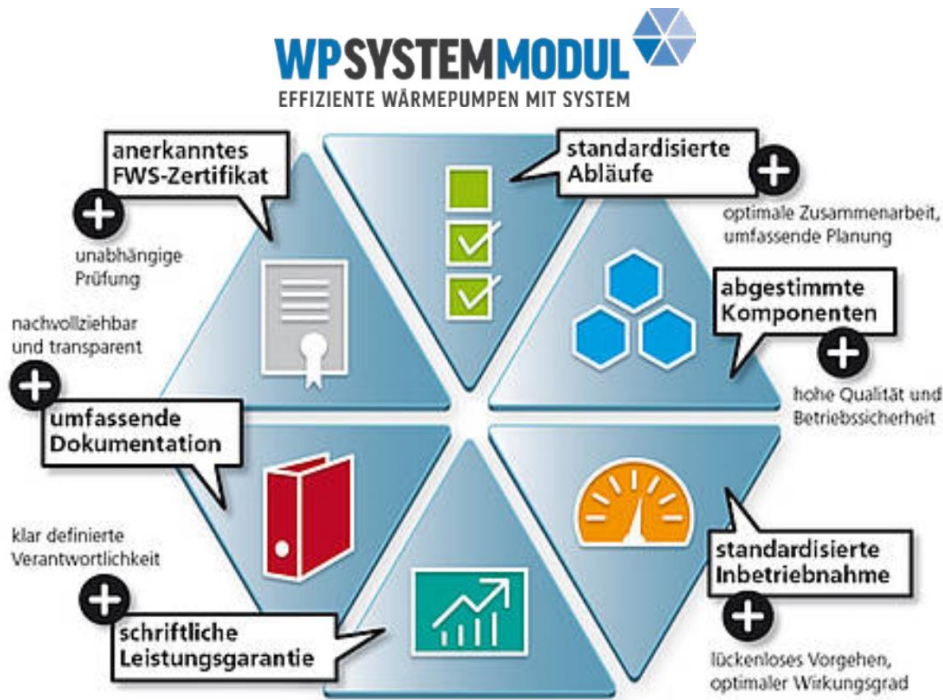


Figure 9: Wärmepumpen System Modul with the corresponding processes (EnergieSchweiz 2016b; EnergieSchweiz 2015).

The associations GKS, suissetec, FWS and SWKI have developed the task booklet for the system module together with major manufacturers/suppliers of heat pumps, as well as with the support of EnergieSchweiz. On this basis, the individual manufacturers/suppliers will develop heat pump system modules and have them checked and certified by an independent expert committee of the FWS. On 23 October 2013, the WP-System module was presented to the manufacturers. To date, approximately 300 installers have been trained, 120 of them specifically for the system module. The website [www.wp-systemmodul.ch](http://www.wp-systemmodul.ch)<sup>26</sup> provides a list of installers filtered by canton who are qualified to plan and install a heat pump system according to the WP system module.

The major benefits of the Wärmepumpen-System Modul can be summarized as follows (EnergieSchweiz 2016b; EnergieSchweiz 2014):

- 1) All processes are standardized. Suppliers and installers have clear obligations which ensures a smooth process.
- 2) All components of the heat pump are carefully matched to each other and form a proven overall system.
- 3) The standardized commissioning of the heat pump and a check after two years ensure that everything runs smoothly during operation.
- 4) The customer of the heat pump receives a written guarantee from the installer and a certificate from an independent body.
- 5) The customer receives a complete documentation of the planning and installation of the heat pump.
- 6) Even years later the customer can understand everything.
- 7) The heat pump system module has a higher energy efficiency and thus consumes less power than an average heat pump.

The funding program of Myclimate<sup>27</sup> supports homeowners with 1'000 CHF when replacing the old oil or natural gas heating system with a heat pump system. In order to guarantee the quality, only

<sup>26</sup> [www.wp-systemmodul.ch/de-ch/page/Installateure/Qualifizierte-Installateure-35](http://www.wp-systemmodul.ch/de-ch/page/Installateure/Qualifizierte-Installateure-35)

<sup>27</sup> [www.myclimate.org/de/klimaschutzprojekte/projekt/schweiz-energieeffizienz-7816](http://www.myclimate.org/de/klimaschutzprojekte/projekt/schweiz-energieeffizienz-7816)

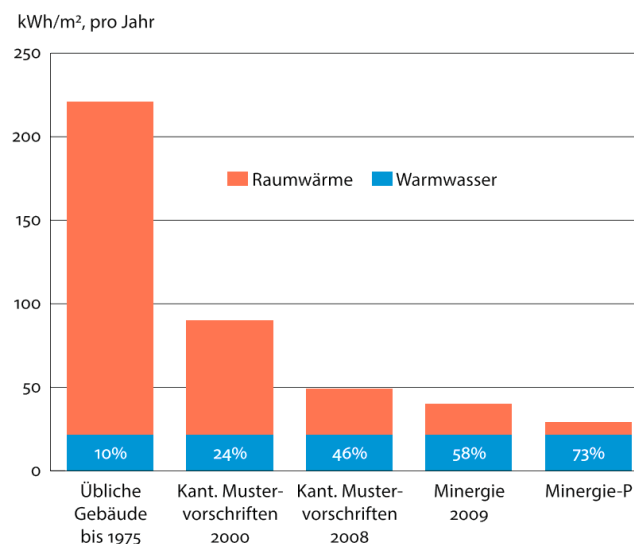
heat pump systems developed in accordance with the quality standard “Heat Pump System Module” (WP System Module) receive a subsidy contribution. The quality label “Heat Pump System Module” is going to be a prerequisite for funding. Starting 2017, some cantons allow heat pump installations only using the “Heat Pump System Module”.

#### vi. Minergie

MINERGIE<sup>28</sup> is a building standard for new and modernized buildings. The trade mark is co-sponsored by industry, the cantons and the Swiss Confederation and is protected against misuse. Main focus is the living and working comfort of building end-users. This comfort is enabled by a high-quality building envelope and a systematic air renewal.

Today, according to the MINERGIE webpage, 36'582 buildings are MINERGIE, 3'038 buildings are MINERGIE-P, and 497 buildings are MINERGIE-A certified.

Figure 10 shows that the heat demand for space heating steadily decreases as the heat insulation at the building envelope and the efficiency of modern heating systems constantly improves (GebäudeKlima Schweiz 2016). The hot water need remained nearly constant over the years. With the high-quality building standards of MINERGIE and modern heating systems, the energy demand for domestic hot water became the largest portion (73% for MINERGIE-P).



Quelle: S.A.F.E.

Figure 10: Annual heat demand for space heating and hot water according to the building standard MINERGIE (GebäudeKlima Schweiz 2016).

Since all electrical energy is penalized by a primary energy factor of 2 for the calculation of the energy index for MINERGIE-certification (MINERGIE 2014), the efficiency of a domestic hot water system featuring a heat pump is very relevant. The MINERGIE-certifications follow the standard SIA 380/1:2009.

Standard solutions for the hot water generation in residential buildings using brine/water and air/water heat pumps with outdoor air as heat source are possible. Required is a quality label approval. As reported by Wemhöner and Kluser (BFE 2013), in most certified MINERGIE-A buildings, an efficient building envelope is combined with a photovoltaics system to balance the energy consumption. In 80% of the MINERGIE buildings, heat pumps are used as a central component of building technology combined with photovoltaics.

<sup>28</sup> [www.minergie.ch](http://www.minergie.ch)

## c. Legislation

This describes the legislation and standards for heat pumps, ranging from:

- Installation guidelines and control
- Explosion, fire safety
- Health i.e. Legionella
- F-gas regulation

**Question:** Are legislative processes harmonized at international level and are there enforcement procedures?

### i. SIA Standard 385/1 and 385/2

The Swiss Society of Engineers and Architects (SIA29) is Switzerland's leading professional association for construction, technology and environment specialists. With 16,000 members from the fields of engineering and architecture, the SIA is a professional and interdisciplinary network whose central aim is to promote sustainable and high-quality design of the built environment in Switzerland. The building industry in Switzerland typically follows the standards SIA 385/1 (SIA 2011) and SIA 385/2 (SIA 2013b) for designing domestic hot water systems. SIA 385/1 defines the basic requirements for domestic hot water systems. SIA 385/2 describes the calculation methods for the planning of domestic hot water systems. The following topics are of major interest:

- legionella prevention
- heat losses (of tubes and storage tank)
- domestic hot water demand
- tapping time
- heat tracing

**Legionella:** The temperature of the hot water is directly related to the legionella. According to the Federal Office of Public Health (BAG<sup>30</sup>) (BAG) there were 275 cases of legionella in 2014, about 10% ending deadly (Lippuner 2015a; Lippuner 2015b). Based on these facts there are many guidelines and instructions published by different institutions in Switzerland regarding legionella prevention. The content is mostly redundant. The SIA 385 systematically implemented the guidelines set by BAG. The major requirements can be summarized as follows:

- Single family and multiple family buildings are classified as "low risk"
- Unused pipes must be renovated
- Domestic hot water of 25°C to 50°C that has not been used during the last 24 hours must be thermally disinfected (Recommendation for low risk class: 1 hour at 60°C (Suter et al. 2010))
- The design of the domestic hot water system requires:
  - 60°C at the storage tank outlet
  - 55°C at the heat traced pipes
  - 50°C at the tapping point
- The amount of water to be stored is determined according to SIA 385/2
- Periodical cleaning of domestic hot water storage tank from limescale
- Avoidance of parallel installed and thermally connected hot and cold water pipes
- Periodical flushing of rarely used tapping points

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<sup>29</sup> [www.sia.ch](http://www.sia.ch)

<sup>30</sup> [www.bag.admin.ch](http://www.bag.admin.ch), Bundesamt für Gesundheit



**System temperatures:** There are two major reasons for having high system temperatures in a domestic hot water system:

1. Legionella prevention
2. Comfort

The legionella prevention has already been mentioned above. In addition, the time until the water reaches a certain temperature at the tapping point outlet is a comfort criterion and is specified in the SIA 385/1 standard (SIA 2011; SIA 2013a) (see Table 6).

Table 6: Specifications of the output time at the water tapping point according to SIA 385/1 standard (SIA 2011; SIA 2013a).

Output time in distribution networks - fully opened tap armature - output time until the water reaches 40°C	
without heat tracing (e.g. without recirculation loop)	with heat tracing (e.g. with recirculation loop)
15 s	10 s

**Domestic hot water demand:** The SIA 385/2 (SIA 2013b) provides tables defining the hot water consumption in different types of buildings (e.g. single and multiple family houses) (see Table 7) and the recommended tapping profiles for rough dimensioning of domestic hot water systems.

Table 7: Hot water demand requirements according to SIA standard 385/2 (SIA 2013b).

Building type	Note	Domestic hot water consumption in standard liter per day	
		average demand per person	maximum demand per person
Single family house, condominium	simple standard	<b>40</b>	50
	normal standard	45	60
	high standard	55	70
Multiple family building	simple standard	<b>35</b>	45
	high standard	45	60
<i>The bold marked values are used for rough dimensioning</i>			

**Hot water loss number:** For domestic hot water supply systems with a heat tracing system (e.g. recirculation loop or heating cable) the SIA 385/2 (SIA 2013b) has introduced the calculation of a “hot water loss number” according to the following formula:

$$\xi_{is} = \frac{\dot{Q}_{W,sto,ls} + f_{hl} \cdot \dot{Q}_{W,hl,ls} + 2.5 \cdot \dot{E}_{W,aux}}{\dot{Q}_W}$$

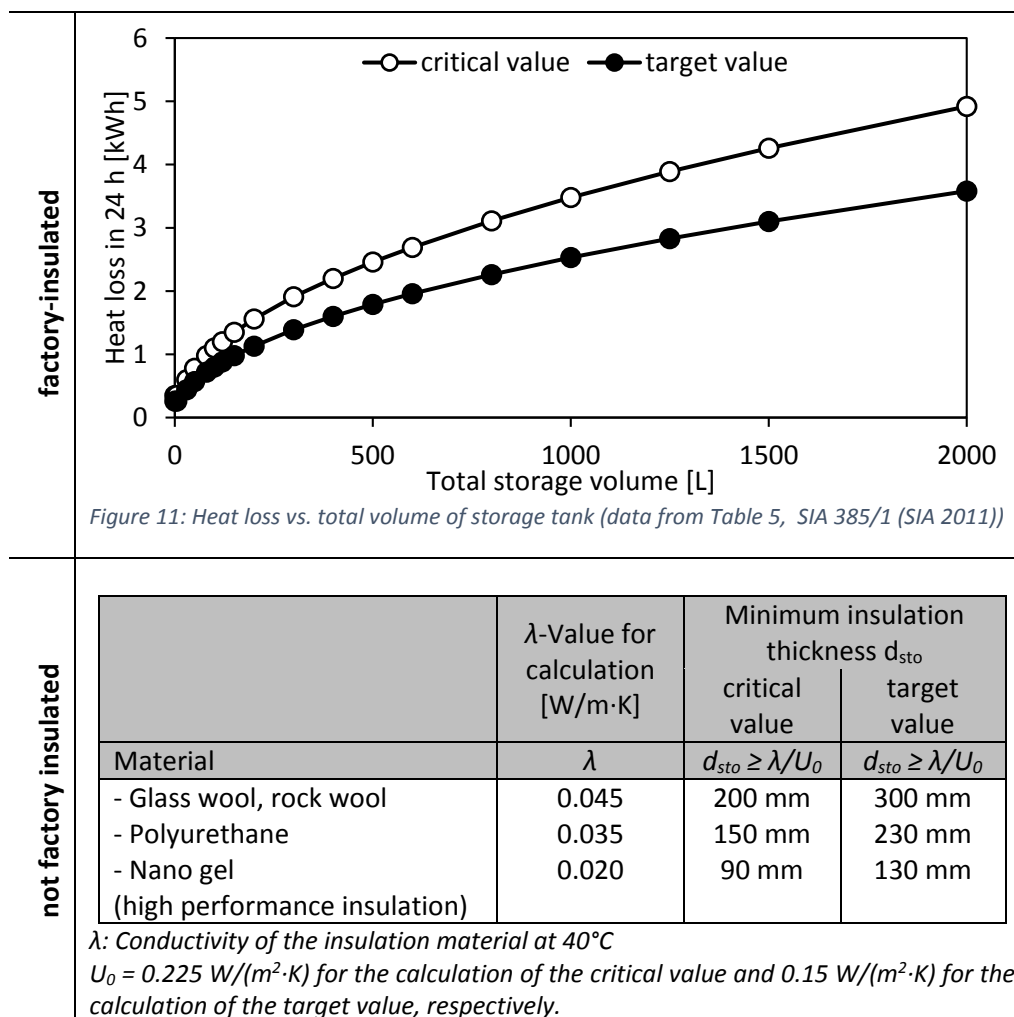
$\xi_{is}$	hot water loss number
$\dot{Q}_{W,sto,ls}$	storage tank heat loss [kWh/d]
$f_{hl}$	factor depending on the heat tracing method $f_{hl} = 0.333$ for heating cable $f_{hl} = 1$ for all other methods (e.g. recirculation loop)
$\dot{Q}_{W,hl,ls}$	heat loss of heat traced tubing [kWh/d]
$\dot{E}_{W,aux}$	auxiliary energy [kWh/d]
$\dot{Q}_W$	heating demand for domestic hot water [kWh/d]

The “hot water loss number” must not be higher than 0.5. If the calculation ends up with a higher number, the SIA 385/2 (SIA 2013b) lists several measures to improve the system performance to

achieve the target value of 0.4. It is worth to mention that die SIA 385/2 does not particularly exclude the heating cable as one heat tracing method.

**Storage tank heat losses:** The SIA 385/1 standard defines minimum heat losses of storage tanks. There are storage tanks with and without factory-made insulation. The requirements are summarized in Table 8. In similar manner, the insulation of the tubing is defined. More details can be found in the standard SIA 385/1.

Table 8: Heat loss requirements for storage tanks according to SIA 385/1 (SIA 2011).



## ii. Energieverordnung (EnV) 730.01

Heat pumps may only be placed on the Swiss market if they fulfill the minimum energy requirements and the requirements for the device-specific control described in Energy Regulations (EnV 730.01, Annex 2.16) (EnV 1998). The regulations are valid for electric-driven heat pumps for room heating and for domestic hot water generation. Table 9 lists the minimal COP requirements.

Table 9: Minimum energy requirements (COPs according to EN 14511) of heat pumps for placing on the market (EnV 1998).

	Messpunkt(e)	Leistungskennzahl nach EN 14511 <sup>24</sup> (COP)
Sole/Wasser-Wärmepumpen	B0/W55	$\geq 2.50$
Wasser/Wasser-Wärmepumpen	W10/W55	$\geq 3.30$
Luft/Wasser-Wärmepumpen	A7/W55	$\geq 2.6$
	A-7/W55	$\geq 1.8$



### iii. Refrigerants and ChemRRV

In Switzerland, the legal basis for refrigerants are regulated by Annex 2.10 of the Chemical Risk Reduction Ordinance (ChemRRV SR 814.81)<sup>31</sup> (ChemRRV 2016; UVEK 2014). The ChemRRV provides an extended list of substances that were prohibited or restricted for use as refrigerants due to their impact on the ozone layer and climate (Figure 12).

From 1 September 2015 on, the ChemRRV implemented adaptations to the existing restrictions of refrigerants stable in the atmosphere (BAFU 2015c). Charge restriction values (e.g. R134a systems with > 100 kW cooling capacity: 0.4 kg/kW) were defined for the permitted amount of refrigerant per cooling capacity produced, and the use of waste heat was considered. The leaflet (BAFU 2015a) gives a summary about the handling of refrigerants. A detailed overview of the use of refrigerants is available online by the Swiss Federal Office for the Environment (BAFU 2015b)<sup>32</sup>. A special licence is required for handling refrigerants, according to the ordinance (VFB-K, SR 814.812.38)<sup>33</sup> (UVEK 2007).

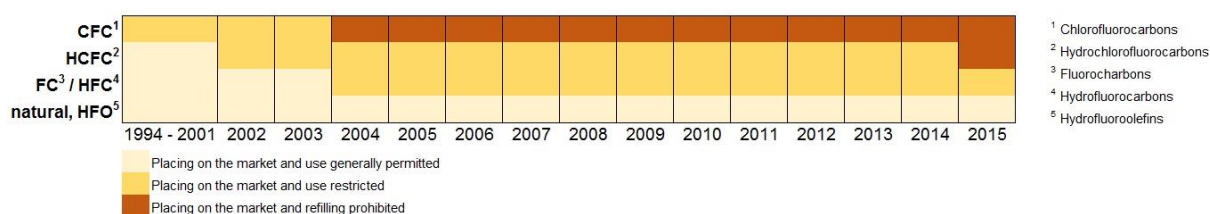


Figure 12: Graphical presentation of the temporal development of the refrigerants regulation in the Chemical Risk Reduction Ordinance (ChemRRV) (source online: [www.bafu.admin.ch/chemicalien](http://www.bafu.admin.ch/chemicalien)).

It is recommended to consider the security standards of the German Industrial Standard SN EN 378 for stationary systems. DIN EN 378-1 2008-06 regulates the safety and environmental requirements for refrigeration systems and heat pumps. Details about the permitted filling capacity of a refrigerant are described. It depends mainly on the nature of the refrigerant (combustibility, toxicity), safety group according to SN EN 378-1:2008+A2:2012, the installation site of the system, and the construction of the plant.

### iv. Drinking water heat exchanger

In building installations there is the risk of drinking water contamination (Sandre 2015). The W3 / E1 directive (SVGW 2012) regulates the backflow prevention in sanitary installations. Water fluids are structured into 5 categories, where category 4 fluid (LD<sub>50</sub> = 200 mg/kg body weight) causes serious health hazard due to the presence of one or more toxic, radioactive, mutagenic or carcinogenic substances. Category 5 fluids are able to provoke water-communicable health hazards and diseases due to the presence of microbial or viral pathogens. The category 5 includes e.g. sewage water, rainwater, toilet water, body cleaning water, pool water, or dish washing water (SVGW W3 Supplement 1, Table 2). Paragraph 6.2 declares that liquids of category 4 and 5 require a double separation with a neutral intermediate zone (e.g. gas, inert porous material or liquid of category 1, 2 or 3) (Sandre 2015).

Since refrigerants are commonly in gaseous state at ambient pressure, there is no LD<sub>50</sub> number available. Therefore, for DHW heat pumps only the applied oil in the refrigerant can need the installation of a heat exchanger with double wall separation. The vast majority of lubricants do not fall into category 4 or higher because most lubricant products have a dermal LD<sub>50</sub> > 2'000 mg/kg and an oral LD<sub>50</sub> > 10'000 mg/kg (Mang & Dresel 2007). Also the commonly used additives are within this LD<sub>50</sub>-range. However, the LD<sub>50</sub> of some specific substances and their concentrations in the final product have to be considered for the design of drinking water installations. Still, most DHW heat pumps in Switzerland use a double wall heat exchanger or intermediate loop.

<sup>31</sup> <https://www.admin.ch/opc/en/classified-compilation/20021520/index.html>

<sup>32</sup> <http://www.bafu.admin.ch/chemikalien/01415/01426>

<sup>33</sup> <https://www.admin.ch/opc/de/classified-compilation/20041557/index.html>

## d. R&D program

This describes governmental programs on R&D.

**Question:** Is there a budget available from the government and how much of that is spent on R&D on hot water systems, if any?

### i. Public expenditure for energy-related research and pilot and demonstration projects

The Swiss Federal Office of Energy (SFOE)<sup>34</sup> supports and coordinates application-oriented energy research and innovation in the energy sector and ensures the access of Swiss researchers to the research programs of the International Energy Agency (IEA) and the EU (Research Framework Programs, Strategic Energy Technology Plan (SET-Plan)). The funding is based on the Federal Government's "Energy Research Masterplan" (CORE 2015), which is revised every four years by the Swiss Federal Energy Research Commission (CORE). It includes scientific research, as well as pilot, demonstration and lighthouse projects.

In addition to national networking, the SFOE's central pillars are active dissemination of knowledge, as well as international exchange and cooperation (CTI = Commission for Technology and Innovation, EU = European Union, SNSF = Swiss National Science Foundation).

The SFOE publishes annual statistics on the government expenditure on energy research. The ARAMIS<sup>35</sup> internet database contains all research projects supported by the Federal Government. The SFOE records the public expenditure for energy-related research and pilot and demonstration projects (SFOE 2015). Each year around 1,500 projects are recorded, examined and statistically evaluated. An overview of the data collection process is published on the energy research website<sup>36</sup>. Figure 13 gives the overview of public expenditure on applied energy research, including pilot and demonstration projects (SFOE 2015).

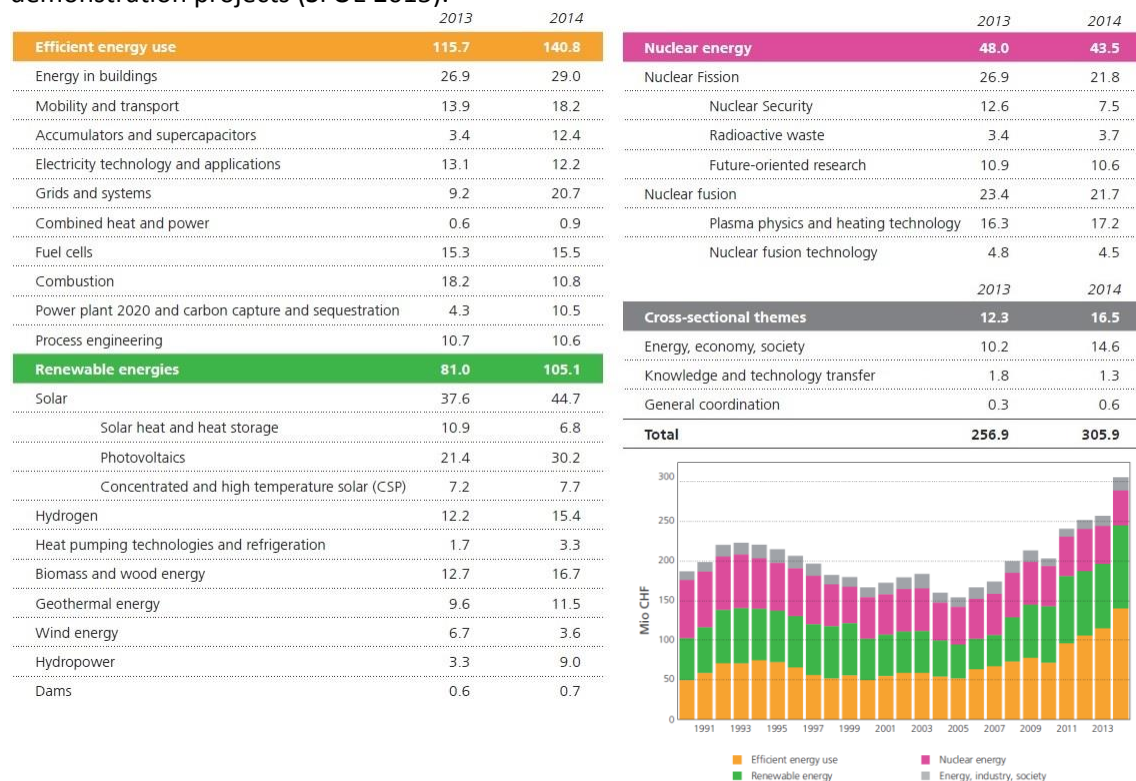


Figure 13: Overview of public expenditure on applied energy research, including pilot and demonstration projects, in Mio CHF (SFOE 2015).

<sup>34</sup> [www.bfe.admin.ch/themen/00519/index.html?lang=en](http://www.bfe.admin.ch/themen/00519/index.html?lang=en)

<sup>35</sup> [www.aramis.admin.ch](http://www.aramis.admin.ch)

<sup>36</sup> [www.energy-research.ch](http://www.energy-research.ch)

The expenditure has steadily increased since 2005. In 2013, various measures related to the reactor accident in Fukushima 2011 came into force. For example, the Swiss parliament approved the action plan for coordinated energy research in Switzerland, amounting to CHF 202 million for the period 2013 to 2016, for boosting capacity building at Swiss universities in the energy sector, of which 72 million CHF were spent on setting up eight Swiss Competence Centers In Energy Research (SCCER<sup>37</sup>). The SFOE's pilot & demonstration program has been boosted to 35 million CHF and two national research programs on "Energy" (NRP 70 "Energy Turnaround"<sup>38</sup> and NRP 71 "Managing Energy Consumption"<sup>39</sup>) with a budget of 45 million CHF were launched over five years (BFE 2014a). The public expenditure on energy research covers the entire spectrum of energy research and conducts 24 research programs which focus on energy efficiency use, renewable energy, nuclear energy and a socio-economic research. In 2014, the total investment of 305.9 million CHF was distributed in the 4 fields of research as follows (Figure 13):

- efficient energy use (140.8 million CHF),
- renewable energy (105.1 million CHF),
- nuclear energy (43.5 million CHF), and
- energy, industry and society (16.5 million CHF).

Figure 14 presents the distribution of the investment at various Swiss universities of technology and research institutes (SFOE 2015). 77.8% of Swiss energy research activities is carried out at the Swiss Federal Institutes of Technology Domain (at ETH Zurich, EPFL Lausanne and Empa (Swiss Federal Laboratories for Materials Science and Testing), the Paul Scherrer Institute (PSI), Eawag and WSL (Swiss Federal Institute for Forest, Snow and Landscape Research), followed by the universities of applied sciences (17.4 %) and cantonal universities (2.3%).

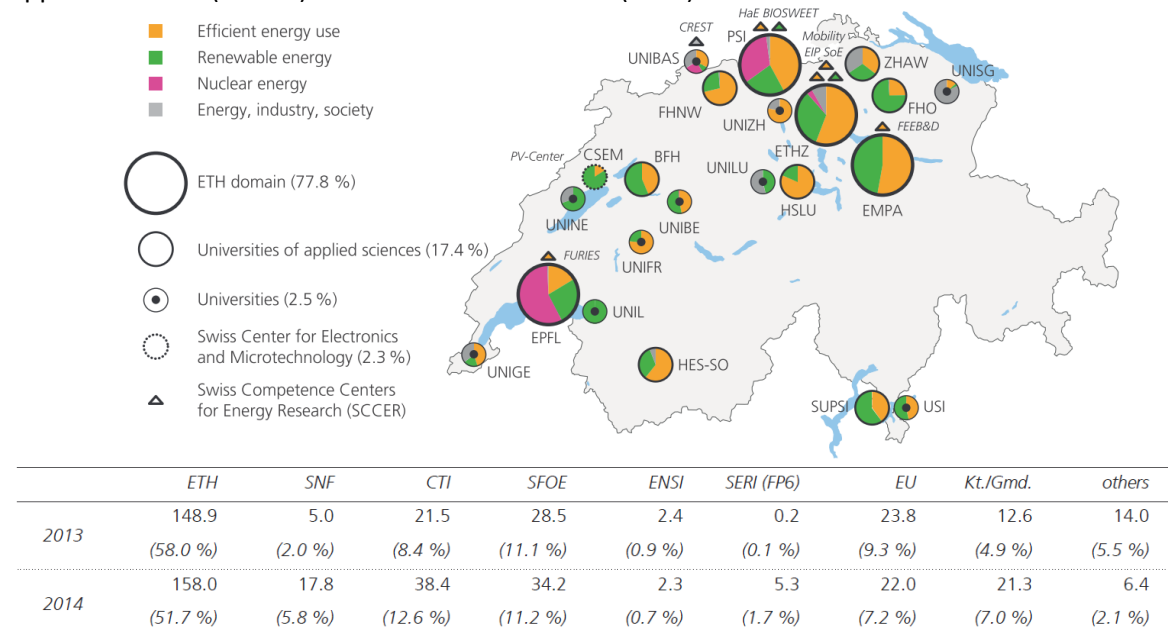


Figure 14: Investment of the public funding in the four fields of research, "efficient energy use", "renewable energy", "nuclear energy" and "energy, economy and society" at various Swiss universities and colleges of technology (figures for 2014, in Mio CHF) (SFOE 2015). ETH = Federal Institutes of Technology and associated entities: Federal Institute of Technology, Zurich; Federal Institute of Technology, Lausanne; Empa [Swiss Federal Laboratories for Materials Science and Technology]; Paul Scherrer Institute; Eawag; Swiss Federal Institute for Forest, Snow and Landscape Research [WSL] / SNF = Swiss National Science Foundation / CTI = Commission for Technology and Innovation / SFOE = Swiss Federal Office of Energy / ENSI = Swiss Federal Nuclear Safety Inspectorate / SERI = State Secretariat for Education, Research and Innovation / EU = European Union / Kt./Gmd. = cantons and municipalities.

<sup>37</sup> [www.kti.admin.ch/kti/de/home/unsere-foerderangebote/foerderprogramm-energie.html](http://www.kti.admin.ch/kti/de/home/unsere-foerderangebote/foerderprogramm-energie.html)

<sup>38</sup> [www.nfp70.ch](http://www.nfp70.ch)

<sup>39</sup> [www.nfp71.ch](http://www.nfp71.ch)

For 2016, the financial budget of the SFOE for the energy research program is (Schmitz 2016):

- Renewable energies (7.5 MCHF)
- Energy efficiency (9.0 MCHF) (including heat pump technologies)
- Socio-economy (2.1 MCHF)
- P + D + L (35 MCHF) (pilot, demonstration and lighthouse projects)

## ii. Research program “Heat Pumping Technologies and Refrigeration”

In the field of “renewable energies” there is the research program “Heat Pumping Technologies and Refrigeration”<sup>40</sup> with a funding of 3.3 million CHF in 2014 and 1.7 million CHF in 2013 (see Figure 15). In 2014, this research money was distributed between the research institutions of ETH Zürich (1.01 million CHF), EMPA (0.24 million CHF) and the universities of applied sciences (1.81 million CHF) (BFE 2014a). The main focus of the of the “Heat Pumping Technologies and Refrigeration Research Programs”<sup>41</sup> from 2011 to 2014 was on (BFE 2009):

1. Improvement of components and cycles of heat pumps and refrigeration plants
2. Efficiency improvement in cogeneration plants and reduction of pollutant emissions
3. System optimization of heat pumps, cogeneration plants, refrigeration and storage
4. Highly efficient systems for hot water treatment with main objectives of A) systems for hot water preparation and B) standardization to reduce costs.
5. Miniaturization and new ways of installing heating and cooling systems with heat pumps (plug and play)
6. Environmentally friendly refrigerants for heat pumps and chillers

For the period 2013 -2016 the main research activities were (SFOE 2013):

1. Reduction of the energy requirement for the compression,
2. Recovery of the expansion energy,
3. Optimization of the control strategies and integration of novel storage systems,
4. Investigation of the system integration of heat pumps into additive, upstream and downstream energy systems,
5. Optimization of large heat pumps and large refrigeration machines,
6. High temperature heat pumps for industry,
7. Strengthening the network between university and industrial research and international

Figure 15 shows the allocation of the funds to the main research areas. It can be concluded that about 5%, or 150'000 CHF of the annual financial budget of the “Heat Pumping Technologies and Refrigeration Research Programme” are spend in the specific research area of water heating.

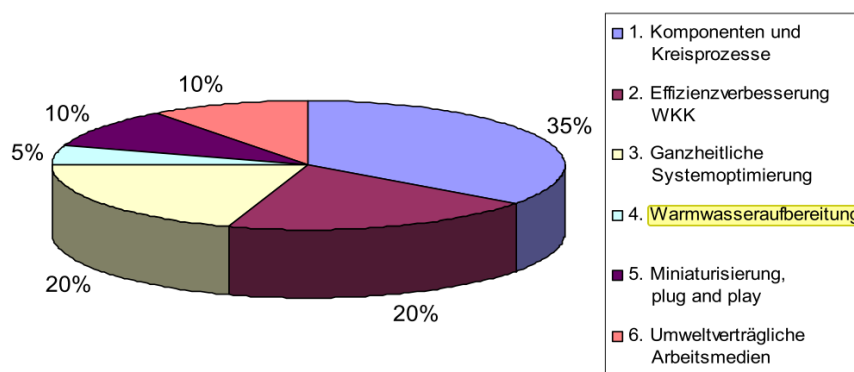


Figure 15: Allocation of the financial budget to the main research areas (BFE 2009) (total annually about 3 million CHF).

<sup>40</sup> [www.bfe.admin.ch/forschungwkk](http://www.bfe.admin.ch/forschungwkk)

<sup>41</sup> [www.bfe.admin.ch/forschungwkk/02351](http://www.bfe.admin.ch/forschungwkk/02351)

In the past years (1989 to 2012), several research studies were sponsored by the SFOE in the field of hot water heat pumps. Table 10 gives an overview of 19 publications listed in the database of the “Heat Pumping Technologies and Refrigeration research programme” with search keywords “Warmwasser” and “hot water”. However, using other keywords more studies related to domestic hot water may be found.

Table 10: Publications listed in the energy research database<sup>42</sup> related to the “Heat Pumping Technologies and Refrigeration research programme” with search keywords “Warmwasser” and “hot water”(database accessed on Nov 11, 2016).

Title	Date of publication	Author(s)
Warmwasserbereitstellung mittels Wärmepumpen in Mehrfamilienhäusern - Schlussbericht 2012	04/01/2012	S. Bertsch, B. Vetsch, A. Gschwend
Zirkulationsverluste in Brauchwarmwasseranlagen; Phase 1: Analyse - Jahresbericht 2010	31/12/2010	S. Bertsch
Ölfreier CO <sub>2</sub> -Kompressor für Grosswärmepumpen zur Warmwassererzeugung; Funktionsmuster - Jahresbericht 2010	31/12/2010	J.V. Völk, D. Frehner, D. Uhlenhaut
Ölfreier CO <sub>2</sub> -Kompressor für Grosswärmepumpen zur Warmwassererzeugung - Jahresbericht	14/12/2009	Markus Friedl
Warmwasserbereitung mit Wärmepumpe und sekundärseitiger Laderegulierung; Messungen an einer Anlage in Uttwil - Schlussbericht	30/06/2009	Th. Baumgartner, H.R. Gabathuler, H. Mayer
Domestic Hot Water Heating Using Heat Pump and Storage Temperature Control in the Secondary Circuit, Measurements at a Heat Pump Facility in Uttwil TG - Annual report 2008	30/11/2008	H.R. Gabathuler, H. Mayer, Th. Baumgartner
Domestic Hot Water Heating Using Heat Pump and Storage Temperature Control in the Secondary Circuit, Measurements at a Heat Pump Facility in Uttwil TG - Annual report 2008	30/11/2008	H. Mayer, H.R. Gabathuler, T. Baumgartner
Warmwasserbereitung mit Wärmepumpe - Messungen an einer Anlage in Rorschacherberg - Schlussbericht	31/07/2007	H. Mayer, H.R. Gabathuler, T. Baumgartner
Test procedure and seasonal performance calculation for residential heat pumps with combined space and domestic hot water heating - Executive summary	31/01/2007	Th. Afjei, C. Wemhöner
Test procedure and seasonal performance calculation for residential heat pumps with combined space and domestic hot water heating - Executive summary	31/01/2007	C. Wemhöner, T. Afjei
Seasonal performance calculation for residential heat pumps with combined space heating and hot water production (FHBB Method)	01/10/2003	Th. Afjei, C. Wemhöner
Seasonal performance calculation for residential heat pumps with combined space heating and domestic hot water production	19/12/2002	Th. Afjei, C. Wemhöner
Wärmepumpentest für die kombinierte Raumheizung und Warmwasseraufbereitung	01/10/2003	A. Montani
Wärmepumpentest für kombinierte Raumheizung und Warmwasserbereitung	19/12/2002	A. Montani
Wärmepumpen -Warmwassererwärmer: Energienutzung und Planungshinweise	01/08/1999	S. Schmid, A. Thüler
Bivalente Kleinwärmepumpe mit Stufenladung für Heizung und Brauchwarmwasser in einem Mehrfamilienhaus in Dornach - Schlussbericht	31.07.1997	E. Längin, A. Thüler
Wärmepumpen - Warmwassererwärmer; Anhang: Messbericht und Modellrechnungen	01/11/1993	N. Herzog
Domestic Hot Water Heat Pumps in Residential and Commercial Buildings	31/03/1989	R. Caneta

<sup>42</sup> [www.bfe.admin.ch/dokumentation/energieforschung](http://www.bfe.admin.ch/dokumentation/energieforschung)



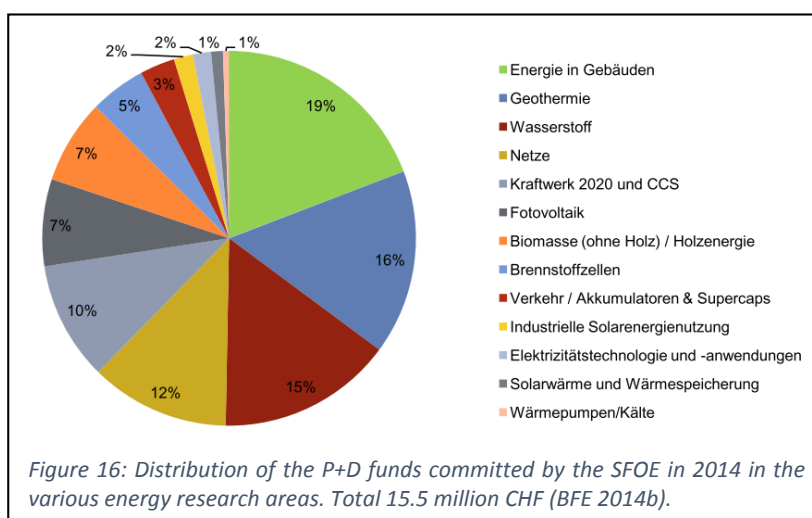
The ARAMIS<sup>43</sup> information system contains information regarding the research projects that are either run or funded by the Federal Administration since 1997. When using the Full Text Search in ARAMIS the number of projects and granted total costs can be found. Table 11 summarizes some search results. The average granted total costs per project is around 175'000 CHF.

Table 11: Search results of projects and granted total costs in the database [www.aramis.admin.ch](http://www.aramis.admin.ch) (visited on Nov 11, 2016).

Search Keyword	# of projects	Granted total costs (in million CHF)
"Warmwasser"	81	11.7
"Wärmepumpe"	75	13.1
"Warmwasser Wärmepumpe"	11	2.2
"Hot water"	36	9.5
"Heat pump"	65	11.5
"Hot water heat pump"	4	0.6

### iii. Pilot, demonstration and flagship projects

The Swiss Federal Office of Energy SFOE promotes the near-market development of innovative technologies and solutions in the cleantech sector with the pilot, demonstration and lighthouse program (P + D + L program). Projects are supported, which serve the economical and rational energy use or the use of renewable energies (SFOE 2016). The distribution of about 75 P+D projects active at the SFOE at the end of



October 2014, is shown in Figure 16 by area. The commitment for 2014 was 15.5 million CHF. For the year 2016, CHF 35 million CHF were budgeted (BFE 2014b). About 1% (or 150'000 to 350'000 CHF) of the annual P+D funds are related to heat pumps and refrigeration.

### iv. CTI – Commission for Technology and Innovation

The CTI<sup>44</sup> is the federal government's agency for the promotion of innovation. It is responsible for supporting science-based innovations in Switzerland by providing financial resources, professional consulting and networks. Its focus in the period from 2013 to 2016 is on energy research<sup>45</sup>. Depending on the individual case, CTI-projects are also sponsored in the field of hot water heat pumps, e.g. the CTI-project "KoDeWa: Compact, decentralized hot water supply from exhaust air and solar power" in 2014 (Büchel et al. 2016). In accordance with the Swiss Coordinated Energy Research action plan, the CTI has the mandate to finance and manage the research networks between higher education institutions, the Swiss Competence Centres for Energy Research (SCCERs) with a budget of 72 million CHF. In addition, the CTI received 46 million CHF for R&D projects in the field of energy. Soon, the CTI will be converted from a public authority to a public-law institution called "innosuisse"<sup>46</sup>. Innosuisse will have a more flexible structure and better governance to even better support the innovative power of the companies.

<sup>43</sup> [www.aramis.admin.ch](http://www.aramis.admin.ch)

<sup>44</sup> [www.kti.admin.ch](http://www.kti.admin.ch)

<sup>45</sup> [www.kti.admin.ch/kti/de/home/unsere-foerderangebote/foerderprogramm-energie.html](http://www.kti.admin.ch/kti/de/home/unsere-foerderangebote/foerderprogramm-energie.html)

<sup>46</sup> [www.kti.admin.ch/kti/de/home/ueber-uns/Innosuisse.html](http://www.kti.admin.ch/kti/de/home/ueber-uns/Innosuisse.html)

## 2. Present market situation

Market development:

### a. Building stock (numbers and ownership)

- Single family buildings
  - New
  - Existing
- Multi Family buildings
  - New
  - Existing
- Agriculture and dairy farms
- Miscellaneous

The existing building stock is always seen as the biggest challenge for renovation.

#### Questions:

- Are domestic hot water systems already correct designed and installed in new buildings?
- Which part of the renovation market is the real challenge?

#### i. Building stock

The Swiss Federal Statistical Office ([www.bfs.admin.ch](http://www.bfs.admin.ch)) provides yearly statistic about the building stock (BFS 2016a). Figure 17 shows that in 2014, 57% of all buildings with residential use were single family houses. The trend towards single-family house is unbroken. Since 2000, 70% of all built buildings with residential use are single-family homes. However, less than 1/3 of all people are living in such buildings (28%). Apartment buildings with secondary usage, e.g. buildings that primarily serve as residential apartments, but also include shops, workshops etc., make 12% of the stock of buildings with residential use. 16% of the population living in apartments belong to this category.

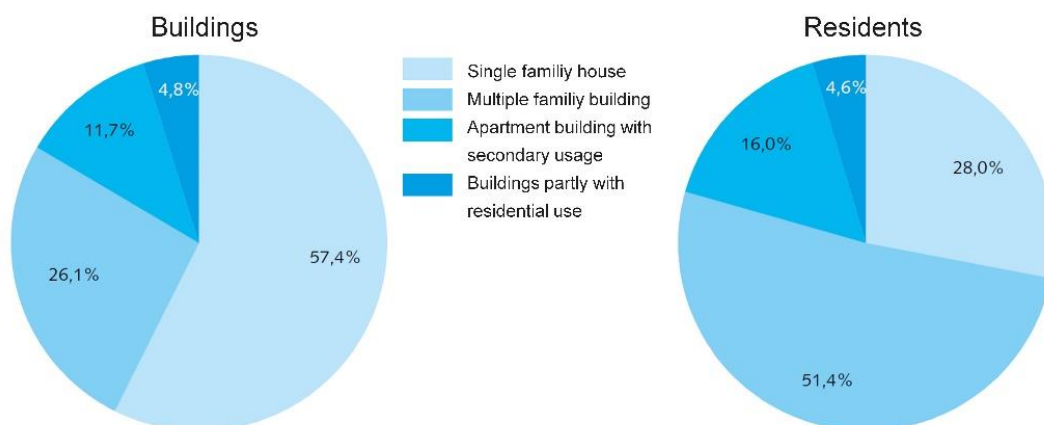


Figure 17: Distribution of the buildings and their residents by building category in 2014 (BFS 2016a).

Switzerland's total dwelling stock accounts for 4.3 million homes in 2014 (BFS 2016b). Figure 18 illustrates that just over half (55%) of the dwelling stock were 3- and 4-bedroom apartments. 20% were apartments with 1 to 2 rooms and 26% had 5 or more rooms. This ratio has not changed much since 1970. More than half of the Swiss population (54%) lived 2014 in a 3- or 4-room apartment, 11% in an apartment with 1 or 2 rooms.

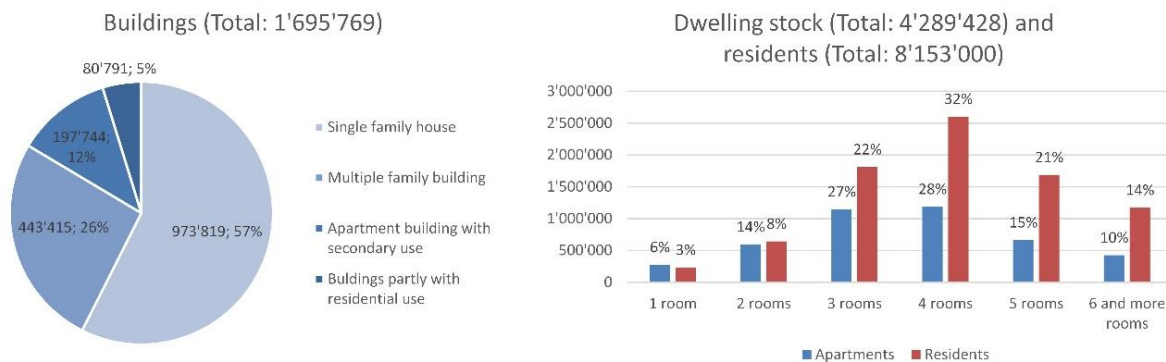


Figure 18: Distribution of the buildings and dwelling stock in 2014 (BFS 2016b).

The average living space per person increased slightly from 44 m<sup>2</sup> in 2000 to 45 m<sup>2</sup> in 2014. In apartments built after 2000, the living space per person is 48 m<sup>2</sup> (BFS 2016a). The average living space per person in households with more than one person (only Swiss) lies at 43 m<sup>2</sup> in 2014. In households, whose members are all foreigners the living space per person is 30 m<sup>2</sup> (BFS 2016b).

## ii. Energy sources for building heating and domestic hot water

90% of the Swiss population lives in a building with a central heating system which provides one or more buildings with heat. 2% of the building stock and 4% of the population are connected to public district heating supply (BFS 2016a). 64% of residential buildings are heated by fossil fuels that is oil or gas (Figure 19). Coal is only used in a vanishingly small part of the buildings. 73% of the Swiss population lives in buildings heated with fuel oil or gas.

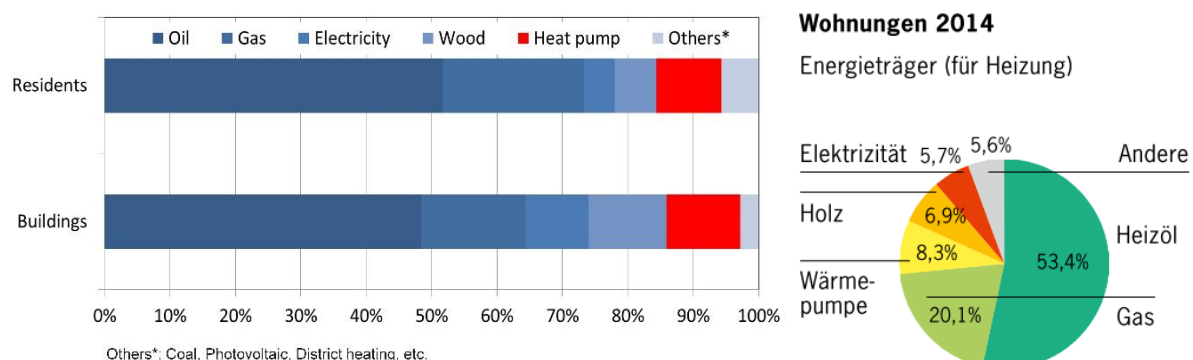


Figure 19: Energy sources for heating by residents and in residential buildings (BFS 2016a) and (BFS 2016b).

For DHW production, oil, gas and electricity are the most often used energy sources in multi-family and single-family houses (see Figure 20). Until now, heat pumps are only applied in about 8% in single family houses and 5% in multi-family houses for domestic hot water. There is still a great potential for future retrofitting market to reduce the usage of oil, gas and electricity. For that purpose, heat pump water heaters (HPWH) offer a suitable plug-and-play solution in single family houses. Similar solutions to replace e.g. electric water heaters in multiple family houses are not yet available.

Figure 21 illustrates the number of buildings built over time and the development of the energy sources for space heating (BFS 2016a). The heating of 48% of all buildings with residential use, or 52% of the population is powered by oil. The difference is more pronounced with gas: 16% of the buildings are heated by gas, and 22% of the population lives in such buildings. 3 out of 10 buildings are heated either with wood, electricity or a heat pump (12%, 10% and 11%). Unlike fossil fuels, these resources affect a smaller proportion of the population, namely a total of one in five people (6%, 5% and 10%). Solar panels is the main energy source only for very few buildings and few people.



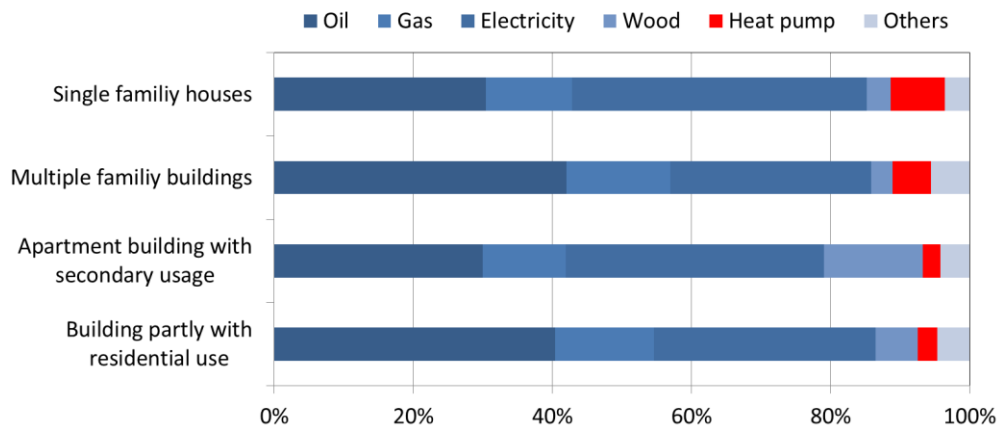


Figure 20: Energy sources for domestic hot water in different types of residential buildings (BFS 2014a).

Figure 21 shows the steady increase of heat pump installation over time as main energy source for heating. In the building phase 2001-2014 the market share of heat pumps reached about 70%. DHW heat pumps are popular in Switzerland. More details about the Swiss heat pump market and sales figures (FWS 2015b) will be discussed in chapter 3.

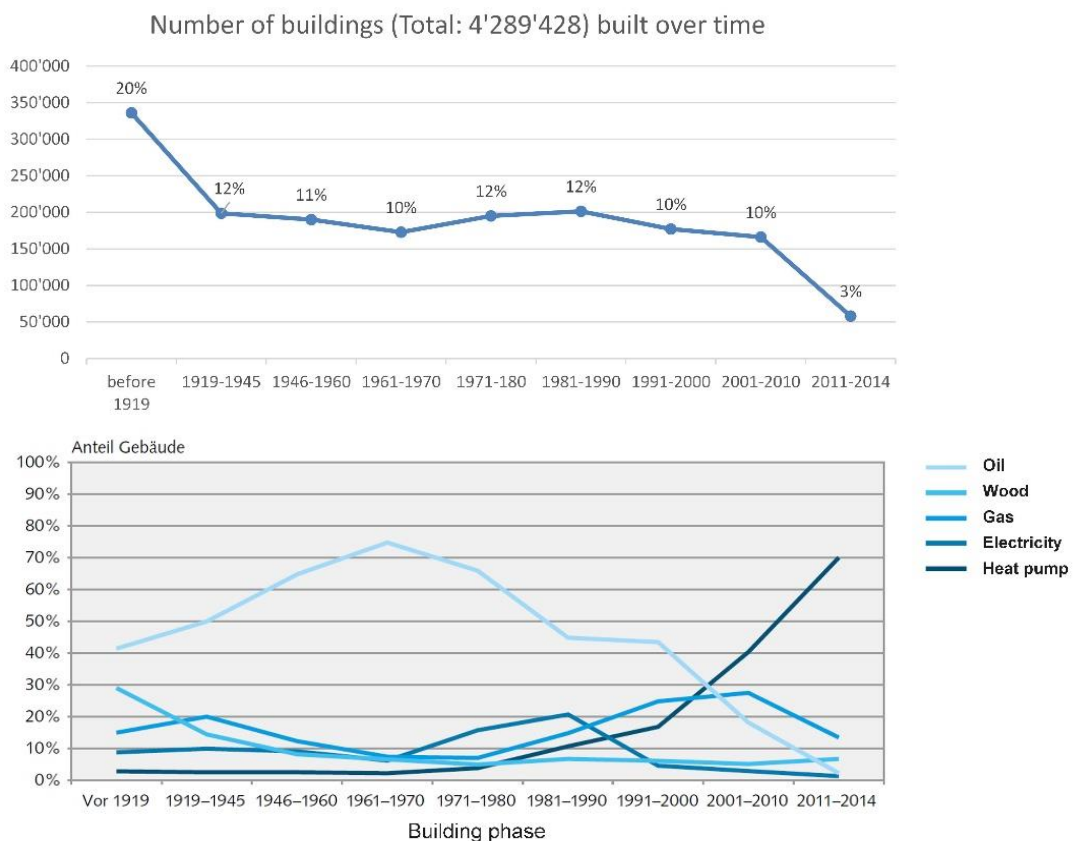


Figure 21: Number of buildings built over time and development of the energy sources for space heating (BFS 2016a).

The number of heat pumps has increased significantly in recent years. The technology of environmental heat use from air, surface water, ground water or geothermal energy combined with electrical drive shows an increasing share in the new installation of heating systems (BFE 2015c). According to the Swiss statistics on renewable energies (BFE 2016c, p. 52) by 2015, there are 256'847 electrically driven heat pump system installed on the Swiss market (61% air/water, 36% brine/water, 3% water/water, 1% air/air heat pumps), compared to 240'887 units in 2014. In 2015, 23'237 heat pumps were sold, whereof 4'919 units of hot water heat pump (boilers).

## b. Hot water systems

This describes the momentary and often conventional market of hot water systems in the residential sector:

- Individual standalone water heaters
  - Instantaneous water heaters (Durchlaufwassererwärmer, Frischwasserstation)
  - Storage water heaters (Warmwasserspeicher)
- Individual combined heat generators for space heating and hot water (and cooling)
- Collective water heaters for multiple family applications or in district heating (Überbauung)
- Innovative first applications

Making hot water with a heat pump almost all fall under the category of storage water heaters, except for hybrid heat pump where the gas boiler back-up is used as an instantaneous water heater or with a heat pump in a central distribution system.

- Single DHW Heat Pump on ventilation air or ground source
- Combi HP for space heating and cooling and domestic hot water
- Combination of space and domestic hot water heating at the same time
- Booster Heat Pump
- Solar assisted Heat Pump Water Heater
- Air conditioning combined with domestic hot water
- CO<sub>2</sub> DHW Heat Pumps
- Other

**Question:** Which are the capacities of storage systems and heating systems?

### i. Hot water heat pumps in single family houses

Figure 26 illustrates the three most ecological hot water generating systems in Swiss single family houses according to “Fachvereinigung Wärmepumpen Schweiz” ([www.fws.ch](http://www.fws.ch)). The ecologically most useful system for hot water production in households are combinations with solar-powered heat systems<sup>47</sup>.

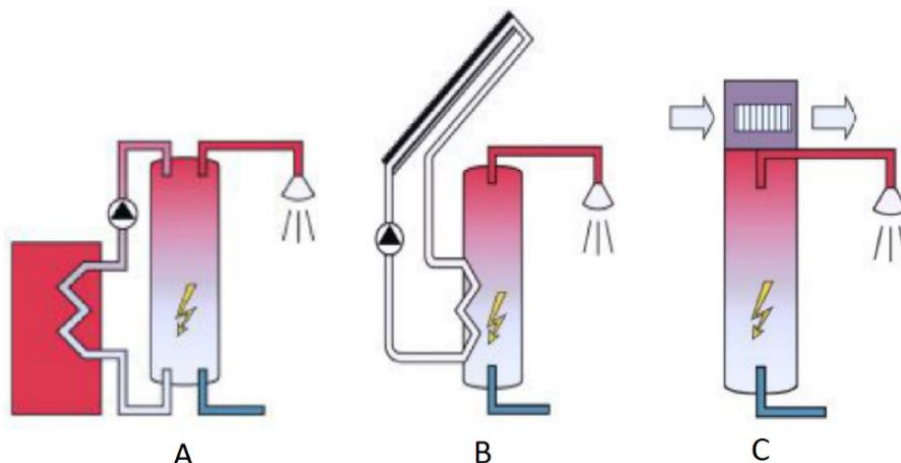


Figure 22: The 3 most ecological systems of hot water generation systems in Swiss single family houses: A: Heat pump for room heating and hot water, B: Solar thermal system (without heat pump operation), C: Heat pump boiler ([www.fws.ch](http://www.fws.ch)).

#### A: Heat pump for room heating and hot water:

The heat pump heats the house and simultaneously generates hot water. The advantage of this system is the use of natural energy sources such as air, ground heat or water. The system is popular because it only needs one heat pump unit and the investment costs are relatively low. However,

<sup>47</sup> <http://www.fws.ch/warmwassererzeugung.html>

simulations by (Vetsch et al. 2012) showed that this system is less efficient than using a dedicated DWH heat pump and an independent space heating system. These findings were confirmed by many experts.

### **B: Solar thermal system:**

Solar energy for hot water is the most direct solar energy utilization (GebäudeKlima Schweiz 2012). The hot water is generated with a solar thermal system (without the operation of a heat pump, as shown in Figure 22). Ideal for this are flat roofs and pitched roofs with south, southwest and southeast orientation. 4 to 6 m<sup>2</sup> of collector area cover up to 70% of the annual energy requirement of a 4 person household. The remaining energy must be generated in another way, for example with a heat pump. Solar thermal systems are easily implemented. In most cases, no building permit is necessary, but a clarification at the municipality is meaningful. The advantage of a solar thermal system is obvious: Clean energy. In addition, such systems are almost maintenance-free and can also be used to support the heating system.

Other systems combine a solar thermal system with a heat pump (see Figure 23). The collector (1) takes sunlight, converts it into heat and gives this heat to a special water-antifreeze mixture in the collectors. A circulating pump (2) transports this medium in well-insulated piping (3) to a heat exchanger (4) in the lower area of the storage tank. This transfers the thermal energy to hot drinking water increasing its temperature. If there is insufficient solar energy available, the heat pump (5) provides the extra heating. Such compact units for single family houses are normally mounted within 1 to 2 days and ready to use (GebäudeKlima Schweiz 2012a)

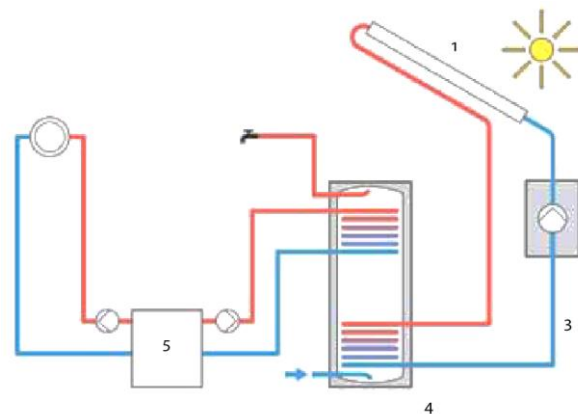


Figure 23: Combined solar thermal system and heat pump system (GebäudeKlima Schweiz 2012a).

### **C: Hot water heat pump (heat pump boiler):**

The hot water heat pump enables autonomous water heating with renewable energy. It consists of a hot water tank with its own air-to-water heat pump installed on top (see Figure 28). The typical storage tank volumes are between 80 and 500 liters for a single-family house. The heat pump boiler is used for the efficient and economical hot water supply. Internal or external air serves as heat source. Particularly suitable is the installation of a compact hot water heat pump in rooms with waste heat from a technical heating room, a workshop room or a laundry room (heat source = internal air). The surplus heat is removed from the ambient air. The exiting cooler air can, for example, be used for the climate control of a wine cellar (Banach & Fahrni 2014). Such a system can also be combined with photovoltaic (Schmid & Scheidegger 2014; BFE 2013, p. 94-107). Photovoltaic systems can be used specifically for water heating, for the electrical supply of the hot water heat pump or the hot water storage tank. Existing electric driven water heaters with storage tanks can be retrofitted to photovoltaic operation, which complies with the energy regulations of the cantons (MuKE). The economic feasibility of such a photovoltaic driven heat pump boiler depends on the expected feed-in tariff.

In practice, the heat pump boiler is delivered plug-in and is a simple substitute for an electrically heated boiler. The hot water heat pump is available both as a split version (GebäudeKlima Schweiz 2012) and as a compact version with a duct system, which - with the outside air as energy source - serves to heat the water and again delivers the air to the outside (Figure 28). This system reduces power consumption by two-thirds compared to the known electroboilers (Banach & Fahrni 2014). The payback time for the surplus investment costs is expected to be 5 years. The heat pump is easy to install and looks like a normal electroboiler.



Figure 24: Left: Air/water heat pump: The outer part of the split unit. Inner part with buffer storage and hydraulic control system; up to 63°C (Photo: Vaillant Schweiz GmbH), Middle: Air/water heat pump boiler (energy source air). Outdoor air or indoor air with duct system. Built-in heat exchanger for solar or other energy sources. (Photo: Cipag AG), The picture shows a section through a hot water heat pump (boiler): At the top, the air is sucked in with the fan through the evaporator. In the middle, there is the heating coil, which transfers the heat to the drinking water, as well as the condenser at the bottom. Right: Outdoor unit of a split-system hot water heat pump.

The website [www.topten.ch](http://www.topten.ch) gives an overview of the commercially available heat pump boilers in Switzerland. Table 12 summarizes typical technical data of those heat pump boilers. The calculated average values are derived from data of 31 suppliers and 78 models (source: [www.topten.ch](http://www.topten.ch), visited on October 28, 2016)

Table 12: Overview of commercially available heat pump boilers in Switzerland, data from 31 suppliers and 78 models (source: [www.topten.ch](http://www.topten.ch), visited on October 28, 2016).

Description	Range	Average value
COP at A20	3.2 to 4.0	3.6
COP at A15	2.9 to 3.6	3.2
Sales price	2'850 to 5'400 CHF	3'733 CHF
Noise level	50 to 67 dB	60 dB
Storage volume	200 to 450 Litre	277 Litre
Elektroeinsatz	1.0 to 3.0 kW	1.7 kW

As shown in (Figure 25), the sales numbers of hot water heat pumps has increased from 364 in 2009 to 4'919 units within 6 years (FWS 2015b)(BFE 2016c).

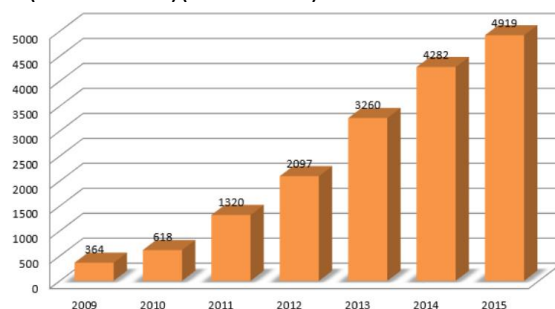
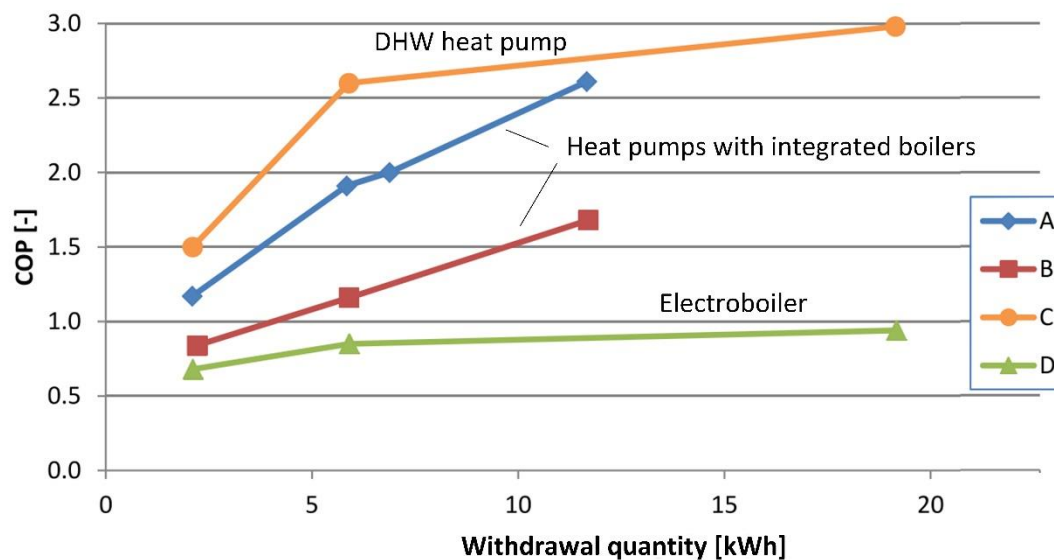


Figure 25: Development of hot water heat pumps sales in Switzerland (4'919 units in 2015) (FWS 2015b)(BFE 2016c).

When replacing electric boilers, hot-water heat pumps are a good solution. According to the MuKE electric boilers are no longer allowed to be used in new installations and in renovations of hot water systems. This means that hot water heat pumps are of greater importance, especially in the retrofit market. Measurements of (Hubacher & Bernal 2015) in the field confirmed that a heat pump boiler is approximately 3 times more efficient than an equivalent electric water heater. This is independent of low or high hot water use.

At the heat pump test centre WPZ experimental comparison of different water heating systems were performed (Eschmann 2015a; NTB 2016b). Two heat pumps (speed-controlled air-to-water heat pumps in split design) with integrated hot water tanks (A, B) (175 and 260 L), a DHW heat pump (C) (270 L) and an electroboiler (D) (300 L) were tested at different tap profiles (S, M, L, XL) according to EN 16147. As shown in Figure 26, a dependency between the efficiency and the withdrawal quantity could be determined. The highest efficiency was achieved if the individual withdrawal quantities were large. For small collected quantities the heat losses are more dominant. This effect is much greater for the heat pumps than for the electroboiler (BFE 2015a). The experimentally measured COPs according to EN16147:2011 match well with the simulated annual efficiency coefficients (Markstaler & Bertsch 2015; NTB 2016a).



Zapfprofil	Entnahmemenge [kWh]	COP			
		A Heizwärmepumpe mit integriertem Speicher (175 Liter)	B Heizwärmepumpe mit integriertem Speicher (260 Liter)	C Brauchwarmwasser- Wärmepumpe (270 Liter)	D Elektroboiler (300 Liter)
S	2.1	1.17	0.84	1.50	0.68
M	5.8	<b>1.91</b>	<b>1.16</b>	<b>2.60</b>	<b>0.85</b>
Praxis 1	6.8	2.00	-	-	-
L	11.7	2.61	1.68	-	-
XL	19.1	-	-	2.98	0.94
Verlustleistung [W]		42	60	27	63

Figure 26: Dependency of the efficiency on the withdrawal quantity (tap profile S, M, L, XL) for two heat heat pumps (speed-controlled air-to-water heat pumps in split design) with integrated hot water tanks (A, B), a DHW heat pump (C) and an electroboiler (Eschmann 2015a; BFE 2015a; NTB 2016b).

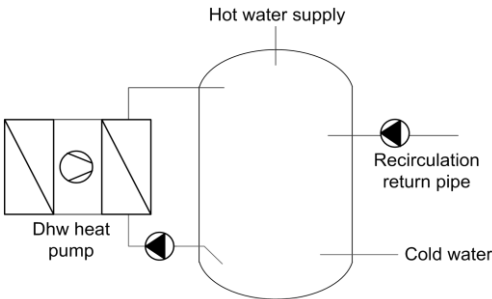
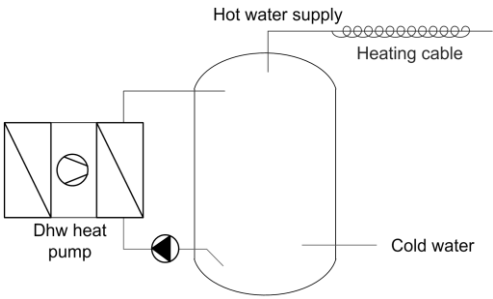
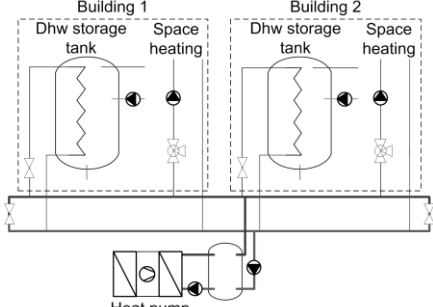
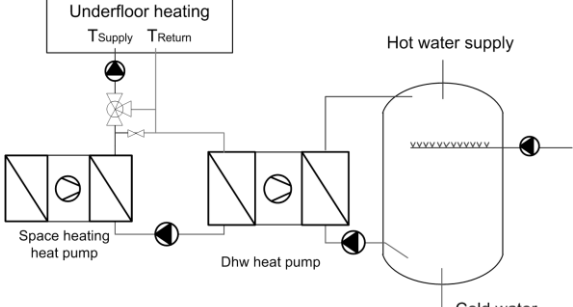
## ii. Hot water heat pumps in multiple family houses

In newer multiple family houses, the hot water can be generated centralized, decentralized or locally.

- **Centralized:** The water for multiple family buildings is heated in one large boiler and from there distributed to the different extraction points in each building. Due to long tubing runs, this installation often results in large heat losses. Often, these losses need to be compensated by a heat tracing method.
- **Decentralized:** In the case of decentralized systems, the boiler is installed at the individual building and from there distributed to the different extraction points. Choosing a decentralized system might spare the need for a heat tracing system.
- **Locally:** One boiler is installed at the individual apartment. As a result, the hot water is produced as close as possible to the place of consumption. Losses on the lines are therefore reduced and the hot water consumption can be billed easily. However, such systems using a heat pump have not evolved in the past years.

Table 13 gives a summary of the most popular hot water heat pump systems in Swiss multiple family houses according to (Vetsch et al. 2012; Vetsch et al. 2013a; Vetsch et al. 2013b; NTB 2011).

Table 13: Typical hot water heat pump systems in Swiss multiple family houses (Vetsch et al. 2012; Vetsch et al. 2013a; Vetsch et al. 2013b; NTB 2011).

1) Centralized hot water heat pump with storage tank and recirculation loop	2) Centralized hot water heat pump with storage tank and trace heating
	
3) Combined system - heat pump for space heating and domestic hot water heating at the same time	4) Central heat pump with decentralized hot water heat pumps
	

In **centralized hot water heat pumps with storage tank and recirculation loop**, the hot water circulates continuously from the top of the storage tank through the entire network and reaches every residential connection before it is fed into the storage in a separate circulation line. Advantages of this type of system are:

- + Heat tracing energy to maintain the temperature is efficiently generated by the heat pump
- + No stagnant water in the distribution network
- + Simplicity of installation
- + Use of the heat pump to cover the entire heat demand for DHW production
- + The hygienic requirement of a daily thermal disinfection of DHW at 60°C can be fulfilled

- + Good efficiency with careful design and installation

The major challenges are as follows:

- Increased error rate during dimensioning
- Double size line network through the return line
- Stratification disturbance in the storage tank (reduces the efficiency of the heat pump)
- Determination of circulation volume flow is relatively sensitive (Tradeoff between good comfort and little disturbance of stratification in the storage tank)

With **heating cable** there is no recirculating circulation line in the distribution network. Instead, self-regulating electrical heating tapes are installed on all hot water pipes, which keep the stagnant water warm (EnergieSchweiz 2016a). Advantages of trace heating systems are:

- + Low error rate during dimensioning and design
- + No disturbance of the layers in storage tank
- + Relatively low investment and installation costs
- + Simplicity of installation
- + Competitive to circulation (efficiency-wise) when carefully installed and excellent insulated.

Disadvantages are:

- Direct electrical power input, which gives an unfavourable rating in MINERGIE buildings.
- Increased sensitivity to insulation quality.
- Increased sensitivity to large distribution lines.
- Difficulty to repair the heating tape in case of defects (accessibility usually no longer given)

In large building complexes a **combination of space heating and hot water system** is often applied (Vetsch et al. 2012). Here, a central heat pump provides the heat for space heating of the building via a local heating network to the decentralized hot water storage tanks. Depending on the request of the storage tanks, the temperature in the whole distribution network has to be raised to over 60°C. A disadvantage of this system is that the space heating network is only on heating temperature during the heating season. During the off-season the distribution network cools down, the heat losses increase the energy consumption. To load the decentralized hot water storage tanks the entire network must be heated to the hot water temperature. Moreover, particularly unfavorable is the fact that the heat pump must be operated over a wide period of time at high temperature of 60°C, reducing the efficiency to provide the space heating energy significantly. Finally, in these systems, a higher condensation temperature is required in the heat pump as the supply temperature has to be about 5°C higher due to the required heat transfer over the heat exchangers inside the hot water storage tanks.

Some systems were built connecting the **central heating heat pump with decentralized hot water heat pumps** (Vetsch et al. 2012). The decentralized DHW heat pumps are installed in every building and use the return line of the space heating as heat source. In this way, the supply temperature of the heating is kept at the space heating temperature level and the DHW heat pump receives a high temperature source and improves in efficiency. In summer mode, the heat source of the decentralized DHW heat pumps can be supplied through the district heating network and the main heat source. The integration of solar heat into the space heating network or active cooling of the floor is possible.

Table 14 and Figure 27 provide a summary of applied domestic hot water (DHW) heat pump systems in Swiss single and multiple family houses. Basic systems are listed, but can of course still have different characteristics in their details.

- **Heat sources:** Typical heat sources in multiple family houses are: ground heat, ground water or sewage water of the building (e.g. warm shower or dish water). More often water from the heating system is used in decentralized domestic hot water heat.
- **Basic heat generation:** Compact indoor heat pumps are often applied with heat transfer across the condenser to the drinking water.



- **Hot water pipe distribution network:** Today, in new multiple family houses, the heat distribution through the hot water pipe network is about half-half divided between recirculation loops (moving hot water from storage through the pipe network) and heating cable (stagnant filled pipes kept warm with heating tapes). However, there is clear trend towards recirculation loop systems due to the unfavourable rating of electrical heating in MINERGIE buildings.
- **Legionella prevention:** Typically done by at least one daily charge to 60°C.
- **Solarthermal secondary heat generation:** In a pilot and demonstration project, (Naef & Stemmler 2014) upgraded an existing central hot water system with solar collectors and a heat pump. With 65m<sup>2</sup> surface of solar absorbers and the heat pump, a solar gain of 450 kWh/m<sup>2</sup> (optimised approx. 540 kWh/m<sup>2</sup>) was generated for the 66 residents in a multiple family building. The direct use of the solar heat (without the operation of the heat pump) added up to 244 kWh/m<sup>2</sup>.

Table 14: Domestic hot water (DHW) heat pump systems in single and multiple family houses (X: indicates usage).

		Single family house	Multiple family house
Heat sources	Ground	X	X
	Ambient air	X	X
	Water (lake, ground water)	X	X
	Sewage water	X	X
	Ventilation air		X
	Basement air	X	
	Return flow of space heating		X
DHW storage type	Separate storage tank	X	X
	Built-in storage tank	X	
	Combined storage tank	X	
	No tank	X	
DHW storage location	Basement	X	
	Centralized in whole building complex		X
	Decentralized in each building		X
	Local in each apartment		X
Basic heat generation	Indoor heat pump	X	X
	Outdoor heat pump	X	X
	Split heat pump	X	X
	Heat pump water heater	X	
System	Dedicated DHW system	X	X
	Combined space heating and DHW	X	X
	Simultaneous operation	X	X
	Switching operation	X	X
Legionella prevention	Periodical thermal disinfection	X	X
	Maintain high temperature	X	X
	UV treatment		X
	No measures	X	
Comfort	Short tubing	X	X
	Trace heating: Heating cable	X	X
	Trace heating: Recirculation loop	X	X
Secondary generation	Solarthermal	X	X
	Wood	X	X
	Gas	X	X
	Oil	X	X
	Backup: Resistance heater	X	X
Refrigerant	R134a	X	X
	R410A	X	X



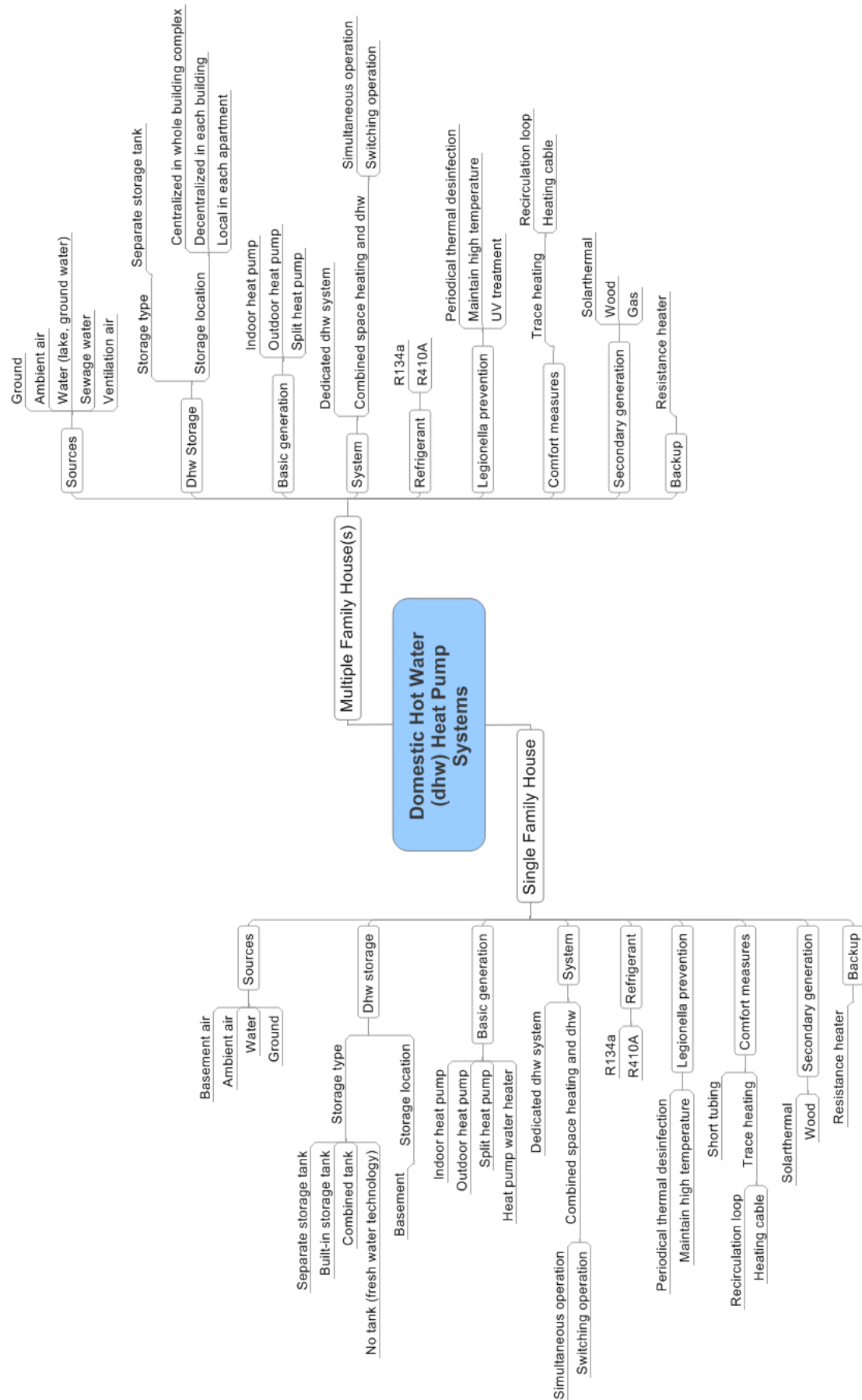


Figure 27: Overview of domestic hot water (DHW) heat pump systems for single and multiple family houses.

### iii. Other hot water systems with heat pumps in research status

This section introduces some new hot water systems using a heat pump in research status.

#### **NaOH sorption storage for seasonal solar thermal storage**

Within the scope of the IEA SHC Task 32, new or advanced solutions for storing thermal energy for heating or cooling buildings have been investigated. In this context, (Fumey & Weber 2016) developed, built and tested a laboratory prototype of a NaOH sorption storage for seasonal solar thermal storage. NaOH sorption storage was found to be a promising solution due to its high volumetric energy density and negligible loss during storage.

#### **SOFOWA**

A contribution to the project "Solar and Heat Pump Systems" (IEA HPP Annex 38 / SHC Task 44) of the International Energy Agency IEA is the project SOFOWA (Kombination von Solarthermie, Fotovoltaik und Waermepumpen) which aims to optimize combined heat pump systems with solar technology for the heat supply of buildings (BFE 2012, p. 76-87) (BFE 2015a, p. 29-44). The following systems were compared by simulation studies:

- a big solar thermal plant with seasonal heat storage,
- a photovoltaic system with surplus electricity in combination with a heat pump, as well as
- a system concept with solar thermal absorber and ice storage as heat source for a heat pump and the potential use of photovoltaic-thermal collectors.

Dimensioning, characteristics and hydraulic system of an ice storage system were examined in detail in the simulations. Temperature and heat flow measurement results of a buried ice storage showed that comparable performance factors like in ground source heat pumps can be reached. The combination of heat pumps with photovoltaics proved to be a cheaper solution.

#### **HEXModul All-In-One**

To ease the installation of the ventilation system in multiple family buildings the "HEXModul" was developed. It is a special kind of air duct with integrated heat exchanger which is mounted vertically in a building within the thermal insulation. In the project HEXModul All-In-One (BFE 2015a, p. 145-156) the system was extended using an air-to-water heat pump for domestic hot water or space heating of the building. The new approach uses the exhaust air of the ventilation system as heat source for the heat pump. The combination of ventilation and heat pump generates an efficient system for both, building refurbishment and new buildings.

#### **AquaPacSol - Solar assisted Heat Pump Water Heater**

This project investigated the combination of solar thermal collectors with a heat pump for hot water generation (BFE 2015a, p. 61-74). Here, the evaporator of the heat pump was coupled with the solar panels in order to maximize the solar energy efficiency and thus to increase the COP of the system up to 39%. The heat pump is operated only when the direct solar thermal power is not sufficient. In addition, the use of glass or vacuum solar panels allows a further increase in efficiency

#### **Continuous flow water heater (fresh water module)**

As an alternative to the storage of drinking water, the energy can also be stored in a storage tank without heating surfaces. The cold water is heated in the fresh water module via a high-capacity plate heat exchanger at the time of consumption. Such a system can be combined with all heat generators and is characterized by high energy efficiency and hygiene. A thermal disinfection of the water storage tank is no longer necessary. The fresh water module is designed for a tap temperature of 50°C, if necessary also with integrated circulation (55°C). Since the domestic hot water heater permits lower operating temperatures, the fresh water module is particularly suitable for low-temperature heat generation with a heat pump (Heim et al. 2016; GebäudeKlima Schweiz 2016).

**KoDeWa**

In the CTI-project “KoDeWa” (Kompakte, dezentrale Warmwasserbereitstellung aus Fortluft und Solarstrom) a compact decentralized domestic hot water supply system for front-wall installations of bathrooms was developed, built and tested (Büchel et al. 2016). The KoDeWa system from the company Swissframe AG consists of a waste heat recovery system for ventilation of the complete housing unit. In the project the front-wall installation was extended with a boiler with a high tech isolation, a small heat pump and an intelligent control. The heat pump is sourced by solar electricity and the remaining energy in the exhaust air is recovered by the heat pump, upgraded and delivered to the hot water boiler. Based on these new components the front-wall installation is able to reduce the passive energy losses of the accommodation. A patent application for the front-wall installation has been successfully filed.

### c. Statistics on hot water use

In general testing procedures are built upon tapping curves simulating the hot water use. In practice there is a great variety in water usage based upon human behaviour factors.

For the further tasks in the Annex it is of interest to get an insight in these factors.

*Question: Trend and tradition?*

#### i. Energy consumption in households

On behalf of the Swiss Federal Office of Energy (SFOE), annual analyses of the energy consumption in Swiss households are carried out by ex-post analysis of (Prognos AG 2015). In the household sector, the energy consumption is differentiated between:

- space heating,
- hot water,
- cooking,
- cooling and freezing,
- washing and drying,
- lighting, as well as
- entertainment, information and communication.

Table 15 summarizes the development of the most important influencing factors on energy consumption in the years of 2000 to 2014 (Prognos AG 2015). As can be seen, between 2000 and 2014 the average residential population has steadily increased by 13.2% (by 0.9% per annum). The increase in the population has a major impact on the housing stock and on the living space. The average living space per person increased from 57.5 m<sup>2</sup> in 2000 to 62.0 m<sup>2</sup> in 2014 (+9.5%).

The real consumer prices of the individual energy carriers developed differently in the years from 2000 to 2014 (see Table 15). Prices for heating oil (+80.0%) and natural gas (+ 58.7%) rose sharply. The price of wood (+24.1%), district heating (+42.0%), gasoline (+13.5%) and diesel (+16.7%) also rose significantly. For the consumers, only electricity (-3.9%) has become cheaper. Compared with the previous year, however, the real electricity price has risen by 1.4%. Prices for natural gas (+2.6%), wood (+0.6%) and district heating (+2.4%) also rose in 2014. However, mineral oil prices show a positive trend compared to the previous year: heating oil -1.4%, petrol -2.9%, diesel -3.8%.

Table 15: Development of important influencing factors on energy consumption in the period 2000 to 2014 (Prognos AG 2015).

	Einheit	2000	2008	2009	2010	2011	2012	2013	2014
<b>Bevölkerung, Wohnen</b>									
mittlere Bevölkerung (a)	Tsd	7'235	7'711	7'801	7'878	7'912	7'997	8'089	8'188
Haushalte (b)	Tsd	3'144	3'345	3'385	3'419	3'435	3'473	3'515	3'562
Gesamtwohnungsbestand (a, b)	Tsd	3'569	3'870	3'910	3'956	4'003	4'046	4'093	4'139
Wohnfläche (EBF) (b)	Mio. m <sup>2</sup>	416	472	479	486	494	501	508	516
<b>Witterung</b>									
Heizgradtage (c)		3'081	3'347	3'182	3'586	2'938	3'281	3'471	2'782
Kühlgradtage (b, d)		115	124	157	153	128	148	167	83
Strahlung (b, d)	MJ/m <sup>2</sup>	4'170	4'327	4'567	4'299	4'751	4'542	4'313	4'459
GT&S-Faktor (Mittel EZFH/MFH) (b)		0.895	0.951	0.933	1.059	0.819	0.937	1.043	0.782
<b>Preise (real, Basis 2013) (a)</b>									
LIK (2013 = 100)		92.3	100.5	100.0	100.7	100.9	100.2	100.0	100.0
Elektrizität	Rp./kWh	19.9	16.6	17.8	18.7	19.6	19.1	18.9	19.2
Heizöl (3000-6000l)	Fr./100l	55.0	109.1	68.9	84.8	97.2	103.7	100.5	99.0
Erdgas	Rp./kWh	6.5	10.2	9.6	9.0	9.4	10.0	10.0	10.3
Holz	Fr./Ster	45.1	52.3	52.2	52.6	54.8	54.4	55.6	56.0
Fernwärme	Fr./GJ	16.6	22.7	23.5	21.4	22.2	22.8	23.0	23.5
Benzin	CHF/l	1.52	1.78	1.51	1.63	1.72	1.80	1.77	1.72
Diesel	CHF/l	1.56	2.02	1.60	1.71	1.84	1.93	1.89	1.82

GT&S: Gradtag und Strahlung (verwendetes Verfahren zur Witterungsbereinigung)

**Quellen:**

- (a) BFS
- (b) eigene Berechnungen
- (c) BFE
- (d) MeteoSchweiz

Figure 28 shows the distribution of the final energy consumption of private households by usage in 2014. As a result, hot water is beside space heating the 2<sup>nd</sup> most important application in the household sector. The share on providing hot water accounts for 14.9% (31.7 PJ of totally 212.5 PJ) compared to 65.0% for space heating (BFE 2015b). The amount of hot water heating has changed only slightly in the period of 2000 to 2014 (-0.6 PJ, -1.9%) (see Table 16). In contrast to space heating, the consumption of hot water reacts only slightly to changing climatic conditions.

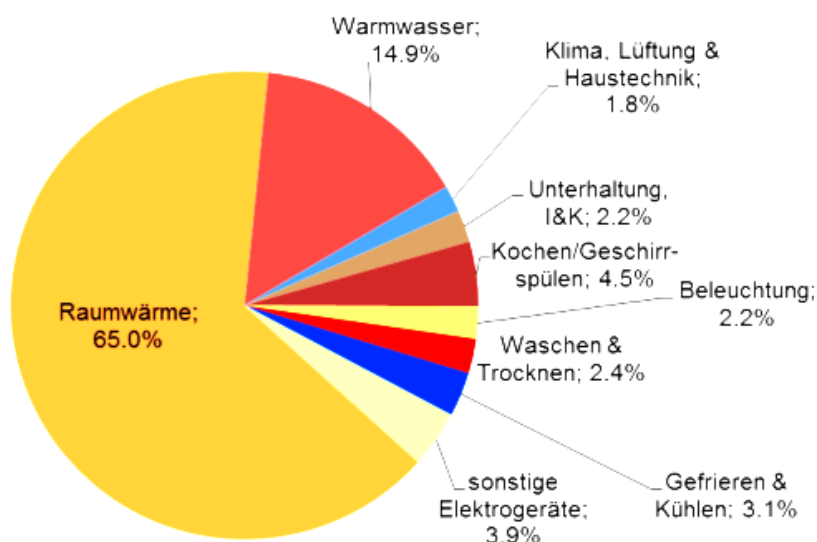


Figure 28: Distribution final energy consumption in private households by usage for the in 2014 (Prognos AG 2015).

Table 16: Final energy consumption in private households from 2000 to 2014, in PJ (Prognos AG 2015) (1 PJ = Petajoule = 278 GWh = 278'000'000 kWh).

	2000	2008	2009	2010	2011	2012	2013	2014	Δ '00 – '14
Raumwärme	167.5	174.3	170.0	190.9	147.7	166.6	183.4	138.0	-17.6%
Raumwärme fest inst.	166.0	172.9	168.6	189.4	146.4	165.3	182.0	136.9	-17.5%
Heizen mobil	1.5	1.4	1.4	1.4	1.2	1.3	1.3	1.1	-26.2%
Warmwasser	32.3	31.9	32.0	32.2	31.6	31.9	32.2	31.7	-1.9%
Klima, Lüftung, HT	3.6	4.0	4.0	4.4	3.8	4.2	4.6	3.9	+8.5%
Heizen Hilfsenergie	2.4	2.6	2.5	2.8	2.2	2.5	2.8	2.1	-12.8%
Lüftung, Luftbefeuchtung	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	+22.7%
Klimatisierung	0.0	0.1	0.1	0.2	0.1	0.2	0.2	0.1	+663.4%
Antennenverstärker, u.a.	0.4	0.5	0.6	0.6	0.6	0.7	0.7	0.8	+76.3%
Unterhaltung, I&K	5.4	5.7	5.7	5.5	5.2	5.1	4.9	4.7	-11.9%
Kochen / Geschirrspülen	8.8	9.1	9.2	9.3	9.3	9.3	9.4	9.5	+8.2%
Beleuchtung	5.7	6.0	5.8	5.7	5.4	5.2	5.0	4.7	-19.0%
Waschen & Trocknen	2.6	4.6	4.8	4.9	5.0	5.1	5.1	5.1	+95.5%
Gefrieren & Kühlen	7.1	7.0	7.0	6.9	6.8	6.7	6.6	6.5	-8.3%
sonstige Elektrogeräte	4.6	6.6	6.8	7.1	7.3	7.7	8.0	8.3	+80.4%
Summe	237.7	249.1	245.2	266.9	222.1	241.9	259.2	212.5	-10.6%

HT: Haustechnik

Quelle: Prognos 2015

Table 17 and Figure 29 show the distribution of energy consumption for hot water by energy source. The consumption is dominated by installed base of heating systems running on oil, gas or electricity. The annual consumption fluctuations are low over the years 2000 to 2014. Efficiency improvements due to the higher utilization levels of the plants are largely compensated by the volume effect (population growth: 2000: 7.0 Mio, 2014: 8.0 Mio).

In 2014, fuel consumption (36.6%), electricity (26.8%) and natural gas (22.4%) accounted for the major share of fuel consumption to produce hot water. Compared to the year 2000, the proportion of these three energy carriers in the total consumption of hot water has decreased from 92.9% to 85.9% (including electricity for heat pumps). The decline is primarily attributed to a reduction in fuel consumption (-5 PJ, -30.2%). The proportion of renewable energies, such as wood, solar and ambient heat increased from 4.4% to 10.8% in the same period (2013: 10.1%).

Table 17: Final energy consumption for hot water from 2000 to 2014 depending on energy sources, in PJ (Prognos AG 2015).

	2000	2008	2009	2010	2011	2012	2013	2014	Δ '00 – '14
Heizöl	16.6	13.9	13.6	13.3	12.7	12.5	12.2	11.6	-30.2%
Erdgas	5.1	6.3	6.5	6.6	6.6	6.9	7.1	7.1	+40.3%
El. Ohm'sche Anlagen	8.1	8.2	8.2	8.3	8.0	7.9	8.0	7.8	-3.7%
El. Wärmepumpen	0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.7	+235.4%
Fernwärme	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.1	+22.9%
Holz	1.0	1.1	1.1	1.2	1.1	1.1	1.1	1.1	+12.5%
Solar	0.1	0.5	0.6	0.7	0.8	0.9	1.0	1.1	+896.7%
Umgebungs-wärme	0.3	0.6	0.7	0.7	0.8	1.0	1.1	1.2	+286.5%
Summe	32.3	31.9	32.0	32.2	31.6	31.9	32.2	31.7	-1.9%

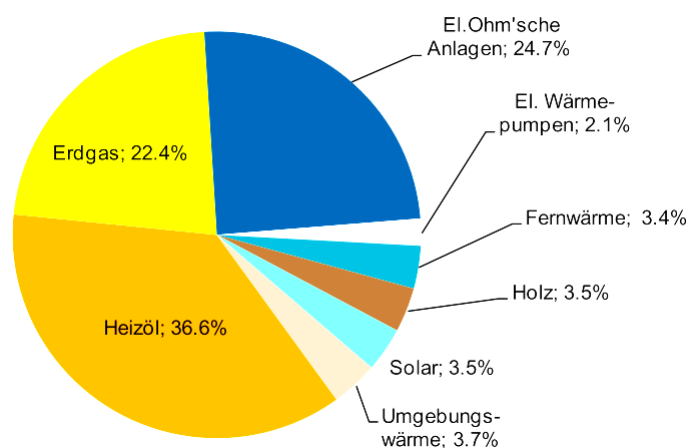


Figure 29: Distribution of the energy sources in the hot water consumption in 2014 (Prognos AG 2015).

Table 18 shows the Swiss population in private households using hot water divided by the energy source applied to produce the hot water (BFE 2015b). In 2014, nearly 35% of the Swiss population obtained their hot water from electricity-based heating systems, including electrical resistance systems (26.7% of the population), heat pumps (7.9%), and solar thermal heating systems (5.2%).

The relative proportions of heating systems for the production of hot water have shifted significantly in the period from 2000 to 2014. The shares of fuel oil (-14%) and the electrical resistance systems (ohmic installations, -4%) have decreased. The shares of natural gas (+7%), electrical heat pumps (+5% -points) and solar thermal (+5%) increased.

The number of inhabitants who produced their hot water by means of solar thermal systems increased by a factor of 10 during the observation period. However, the total share in 2014 was only around 5%. The shares of wood and district heating have not changed much.

The average hot water consumption per person varies between central systems and individual systems. According to the report of (BFE 2015b), the average daily consumption is about 45 to 50 liters per person per day in the case of central systems. For individual systems, the hot water supply is only possible in one or a few places within the household, and it is estimated at 35 liters per person per day.

Table 18: Swiss population in private households (in Tsd) using hot water divided by energy source (BFE 2015b).

	2000	2008	2009	2010	2011	2012	2013	2014	Anteil 2014
Heizöl	3206	2888	2843	2777	2702	2657	2597	2539	31.9%
Erdgas	1084	1493	1535	1575	1611	1678	1723	1768	22.2%
Holz	166	194	201	207	206	204	205	207	2.6%
Kohle	0	0	0	0	0	0	0	0	0.0%
Fernwärme	213	225	228	231	240	251	262	274	3.4%
El. Ohm'sche Anlagen	2143	2177	2181	2193	2160	2120	2123	2126	26.7%
El. Wärmepumpen	175	333	369	410	465	518	575	632	7.9%
Solar	41	169	214	254	300	342	379	416	5.2%
Summe	7028	7479	7570	7648	7684	7770	7864	7962	100.0%

Quelle: eigene Fortschreibung der Volkszählung 2000

Table 19 shows the fuel consumption (incl. district heating, environmental heat and solar heat) from 2000 to 2014 according to usage. In 2014, 84.2% of the "fuels" were used to generate space heating and 15.5% to supply hot water.

Table 19: Fuel consumption from 2000 to 2014 according to usage, in PJ (Prognos AG 2015).

	2000	2008	2009	2010	2011	2012	2013	2014	Δ '00 – '14
Raumwärme	155.3	159.9	155.7	174.9	134.9	152.3	167.6	125.8	-19.0%
Warmwasser	24.0	23.3	23.4	23.5	23.0	23.4	23.6	23.2	-3.3%
Prozesswärme	0.8	0.6	0.5	0.5	0.5	0.5	0.5	0.4	-44.5%
Summe	180.1	183.8	179.6	198.9	158.4	176.2	191.6	149.4	-17.1%

In contrast to the fuels, electricity has a broader range of use (see Table 20). In 2014, 13.5% (or 8.5 PJ of 63.1 PJ) of the electricity consumption was accounted for hot water heating and 19.4% (or 12.3 PJ) for space heating (see Figure 30, left) (Prognos AG 2015). Like in space heating, hot water heating is mainly supplied by central systems. Figure 30 (right) presents the distribution of typical electricity consumption in a Swiss multiple family house consuming totally 3'500 kWh (Nipkow et al. 2007).



Table 20: Electricity consumption from 2000 to 2014 according to purpose, in PJ (Prognos AG 2015).

	2000	2008	2009	2010	2011	2012	2013	2014	Δ '00 – '14
Raumwärme	12.2	14.4	14.2	16.0	12.8	14.3	15.8	12.3	+0.6%
Warmwasser	8.3	8.6	8.6	8.8	8.5	8.5	8.6	8.5	+2.1%
Kochen/ Geschirrspülen	8.0	8.5	8.6	8.7	8.8	8.9	9.0	9.1	+13.4%
Beleuchtung	5.7	6.0	5.8	5.7	5.4	5.2	5.0	4.7	-19.0%
Kühlen und Gefrieren	7.1	7.0	7.0	6.9	6.8	6.7	6.6	6.5	-8.3%
Waschen und Trocknen	2.6	4.6	4.8	4.9	5.0	5.1	5.1	5.1	+95.5%
Unterhaltung, I&K	5.4	5.7	5.7	5.5	5.2	5.1	4.9	4.7	-11.9%
Klima, Lüftung, HT	3.6	4.0	4.0	4.4	3.8	4.2	4.6	3.9	+8.5%
sonstige Elektrogeräte	4.6	6.6	6.8	7.1	7.3	7.7	8.0	8.3	+80.4%
Summe	57.6	65.4	65.6	68.0	63.7	65.7	67.6	63.1	+9.6%

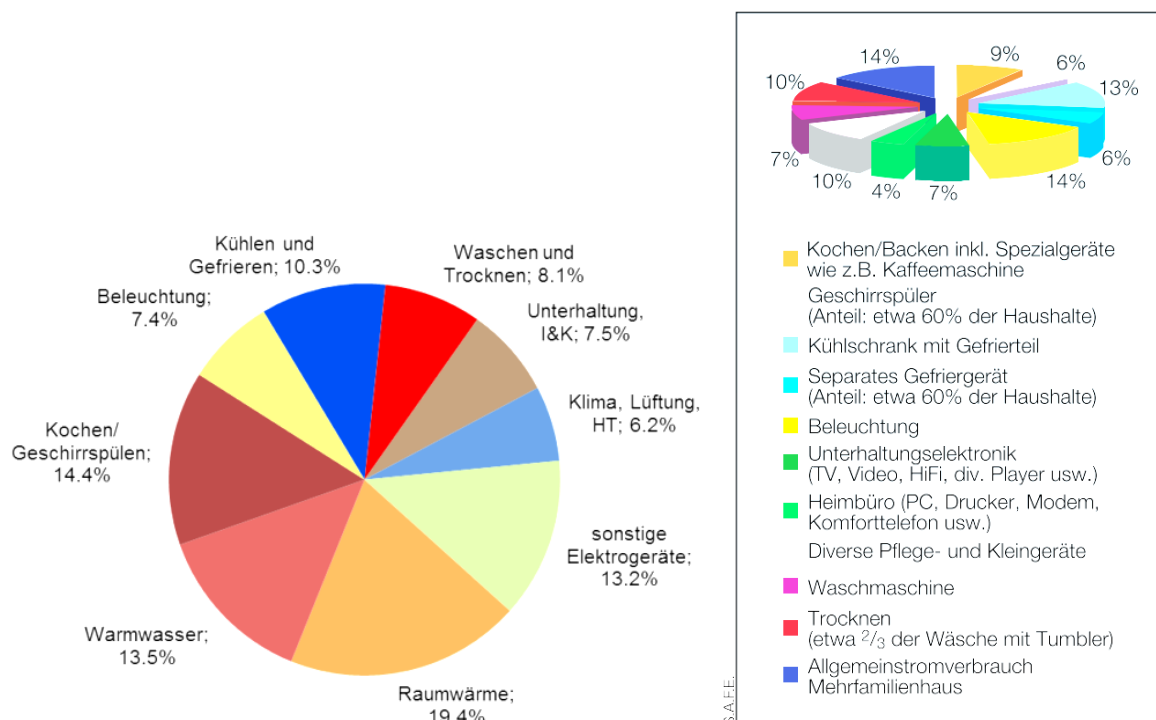


Figure 30: Left: Distribution of the electricity consumption in households in 2014 depending on usage, totally 63.1 PJ (Prognos AG 2015), Right : Distribution of the typical household electricity consumption in a multiple family house, totally 3500 kWh (Nipkow et al. 2007).

## ii. Water consumption

As described in (SVGW 2016), until 1970, the water consumption in Switzerland had risen steadily. This was followed by a stagnation phase until 1985, which was replaced by a slight but steady reduction in water consumption. In 1976, there was an extreme peak consumption as a consequence of an extremely warm and dry summer.

As shown in Figure 31, in 1999, the average overall water consumption was 404 liters per person, which was estimated to be 162 liters per person per day in household. This corresponds to about 40% of the total water consumption. 34% was needed for commerce and industry, the rest consisted of self-consumption of the water supply companies, consumption for wells and public utility, as well as grid losses.

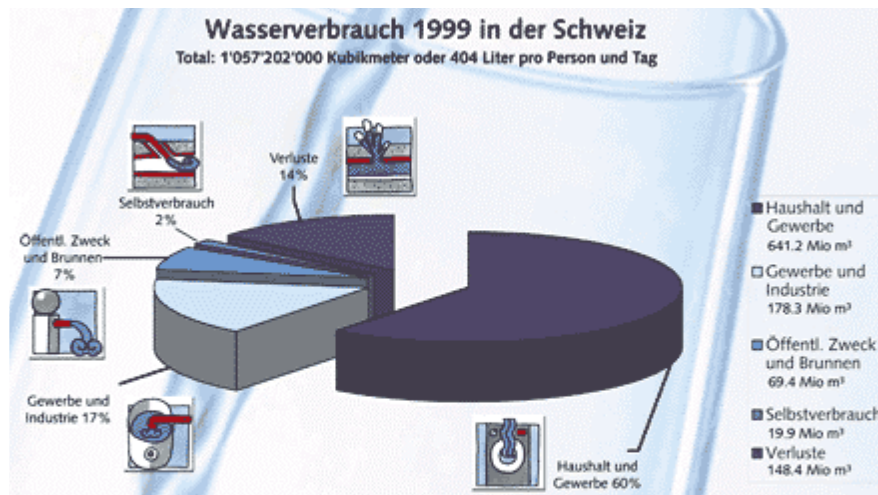


Figure 31: Water consumption 1999 in Switzerland (SVGW 2016).

Figure 32 illustrates the average water consumption of 162 liters per day and person in households (SVGW 2016). The data refers to the drinking water supplied by public utilities. Private water wells are not taken into account. The estimated domestic hot water consumption in Swiss households is about 38.4 litres per day and person. It depends on the water amounts for bathing/shower (50% of 31.7 L), dish washing by hand (50% of 24.3 L) and personal care (50% of 20.7 L).

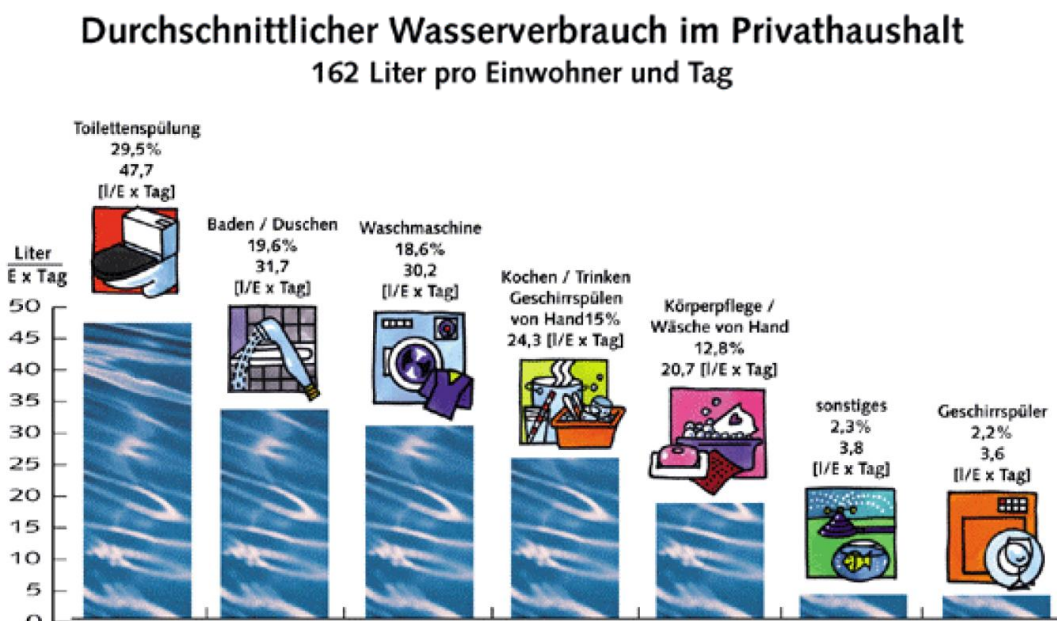


Figure 32: Average water consumption in Swiss households (source: [www.svgw.ch](http://www.svgw.ch)) (SVGW 2016), estimated domestic hot water = bathing/shower (50% of 31.7) + dish washing by hand (50% of 24.3) + personal care (50% of 20.7) = 38.4 L/d per person)).

### iii. Domestic hot water consumption (field measurements data)

In Switzerland, many heat pump manufacturers monitor their products in terms of energy efficiency, flow rate and temperatures. However, their main focus is not on the monitoring of domestic hot water consumption. Therefore, there is not much data available about the average hot water consumption. In the project “Domestic hot water production in multiple family buildings using heat pumps” (Vetsch et al. 2012), field measurements of the domestic hot water consumption were performed in three different objects of multiple family houses.

Table 21 summarizes the measured results (Vetsch et al. 2012). The average hot water consumptions per person varied from 36 to 44 litres per day. The fluctuation range of the consumption

measurements was  $\pm 10\%$  and around 1 to 2 K for the temperature measurement. In all objects, storage tank outlet temperatures above 55°C were observed. The installed storage tank volume matches quite well with the maximum consumption within 24 hours.

Table 21: Summary of field measurement results of 3 multiple family house objects (Vetsch et al. 2012).

	Object 1	Object 2	Object 3
Buildings	2	1	3
Apartments	48	66	73
Residents	97	128	-
<b>Average hot water consumption [litres/day]</b>			
- object	4285 $\pm$ 383	4578 $\pm$ 844	6149 $\pm$ 756
- per apartment	89.3 $\pm$ 8.0	69.4 $\pm$ 6.6	84.2 $\pm$ 10.4
- per person	<b>44.2 <math>\pm</math> 3.9</b>	<b>35.8 <math>\pm</math> 3.4</b>	-
Maximum in 1 hour (litres)	814	868	1'249
Maximum in 24 hours (litres)	5'718	6'237	9'257
Installed storage tank (litres)	6'000	8'000	10'000
Supply temperature (storage tank outlet) [°C]	59.6 $\pm$ 1.1	55.6 $\pm$ 2.2	57.3 $\pm$ 1.9

Taking a closer look to object 1, the consumption profiles look quite regular on a weekly, daily, and hourly base. Saturdays and Sundays slightly differ from weekdays (see Figure 33).

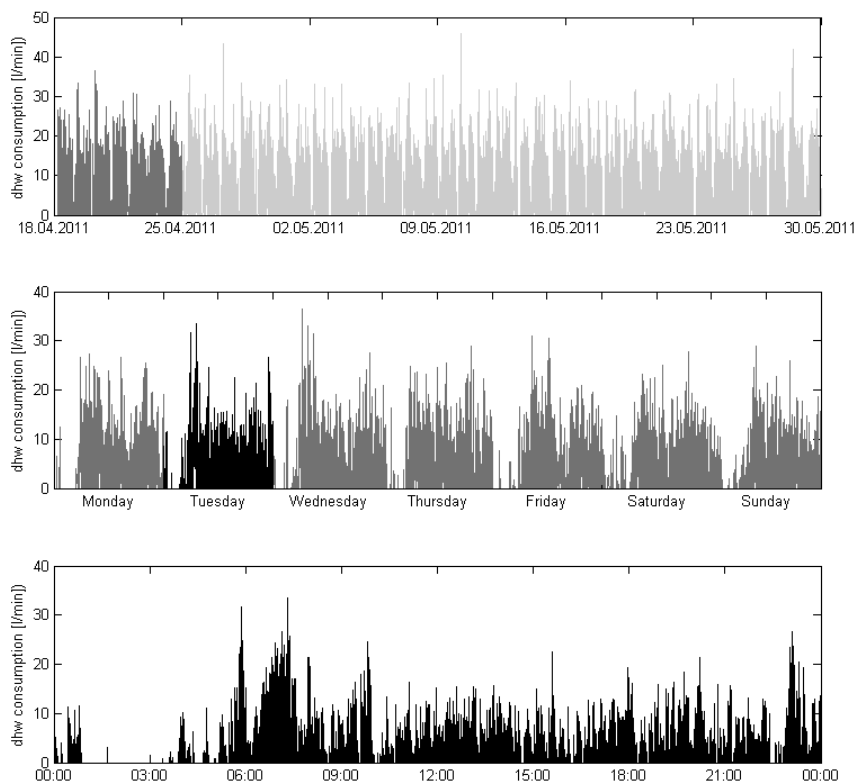


Figure 33: Consumption profiles of object 1 (Vetsch et al. 2012).

Figure 34 compares a typical water consumption profile according to the design Standard SIA 385/2 (SIA 2013b) with the measured consumption of the object 1 described by (Vetsch et al. (2012)). The SIA 385/2 postulates a continuous consumption over nearly the whole day, which has been confirmed by the experimental measurements.

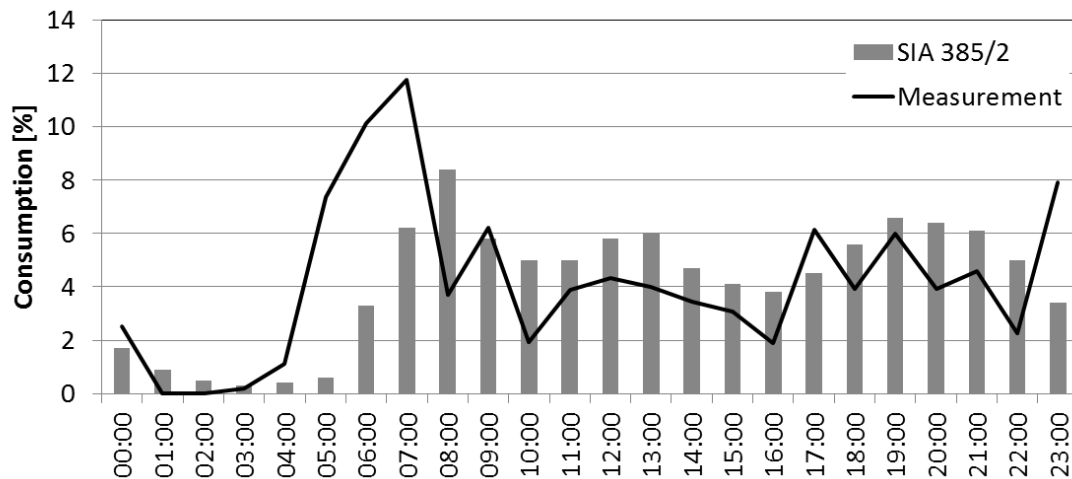


Figure 34: Comparison of the hot water consumption profile (Monday to Thursday) according to standard SIA 385/2 (SIA 2013b) with measurement of object 1 (Vetsch et al. (2012)).

Table 22 summarizes some recent studies of (Bürge et al. 2013) and (Heim et al. 2016) with measurements on the domestic hot water consumption to verify the correct dimensioning and installation of a building complex with MINERGIE-P-Standard. In contrast to (Bürge et al. 2013) and (Vetsch et al. 2012), (Heim et al. 2016) monitored the domestic hot water consumption of single family houses and apartments (in total 10 households) over one year, which enables to derive the individual consumption behaviour.

Table 22: Measurement results from Bürge et al. (2013) and Heim et al. (2016).

	(Bürge et al. 2013)	(Heim et al. 2016)										
	2 buildings and 40 apartments	10 households studied, number of residents living in the household										
												Mean values
No. of residents	80	2	5	4	2	2	4	1	3	2	2	2.7
Installed storage tank [L]	5000	300	210	300	300	300	300	110	280	250	300	265
Supply temperature [°C] (storage tank outlet)	-	69.5	65.4	64.6	63.8	54.3	66	56	60.8	71.3	67.2	63.9
Water Consumption [L/]												
- object	3'320	-	-	-	-	-	-	-	-	-	-	-
- per apartment	83	-	-	-	-	-	-	-	-	-	-	-
- per person	41.5	49	21	39	45	8	18	21	22	65	48	33.6

The measured mean value of 33.6 liters per day and person was close to the 35 liters per day and person for households in multiple family houses described in the guideline Standard SIA 385/2:2015 (for comparison in single family houses 40 liters per day and person are used for design). The individual values of the 10 households studied, fluctuated by a factor of 8 between 8 and 65 litres per day person (Heim et al. 2016). It is worth mentioning that in that study the domestic hot water was supplied by electrical water heaters providing relatively high supply temperatures of 63.9°C in average. Interestingly, there was no correlation between the specific hot water consumption and the number of residents in the households. It is expected that the specific consumption depended much more on the individual activities of the residents, such as the intensity of the personal care or the personal commitment to a more economical water consumption.

Heim et al. (2016) also identified so-called “predominantly morning consumers” and “predominantly evening consumers” when comparing individual tapping profiles (see Figure 35). This is in agreement to the findings of Edwards et al. (2015), who observed similar water consumption patterns between houses in Canada.

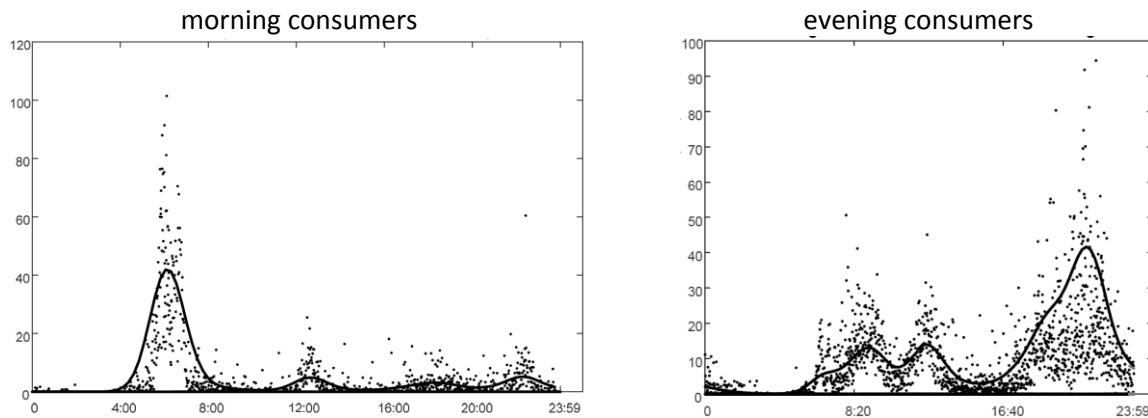


Figure 35: Characteristic hot water consumption profiles (tap profiles) for the predominantly morning and evening consumer (from the measurements of Heim et al. (2016)).

Like in other countries, the hot water consumption profiles (tapping curves) in Swiss multiple family houses are rather continuous due to the averaging effect of the individual human behaviour. In single households a great variety in water usage is found depending upon human behaviour factors (e.g. shower/bathing, personal care, etc.) demanding higher flexibility of the heat pump water heater system and may lead to oversizing of the system.

### 3. Analyses of market trends

In this part the reporter analyses the figures, policies, trends and technology developments and describes the expectations for the market until 2020 - 2030.

- a. Smart grids
- b. Renovation of multiple family buildings
- c. Renovation to Energy Cost Zero
- d. NZEB (net zero energy building)
- e. New buildings
- f. District heating

**Question:** Is there an important growing market for domestic hot water heat pumps and what are the challenges and/or barriers in that market?

#### i. Sales of heat pumps in Switzerland

Looking at the sales figures of heat pumps for space heating within the last three decades (Figure 36), it can be seen that heat pumps represent a market share of around 40 percent of the entire space heating market. In 2015 well over 18'000 units were sold. The data for this are provided by the Fachvereinigung Wärmepumpen Schweiz FWS (FWS 2015b).

The number of heat pumps produced in Switzerland in 2012 was around 7'000 units, with 2'000 of them being exported (Banach & Fahrni 2014). This means that Switzerland has imported over 14'000 devices. If 2'000 units are added, which are not covered by statistics, the sum of some 16'000 imported heat pumps is more than twice as much as the domestic production.

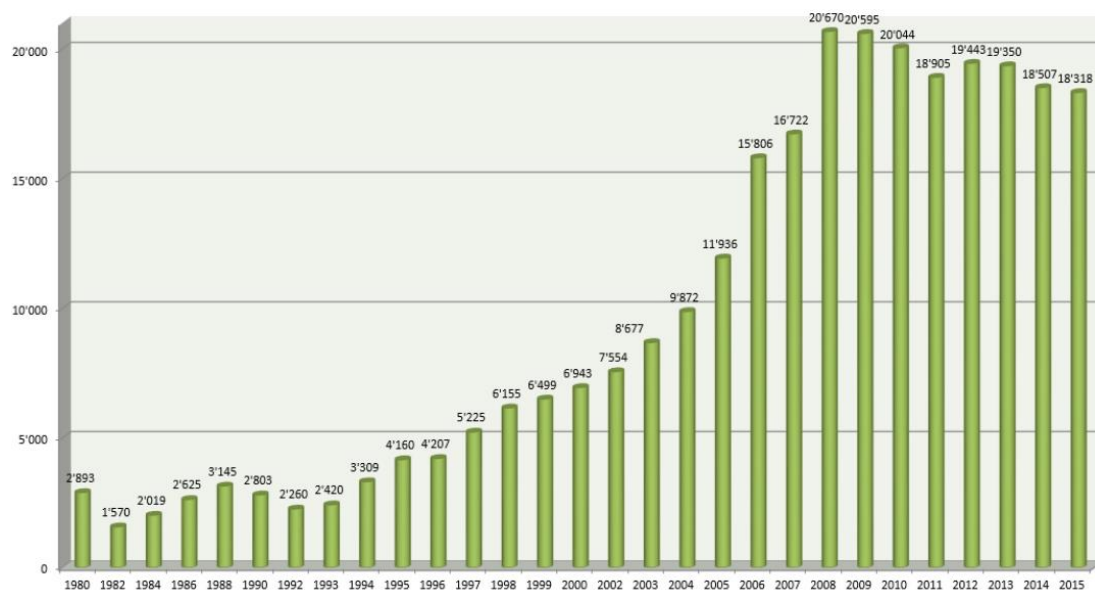


Figure 36: Heat pumps sold in Switzerland per year (FWS 2015b).

Figure 37 shows the distribution of sold heat pumps in Switzerland per energy source air/water, brine/water, water/water and air/air (FWS 2015b). Air-to-water heat pumps are market leading with 64% of the market today. This is especially the case after the introduction of split systems with the inverter technology, which enables to adjust the rotational speed of the compressor depending on the temperature requirements. This avoids a "stop and go" operation and increases efficiency (Banach & Fahrni 2014). Over the years 2006 to 2011 a clear transition from brine to air driven heat pumps was recognized. Figure 38 shows that of all space heating systems, the heat pump (blue curve) is clearly ahead. It can be postulated that the market penetration of DHW heat pumps will behave similarly as heat pumps for space heating in future.

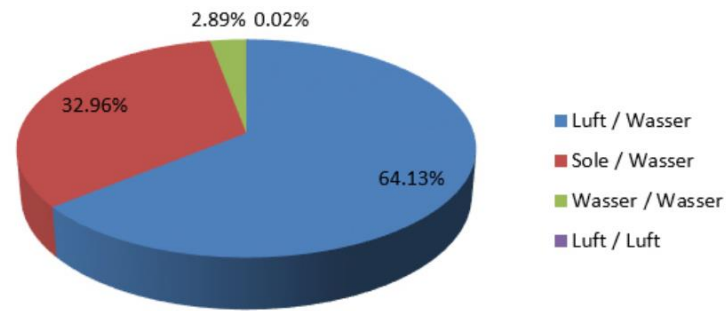


Figure 37: Heat pumps sold in Switzerland per energy source air/water, brine/water, water/water and air/air (FWS 2015b).

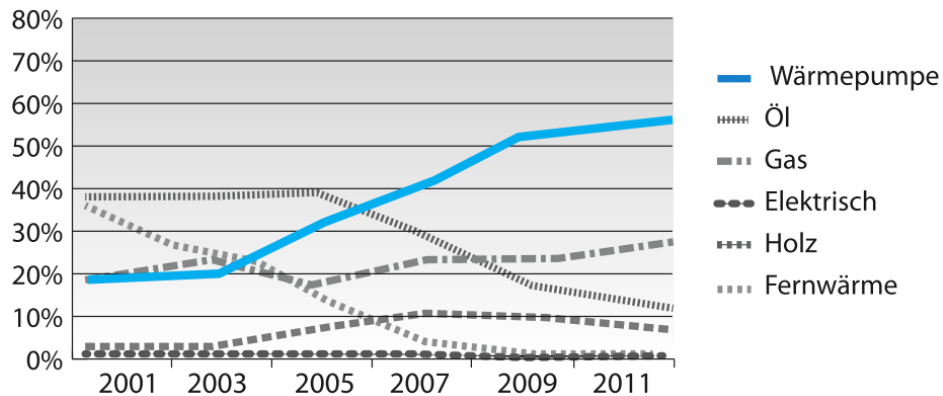


Figure 38: Heat generating installations sold according to the energy sources in percent from 2001 to 2011 (Banach & Fahrni 2014). The heat pump (blue curve) is clearly ahead of all other heating systems.

## ii. Renovation of buildings

A number of predictions favour the hot water heat pumps for the production of hot water in buildings, as those systems can be used in most cases, do not cost much and reduce energy consumption by up to two-thirds (Banach & Fahrni 2014). In refurbishment (retrofit) cases, they can be used without great prior measures and planning, taking into account the installation requirements. The installation is simple and the entire installation does not occupy more space than a conventional boiler. In single family houses there is activity in replacing electric water heaters by DHW heat pump boilers. There are several funding programs in place and ongoing. For multiple family buildings there are local and centralized heating system in place.

## iii. Efficiency increase of heat pumps

The energy efficiency of heat pumps for space heating has steadily improved (Eschmann 2015b). Figure 39 shows the development of the COP of air/water (A2/W35) and brine/water (B0/45) heat pumps for space heating. The average COP value of measured air/water heat pumps in 2015 was 3.54 (according to EN 14511). This corresponds to an average annual efficiency increase of 0.9% between 2005 and 2015. Since 2010, however, the annual measured mean values remained almost constant. The efficiency of brine/water heat pumps has increased since 2005 by an average of approx. 0.8%. The largest increase was achieved in 2011 where the minimum COP to be fulfilled to apply for the EHPA quality label increased from 4.00 to 4.30. In 2015, an average COP of 4.51 was determined at standard test conditions (B0/W35).



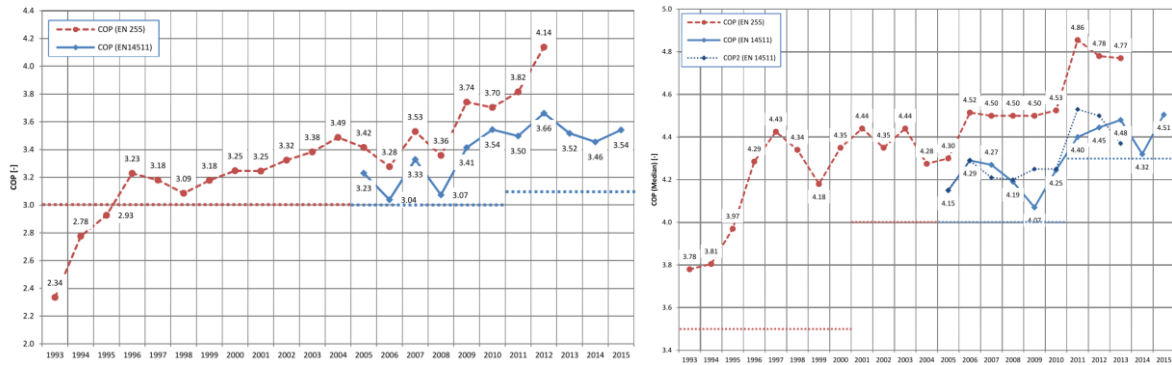


Figure 39: COP development of air/water A2/W35 (left) and brine/water B0/W35 (right) heat pumps since 1993 (Eschmann 2015b).

Figure 40 shows the trend that the efficiency of hot water heat pumps increases annually (Eschmann 2015b). In 2012, 2 out of 3 hot water heat pumps achieved a COP of 2.60 (A15/W10-55), in 2013 already 5 out of 6. In 2014, about 9 out of 10 tested heat pump boilers have reached this value of 2.60. In 2015, however, the percentage of heat pumps reaching a COP of 2.60 fell to 50%, with 50% of the measured COP being higher than 3.2.

New hot water heat pumps placed on the market must meet the requirements of the EU Ecodesign Directive. However, this is not a real hurdle for the market approval of heat pumps in Switzerland (Genkinger & Afjei 2014).

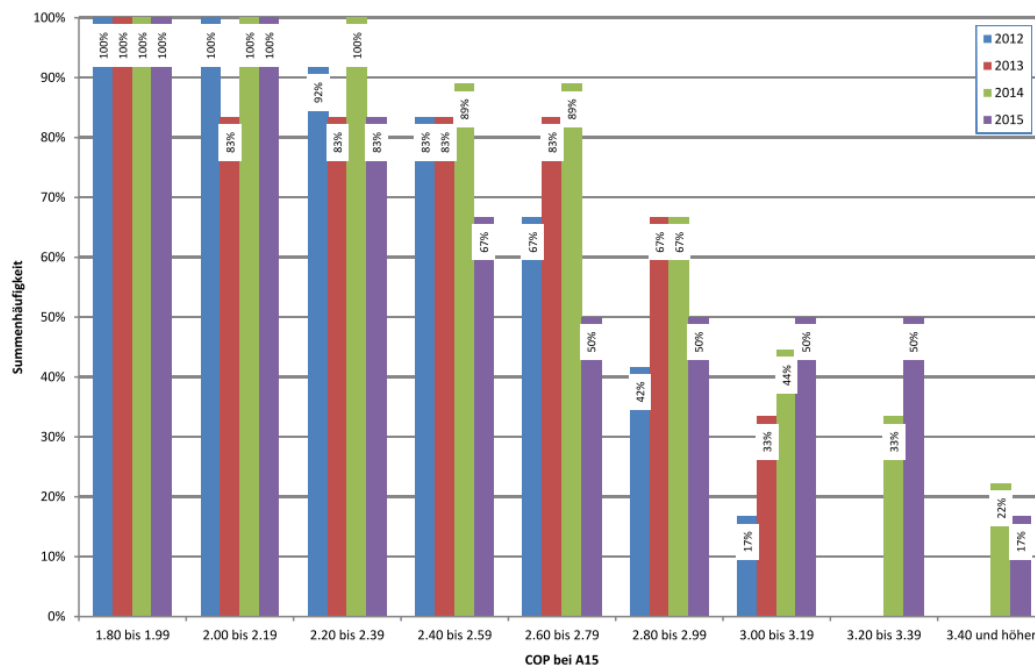


Figure 40: COP development of hot water heat pumps at A15/W10-55 from 2012 to 2015 (Eschmann 2015b).

#### iv. Water saving armatures

There is a trend of installation of water saving armatures<sup>48</sup>, as these limit the water flow rate per minute and thus reduce water consumption. There are armatures which supply cold water in neutral position and/or reduce the water flow by 40% to 50% (EnergieSchweiz 2011). Suitable armatures allow a more economical use of hot water.

<sup>48</sup> <https://www.energie-experten.ch/de/wohnen/wohnen/wasser-spahren-mit-den-richtigen-armaturen.html>

Another way to save water is to install a flush-stop button in the toilet. By means of these two methods, water consumption can already be reduced by 60 to 70%<sup>49</sup>. Parts of the potential are however diminished or influenced by the behavior of the users. There is also a trend towards more comfort and wellness increasing the water consumption again (Jakob et al., 2016). There is a trend that the number of bathrooms in homes increase, as well as the number of showers compared to bathtubs (Stammer 2012). Shower offers quick cleaning in the morning, saves space in the bathroom and saves water. There are several tips published online that promote saving (hot) water<sup>50</sup>:

- Economize hot water, as it must be heated in the boiler where the temperature, but also the germ-freeness of the water is important.
- Periodically check the water temperature. This should be at 55 to 60°C. Too high temperatures increase the calcification of the boiler and consume unnecessarily much energy.
- Regular decalcification of the hot water tank and the water taps.
- Check the switching times of the water circulation pump or of the electrical pipe heating system. Adjust the operating times to the hot water usage time to reduce the energy consumption.

#### v. Real-time feedback on hot water and energy consumption

Studies show that real-time consumption feedback influences hot water use. For example, the Swiss start-up company Amphiro AG<sup>51</sup> developed a real-time feedback device amphiro a1/b1, an intelligent consumption indicator for the shower (Tiefenbeck et al. 2016). Amphiro measures the flow rate and water temperature and calculates the amount of water and energy used per showering. The water and energy consumption is directly displayed during showering and thus promotes a conscious handling of hot water. As the device automatically turns on whenever water flows, it does not require user action to start the measurement process. Test results show that real-time feedback on shower water use leads to very large saving effects. Participants saved on average between 19% and 21% of their energy consumption in the shower (Staake et al. 2016). The payback time of the device is less than 10 months.

#### vi. Other market trends

- **Stronger environmental awareness:** Due to the global political uncertainties, the global warming, CO<sub>2</sub> and a dramatic increase in the price of crude oil, a new environmental awareness is emerging in the direction of a long-term energy policy. The use of regenerative energies in general and the use of the heat pump in particular has become part of the solution to our global environmental (Banach & Fahrni 2014)
- **Market of heat pumps:** There are three development possibilities for the market of heat pumps: refurbishment, installation of heat pump systems or installation of a hot water heat pump without renovation. As far as system construction is concerned, the split systems are the future trend (Banach & Fahrni 2014).
- **Renovation:** In refurbishment it is often more important to first renovate the building envelope in order to reduce heat losses. Then one could think of new heating system, e.g. a heat pump. Especially in the renovation market, hot water heat pump is a rising trend (Banach & Fahrni 2014).
- **Split systems:** Split systems (split air/water heat pumps) are gaining importance. A compact split unit for a single-family house costs around 15'000 CHF. In many cases, there is no need for an extra heating boiler or DHW heat pump, as this is integrated in the split unit. This

<sup>49</sup><https://www.energie-experten.ch/de/wohnen/wohnen/experten-tipps-zum-energiesparen-in-wohnhaeusern.html#sthash.cfH15Gqs.dpuf>

<sup>50</sup><https://www.energie-experten.ch/de/wohnen/wohnen/experten-tipps-zum-energiesparen-in-wohnhaeusern.html#sthash.cfH15Gqs.dpuf>

<sup>51</sup>[www.amphiro.com](http://www.amphiro.com)

reduces the amortization costs. Thus, the system can be used both for space heating and water heating (Banach & Fahrni 2014).

- **Replacement of fossil fuels and electric heating systems (electroboilers) by heat pump boilers or non-fossil heaters (e.g. pellets, wood, etc.):** The building stock is still dominated by fuel driven heating systems, in particular in large buildings, i.e. multiple family houses and non-residential buildings (Jakob et al. 2016). There is the trend of restructuring the building stock towards renewable energies. In the case of new buildings, fossil fuels are of only minor importance for the single-family houses, and the market share of multiple family houses is only between 15% and 30%. In the case of renovating existing buildings, the energy-related market share of fossil systems has declined to 50% to 60% (Jakob et al. 2016, p. 28). A substitution of the energy carrier is possible through combined room heat and hot water systems or as a complement to central hot water systems, e.g. by using solar energy.
- **More single-family houses:** The trend towards single-family house is unbroken. 70% of all buildings built since 2000 are single-family houses (BFS 2016a). Overall, single-family houses represent 57% of all buildings in Switzerland.
- **Increasing living space per person:** The average living space per inhabitant increases gradually, from 38 m<sup>2</sup> in 1990, to 43.6 m<sup>2</sup> in 2010 and 44.95 m<sup>2</sup> in 2012 (BFS 2014b).
- **Reduction of heat losses:** There is a whole package of measures in place to reduce heat losses during hot water storage, distribution and delivery, e.g. by means of control measures as well as by thermal insulation measures of the storage and distribution lines (Jakob et al. 2016).
- **Individual, local hot water generation systems:** For example, the company Swissframe AG<sup>52</sup> produces modular, fully equipped front-wall installations for bathrooms. The front-wall installations consist of a waste heat recovery system for air ventilation. (Büchel et al. 2016) extended the front-wall installation with a decentralized boiler with a high-tech isolation, a small heat pump and an intelligent control. The remaining energy in the exhaust air is recovered by the heat pump and upgraded to be delivered to the hot water boiler. With these modifications, the energy efficiency is increased.

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<sup>52</sup> [www.swissframe.ch](http://www.swissframe.ch)

## 4. Brands and Associations (Verbände)

Describe and name the brands of heating appliances (Geräte, Apparate) and the Associations

### i. Brands of heating appliances

Since 2012, the FWS runs a list of DHW heat pumps (heat pump boilers) with FWS certification<sup>53</sup> (FWS 2016a) including 36 heat pump suppliers and 96 models (see Table 23).

Table 23: Suppliers of domestic hot water heat pumps (heat pump boilers) with FWS certificate (test results based on EN16147:2011), (WPZ 2013) (FWS 2016a) (in alphabetic order).

Manufacturer	Model types	#
Alpha innotec	BWP 307, BWP 307S	2
Apitec AG	DHW300, DHW300+, DHW300d, DHW300d+	2
Atlantic Suisse AG	WPA 303 ECO, Explorer 270L FS, Explorer 270L Cozytouch, WP-B 300	4
Atlis AG	Heatmaster CH-301	1
Berger Boiler Service	AE WPA 303 ECO 300 Liter	1
Buderus Heiztechnik AG	DHW300, DHW300+, DHW300d, DHW300d+	4
Cipag SA	Cipag Nuos Monobloc 250 (see Domotec AG), Cipag Nuos Monobloc 250 SOL, AQUANEXT PLUS 200, AQUANEXT PLUS 250, AQUANEXT PLUS 250 SYS	5
Coolstar AG	CSWB300L	1
CTA AG	CBE WP 300 Eco, CBEW WP 300 Eco CTC	2
CTC Giersch AG	CTC EcoWater300, EcoWater301, EcoWater302, CTC EcoWater WP-LS 300 Liter	3
Delta Solar GmbH	WP-LS-E 300, WP-LS-V 270	2
Domotec AG	SWPL 250, SWPLW 250, NUOS II S 200, NUOS II S 250, NUOS II S 250W1, NUOS II S 250 W2, HPWH 250 SOL	6
Elcotherm AG	Aerotop DHW 200, Aerotop DHW 250, Aerotop DHW 250SYS	3
Energie Est, Ida	Eco 250esm, AquaPura Split 250	2
Energo AG	SOWAPU-300I-13C	1
Glen Dimplex Deutschland GmbH	BWP 30 HM	1
Grünenwald AG	BWW 300, BWW 301 25.09.2014	2
Heim AG Heizsysteme	WPB-300 ECO, WPB-300 ECOplus, WPB-500 ECO	3
HoVal AG	CombiVal WPE 300, CombiVal WPER 300	2
Kibernetik AG	WPLW-KIB-BW-300L, WPLW-KIB-BW-300L-S, F1, F1 WT	4
Makscorn GmbH	RS-3.6FAD/300L	1
MHG Heiztechnik (Schweiz) GmbH	VT 3130, VT 3131, VT 3132	3
Nibe Wärmetechnik	MT-WH 2029-F, MT-WH 2029-1FS	2
Ochsner Wärmepumpen GmbH	Europa 250 DK/DKL, Europa 323 DK	2
Proftech International GmbH	Kolant KL-300-S	1
Peter Wärmepumpen GmbH	Heatmaster AP 304, Heatmaster AP 304 S, HeatMaster AP 307, HeatMaster AP 307 CT, HeatMaster AP 452	5
Stiebel Eltron AG	WWK 300, WWK 300 SOL, WWK 300 electronic CH, WWK 300 electronic CH SOL	4
Swisstherm AG	VT 167, VT167 OHE, VT167E, SWT Eco	3
TCA ThermoClima AG	OH-BWWP270-0, OH-BWWP270-1, OH-BWWP270-2	3
Termo-Tehnika, d.o.o	TC2 VZRT/E-321 ECO NT	1
Tobler Haustechnik AG	FUTURA I T SWP S II 300, I T SWP SW II 300, I T SWP SWW II 300, I T SWP SX 300, I T SWP SWX 300, I T SWP SWWX 300, I T SWP S II 250, I T SWP SW II 250, I T SWP SWW II 250, I T SWP SX 250, I T SWP SWX 250, I T SWP SWWX 250	12
Vesttherm A/S	VT 3130, VT 3130	2
Viessmann (Schweiz) AG	Vitocal 161-A WWK 161.A02, Vitocal 161-A WWKS 161.A02	2
Walter Meier (Klima Schweiz) AG	TWH 300E, TWH 300EH	2
Weishaupt AG	WWP-T 300 WA	1
Windhager Zentralheizung Schweiz AG AquaWINAir	AquaWINAir AWA 270	1
<b>TOTAL: → 36 heat pump suppliers, and 96 models of hot water heat pumps</b>		

<sup>53</sup> [www.fws.ch/tl\\_files/download\\_d\\_f\\_i/Guetesiegel/Guetesiegelliste\\_Warmwasser-WP.pdf](http://www.fws.ch/tl_files/download_d_f_i/Guetesiegel/Guetesiegelliste_Warmwasser-WP.pdf)

In Switzerland, several hundred thousand electric water heaters are in operation in residential buildings<sup>54</sup>. A considerable part of these appliances could be replaced by DHW heat pumps, which work much more efficiently. The energy consumption for the hot water could be reduced to a third. Suppliers of hot water heat pumps can submit a request for inclusion in the list DHW heat pumps. The Heat Pumps Quality Commission checks the submitted documents and decides on the certification. The accredited heat pump test center WPZ ([www.wpz.ch](http://www.wpz.ch)) is performing the quality tests (quality label, FWS certificate) at the University of Applied Science NTB in Buchs Switzerland.

## ii. Associations of heat appliances

Important associations and organizations in Switzerland are the Association for Heat Pumps Switzerland FWS and GebäudeKlima Schweiz GKS. They represent the most important providers of Swiss heat pumps and define and monitor the quality labels. The quality label concerns not only the heat pump device itself, but also the training of installers and planners. This also includes services provided by companies in the field of heat pumps. An important task of those associations is quality control of new and installed heat pump products, e.g. the quality label of the Association for Heat Pumps Switzerland FWS for heat pump systems, and field analysis control by BFE / FWS - or the new heat pump system module (heat generation, drinking water, heat distribution and hydraulics with control technology).

On the Swiss market, there are only a limited number of associations active in the heat pump sector (Banach & Fahrni 2014). The most important organizations are listed in Figure 41 and Figure 42, including:

- FWS<sup>55</sup>: Fachvereinigung Wärmepumpen Schweiz FWS
- GKS GebäudeKlima Schweiz<sup>56</sup>: Schweizerischer Verband für Heizungs, Lüftungs- und Klimatechnik
- Suissetec<sup>57</sup>: Schweizerisch-Liechtensteinischer Gebäudetechnikverband
- SVK<sup>58</sup>: Schweizerischer Verein für Kältetechnik
- ProKlima<sup>59</sup>: Plattform für Informationsaustausch für Hersteller und Lieferanten der Lüftungs- und Klima-Branche
- SHKT<sup>60</sup>: Vereinigung Schweizerischer Heizungs- und Klimatechniker
- BFE<sup>61</sup>: Bundesamt für Energie BFE



Figure 41: Logos of the main associations in Switzerland related to heat pumps.

<sup>54</sup> [www.fws.ch/warmwasser-waermepumpen.html](http://www.fws.ch/warmwasser-waermepumpen.html)

<sup>55</sup> [www.fws.ch](http://www.fws.ch)

<sup>56</sup> [www.gebaeudeklima-schweiz.ch](http://www.gebaeudeklima-schweiz.ch)

<sup>57</sup> [www.suissetec.ch](http://www.suissetec.ch)

<sup>58</sup> [www.svk.ch](http://www.svk.ch)

<sup>59</sup> [www.proklima.ch](http://www.proklima.ch)

<sup>60</sup> [www.shkt.ch](http://www.shkt.ch)

<sup>61</sup> [www.bfe.admin.ch](http://www.bfe.admin.ch)

### iii. Fachvereinigung Wärmepumpen Schweiz FWS

The “Fachvereinigung Wärmepumpen Schweiz FWS” is the responsible authority recognized by the Swiss Confederation and the cantons for the approval of the heat pump quality label (“Gütesiegel”). The procedure to obtain the quality label is based on the regulations of the EHPA Quality Label<sup>62</sup> and includes the European test standard EN 14511. The quality label certification procedure is carried out by the quality label commission of the FWS. The commission is neutral and independent.

The heat pump quality label is a quality award which a heat pump sales company can obtain for heat pump series or individual units and the related services. This means that the quality label not only refers to the technical specifications of the heat pumps, but also to the quality of the planning documents and the service organization. The requirements for the quality certificate are described in the quality label regulations of the European heat pump association EHPA<sup>63</sup>. The regulations apply to standard heat pumps with or without DHW heating up to a heating capacity of 100 kW with the heat sources air, geothermal energy or water.

The quality label serves both the public and professionals, as well as the authorities, electric power companies and banks to set-up programs for funding contributions, reduced tariffs or reduced interest rates depending on the quality label. By purchasing a quality-tested heat pump, the end customer has the certainty to receive a product with a high-quality label and that a sales company with a competent service organization and the necessary services is behind it. The quality certificate is, in particular, also a basis for the agency of funding support programs, and it also makes a significant contribution to achieving the future energy efficiency goals in heating.

The quality label of the heat pumps is performed at the WPZ heat pump test centre<sup>64</sup> in Buchs at the NTB University of Applied Sciences of Technology. The WPZ heat pump test centre is an accredited according to EN 17025 for heat pumps and offers comprehensive test services in the field of heat pump technology, including the determination of the heating or cooling capacity as well as the corresponding performance (COP, EER) (WPZ 2016). The test centre is able to test according to the following international test standards EN 14511, EN 14825 or EN 16147 and the extended requirements of the EHPA test guideline, ErP or NF directives. The WPZ follows the EHPA regulation for heat pump tests (EHPA 2016). The test results of domestic hot water heat pumps based on EN 16147:2011 can be downloaded from the website [www.wpz.ch](http://www.wpz.ch) (WPZ 2016). The rules for the testing of domestic hot water heat pumps are currently adapted to the EN 16147. The EHPA database covers over 1'400 heat pumps tested in Switzerland.

### iv. GebäudeKlima Schweiz

GebäudeKlima Schweiz is the leading association of Swiss manufacturers and suppliers of heating, ventilation and air-conditioning technology. The majority of the members are system providers and maintain sales and service networks throughout Switzerland. The primary goals are higher energy efficiency and increased use of renewable energies, for climate and environmentally friendly technologies, as well as for comfort and industry competency. GebäudeKlima Schweiz emerged at the end of 2010 from a merger between Procal and the Arbeitsgemeinschaft Wärmepumpen (AWP). GebäudeKlima Schweiz comprises a major industry in the Swiss labor market with several thousand employees. GebäudeKlima Schweiz certifies service technicians in the fields of heat pumps, oil/gas and wood. GebäudeKlima Schweiz has seven divisions, including one of heat pumps. Company-neutral information documents are developed, for example for the replacement of conventional electroboilers by hot water heat pumps. Also, members of the group are actively involved in the development of new standards and directives in the various standards committees (SIA, SVGW, Cenelec, CEN, EN etc.). GebäudeKlima Schweiz covers the entire field of house technology and is system-oriented.

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<sup>62</sup> [www.ehpa.org/?id=757&L=1&tx\\_ehpaqualitylabel\\_pi2\[country\]=CH](http://www.ehpa.org/?id=757&L=1&tx_ehpaqualitylabel_pi2[country]=CH)

<sup>63</sup> [www.ehpa.org](http://www.ehpa.org)

<sup>64</sup> [www.wpz.ch](http://www.wpz.ch)



#### v. Suissetec

The Suissetec is an industry and employers' association for the interests of building technicians. Members of the association are organizations and small and medium-sized enterprises (SMEs) from the areas of plumbing, heating, ventilation and sanitation.

Suissetec represents all stages of the value chain, from installers, planning offices as well as manufacturers and suppliers. The suisstec is a federalist organization with 26 regional sections and more than 3'300 members. An important part of the work of the association is further education in the building technology sector, as well as the political commitment to energy, education and economic policy issues. Suissetec is active among other things in the field of heat pump technology, e.g. in the heat pump system module.

#### vi. SVK – Schweizerischer Verein für Kältetechnik

The SVK was founded in 1955. Today, the SVK is the professional Swiss association for industrial refrigeration, air conditioning and heat pump technology and has a membership of 250 member companies. The SVK adapts to the needs of refrigeration companies and promotes and supports them in technical, economic and ecological matters. It maintains contact with the members, as well as the industry in Switzerland and abroad, in order to capture current developments in the refrigeration sector in time and to initiate necessary measures. The SVK is strongly involved in the training and further education of refrigeration specialists, energy efficiency in refrigeration plants and in refrigeration control. Since 1992, the SVK has been a sponsor organization for training courses and specialist examinations to acquire the "Specialized Approval for the Handling of Refrigerants".

#### vii. ProKlima

ProKlima is the platform for information exchange among manufacturers and suppliers of products or systems for the air-conditioning and ventilation industry. The members of ProKlima contribute with their products and services to well-being in rooms and buildings and ensure optimal manufacturing process conditions. The aim of ProKlima's members is the sustainable satisfaction of customer needs. ProKlima promotes joint services for the future-oriented development of its 140 members. The association is a common point of contact for third parties and maintains cooperation with local and foreign associations, organizations, institutions and training centers.

#### viii. SHKT - Vereinigung Schweizerischer Heizungs- und Klimatechniker

The SHKT comprises the Swiss heating and air conditioning technicians. Most important is the exchange of experience as well as education and training. The association is committed to the European recognition of the title "Technician TS". SHKT currently has more than 20 member companies.

#### ix. BFE (Bundesamt für Energie) and EnergieSchweiz

The Swiss Federal Office of Energy (SFOE) is the competence center for energy supply and energy use in the Federal Department of Environment, Transport, Energy and Communications. It creates the prerequisites for sufficient, crisis-proof, broad and sustainable energy supply for high safety standards in the production, transport and use of energy, and promotes a modern supply infrastructure, efficient energy use and renewable energies.

The SFOE conducts «SwissEnergy», the Federal Council's program to promote energy efficiency and renewable energies. Under its umbrella, the Confederation, cantons and municipalities, economic enterprises and industry associations, environmental and consumer organizations as well as education and science institutions are implementing numerous voluntary projects to promote a more economical use of energy and to increase the use of renewable energies in mobility, building industry, commerce and services as well as in the public sector. In the area of heat pumps, "EnergySchweiz" promotes, above all, the training and further education of installers and planners, the information and advice of plant operators and the quality assurance of new and existing plants.



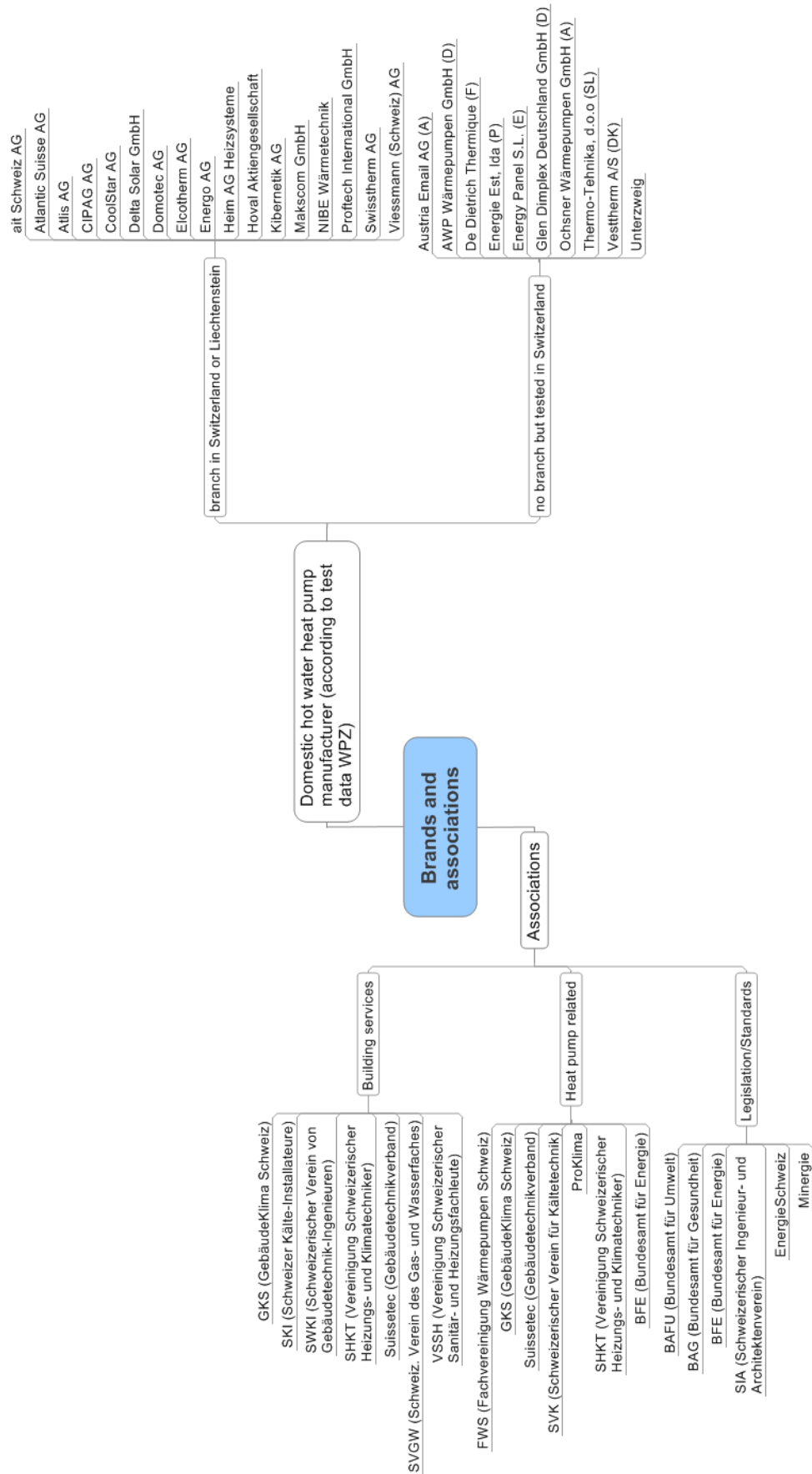


Figure 42: Brands and associations in Switzerland (no claim to be complete).

## 5. Terminology

Basic heat generation system:	Heat pump (e.g. heat pump boiler, split-system)
Backup heating system:	Electrical heater integrated in WP-Boiler
Centralized:	One DHW heating system supplies several multiple family houses in a district
Decentralized:	One DHW heating system per multiple family house in a district
Domestic:	Includes singel and multiple family houses
Domestic hot water (DHW):	Water heated to at least 55°C for the purpose of household washing, bathing and cleaning
HPWH:	Heat pump water heater (in German: WP-Boiler), plug-in system (in German: steckerfertiges Gerät), heat pump can also be attached to the storage tank, i.e. boiler
Local:	One DHW heating system in each apartment
Secondary heat generation system:	A secondary source of water heating in a heat pump water heater (e.g. solar thermal)
Split system:	A complete HPWH system with tank, where the components are not all housed in the same cabine. Usually partially outside and partially inside
Stand-alone HPWH:	HPWH compressor and heat exchanger unit sold without a storage tank

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