

Task 1: Market and energy reduction potential

Country report Switzerland

Title:

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IEA HP-DHC Task 1: Market and energy reduction potential

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1. Executive summary

The catastrophe at the nuclear power plant in Fukushima, Japan, in March 2011 had a huge impact on energy policy in Switzerland. In May 2011, the government decided not to allow the replacement of existing nuclear reactors and therefore to phase out gradually nuclear power at the end of the current plants' lifetime, while redefining the country's energy policy. This led to the elaboration of the Energy Strategy 2050, which has been approved by the population in May 2017. The goals of the Energy Strategy 2050 aim at massively increasing the use of renewable energy and thus decrease the greenhouse gas emissions. After the climate summit in Paris, a revision of the law on carbon dioxide emissions has been implemented. The carbon dioxide emissions have to be reduced by 50% until 2030 and by around 75% until 2050 compared to the level of 1990, when 53,7 Mt CO₂-equivalent were emitted per year. After 2050, the country should reach zero emissions.

Heat pumps are increasingly used in new buildings with floor heating systems, where low temperatures (~ 35 °C) are sufficient. Moreover, heat pumps are slowly being integrated into district heating systems, either centrally or decentrally [1].

Heat pumps can be integrated in district heating systems in different ways and for different purposes (see Report on task 3). Heat pumps have to deal with different heat sources at different temperature levels and have to be dimensioned based on the temperature lift (See Table 1). The possible roles of heat pumps in district heating systems are:

- Decarbonize the heat supply of district heating systems by substituting oil heaters with heat pump based district heating systems supplied by electricity from renewable energy sources.
- Increase the efficiency of the heat supply system, due to the better efficiency of heat pumps compared to existing oil, gas or wood burners.
- Increase the capacity of existing networks by using heat pumps to reduce the return flow temperature of networks and thus increase their capacity.

The heating demand for buildings in Switzerland is currently 85 TWh/a, 6 TWh/a of which are covered by district heating networks. By 2050, the overall heat demand has to be reduced from 85 TWh/a to 45 TWh/a according to the energy strategy 2050 by increasing efficiency (e. g. through insulation). At the same time, demand for district heating has been estimated to increase from 6 TWh/a to 17 TWh/a. This increase of 11 TWh/a in the district heating sector is expected to be covered mostly by heat pumps driven thermal networks, and to a smaller extent (1 TWh/a) by high-temperature networks operated on biomass. Assuming an increase of 10 TWh/a for low-temperature networks at 2000 full load hours per year results in a power of 5 GW to be provided. With an average power of about 50 kW per building (equivalent to approx. 10 residential units), an additional 100,000 buildings will be supplied with energy from thermal networks and heat pumps in 2050. This corresponds approximately twice the building stock of the City of Zurich.

Seasonal storage systems will play an increasingly important role in future to shift the surplus production of the summer (solar production) into the winter months.



2. The energy situation now and in the future.

2.1 Overview of the main challenges in the country

NUCLEAR PHASE-OUT

The accident at the nuclear power plant in Fukushima, Japan in March 2011 had a huge impact on energy policy in Switzerland. In May 2011, the government decided to prohibit replacement of existing nuclear reactors and therefore to gradually phase out nuclear power at the end of the current plants' lifetime, while redefining the country's energy policy. Since nuclear energy provides 40% of Switzerland's electricity generation, the decision to phase it out is very significant. Although the notion of "operational lifetime" of nuclear power plants (NPPs) does not exist in Switzerland, the actual end of operation could occur in the period from 2019 to 2034, with the largest plants retiring towards the end of this period. It may take even longer, as according to the Swiss law, nuclear power plants may operate as long as they "meet the safety criteria". [2]

Phasing out nuclear power gradually provides more than two decades to plan the appropriate policies and measures and for attracting investments. It is also important to note that the phase-out decision was guided by the highly probable rejection of new nuclear plants in foreseeable referendums; in a country of strong direct democracy, the possibility of a further referendum on nuclear energy cannot be ruled out. [2]

ENERGY STRATEGY 2050

Following the phase-out decision, the government adopted an energy strategy for 2050, which aims at substantially reducing final energy demand while keeping electricity use constant. Reaching these strategic goals will likely require great effort, especially as Switzerland's population and economy are expected to grow further. Electricity demand may actually increase in several sectors in the next decades, for example because of potential widespread penetration of electricity-using technologies, such as heat pumps and electric vehicles. [2]

The medium-term policies and measures primarily focus on improving energy efficiency and increasing electricity generation from hydropower, but also from other renewable sources and, as a last resort, from natural gas. The government is currently working on combining long-term policy goals with programmes and policy milestones that keep pace with each nuclear power plant shut-down. In the absence of nuclear power, maintaining sufficient electricity capacity will require strong policies to promote energy efficiency and renewable energy. Such measures have already been outlined, but they will likely not be sufficient. New baseload capacity and imports are options on the supply side. For baseload generation, gas-fired power plants would be the simplest option. Treating their CO₂ emissions the same way as in the neighbouring countries, *i.e.* as part of an emissions trading scheme, would give a strong positive incentive for investors. The building park follows the goals of the SIA technical specification 2040, which complies with the goals of the 2000-W-Society concept and aims at reducing the heating demand and use more local renewable energy. [2]



2.2 Energy demand in the country

PRIMARY ENERGY CONSUMPTION

In 2015, Switzerland's total primary energy supply (TPES) was about 24.5 million tonnes of oil equivalent (Mtoe), reflecting a more or less stable consumption over the last two decades (Figure 1).

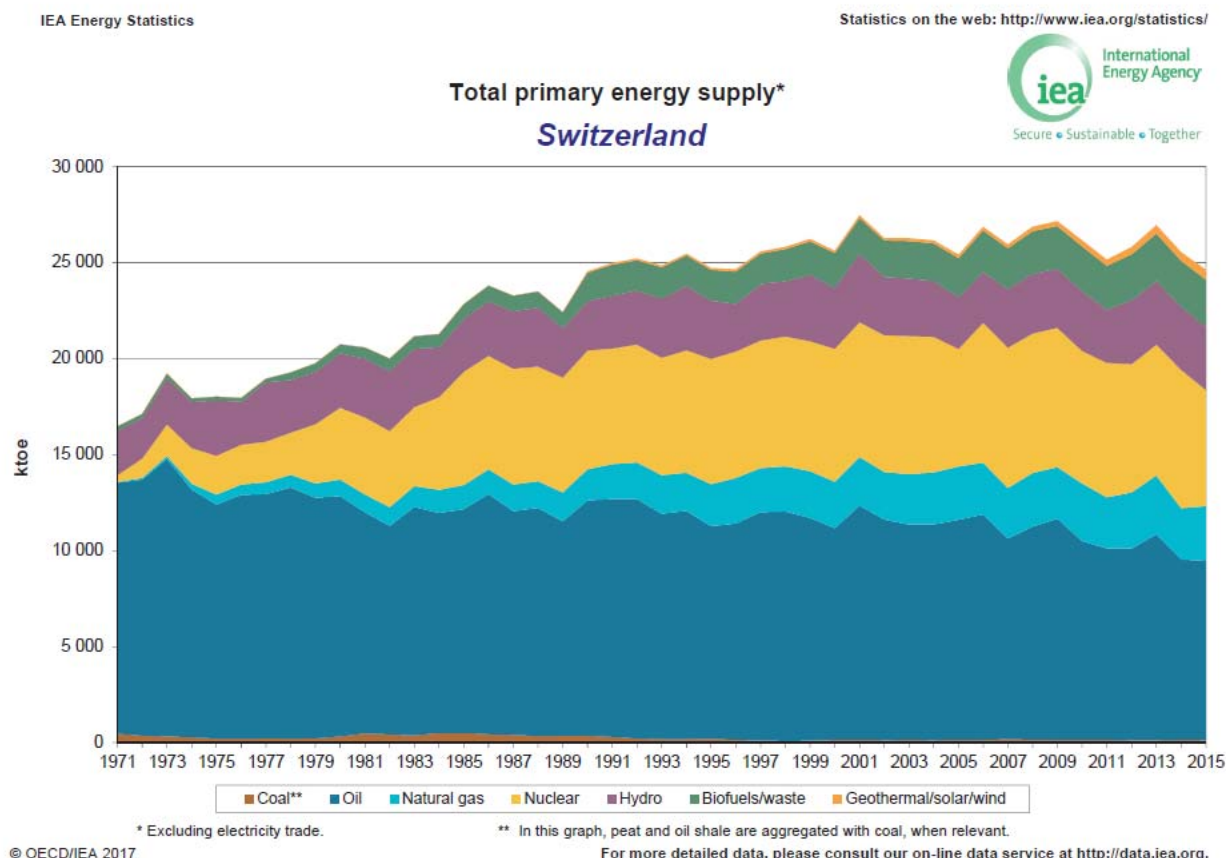


FIGURE 1: EVOLUTION OF THE TOTAL PRIMARY ENERGY SUPPLY MEASURED IN OIL EQUIVALENTS IN SWITZERLAND FROM 1972 UNTIL 2014. [3]

Fossil fuels account for 53% (13.5 Mtoe) of TPES. Switzerland ranks third lowest among the International Energy Agency (IEA) countries in the level of fossil fuels in the energy mix: The IEA average share of fossil fuel in TPES is 80% [12]. Switzerland has a significant share of oil (40 %) in TPES, but very low shares of natural gas (12%) and coal (less than 1%) compared to IEA averages of oil (35%), gas (25%) and coal (20%). Nuclear power, with 26% of TPES in 2010, also makes a large contribution to Switzerland's energy mix, the third-largest share among IEA countries after France and Sweden. Renewable energy sources account for 22% (5.8 Mtoe) of TPES in 2010, mainly hydro (12%) and biofuels (9%). Other renewable sources, such as solar and wind energy, have a much smaller share. Over the last two decades, the energy supply from the three largest energy sources, oil, nuclear and hydro, has slightly decreased. Most of the growth in energy supply was from increases in natural gas, biomass, waste and geothermal energy (extracted by borehole heat exchangers with heat pumps). The country's self-sufficiency, measured as the share of domestic energy production in TPES, was 48%, similar to Finland and France. [2]

FINAL ENERGY CONSUMPTION

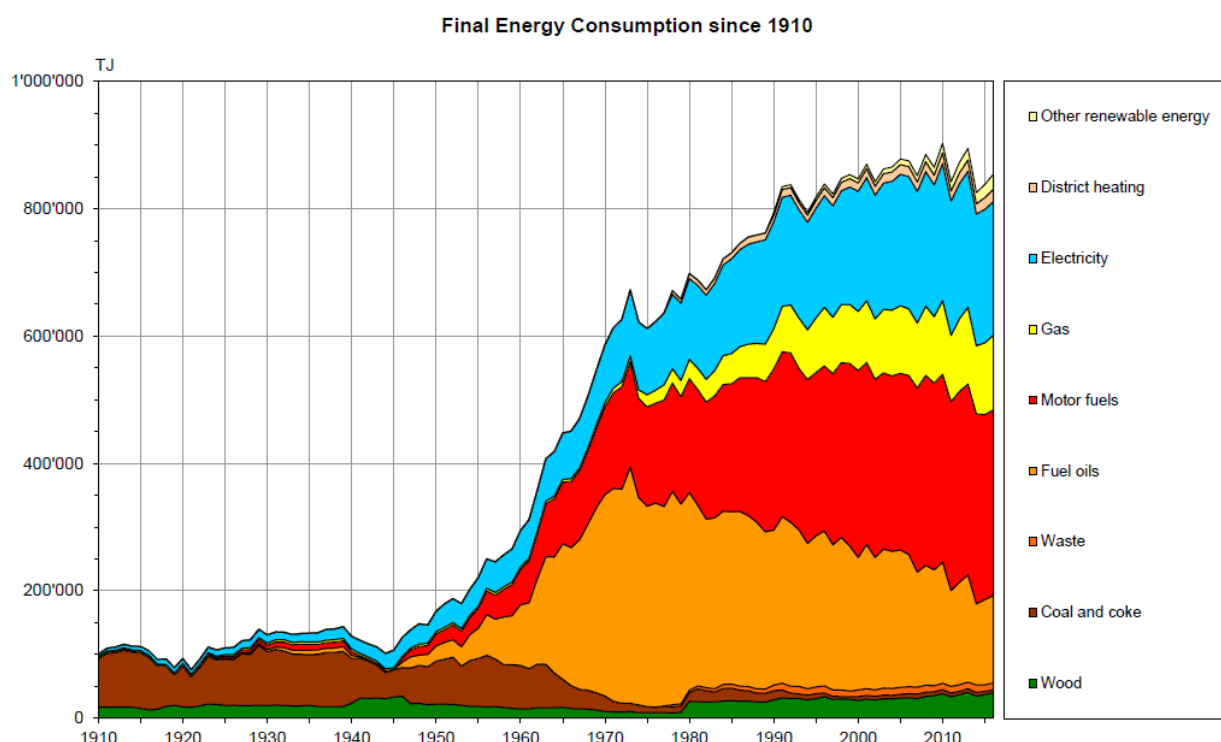


FIGURE 2: FINAL ENERGY CONSUMPTION (IN TERAJOULE) IN SWITZERLAND SINCE 1910. [4]

Since 1950, final energy consumption in Switzerland has increased fivefold. Mineral oil is used for energy production in form of domestic fuel oil or motor oil. While the share of domestic fuel oils has fallen from 31% to 15% since 1990, the share of motor fuels has increased from 32% to 36%. With the decline of domestic fuel oil, natural gas and electricity have gradually gained in importance. Hydropower accounts for around 13% of final energy consumption. Overall, renewable energies account for 21.4% of final energy consumption, compared with 15.8% in 1990.

In total, about 850'000 TJ of final energy are consumed annually; 28% of it is used for households, 18% for industry, 17% for services and 36% for mobility. [5]

Approximately 81% of the final energy consumed in households, 15% in industrial buildings and 60% in the service sector, is used to cover space heating and domestic hot water demands [6]. Over all sectors, around 36% (roughly 85 TWh/a) of the total final energy consumption of the building park is used to cover the demand for space heating and domestic hot water.

2.3 Housing stock characteristics

TYPE OF BUILDINGS

In Switzerland, the housing stock is well documented for residential buildings according to the data of the Swiss Federal Office of Statistics [7], whereas data for non-residential buildings are scarcely documented. According to a study from IP Bau of the 1990's, the share of non-residential to residential buildings is about 50%. The number of residential buildings is roughly 1.7 million, most of them being single family and multiple family houses. The highest share of residential buildings was built in the early 20th century, before 1919, with nearly 20% of the total residential building stock. This share represents mostly the historical buildings of the city centres with other uses like commercial activities. At the same time, they represent also the buildings with a high specific energy demand and a high share of fossil fuels to cover space heating and domestic hot water demand (See Figure 3 and 4).

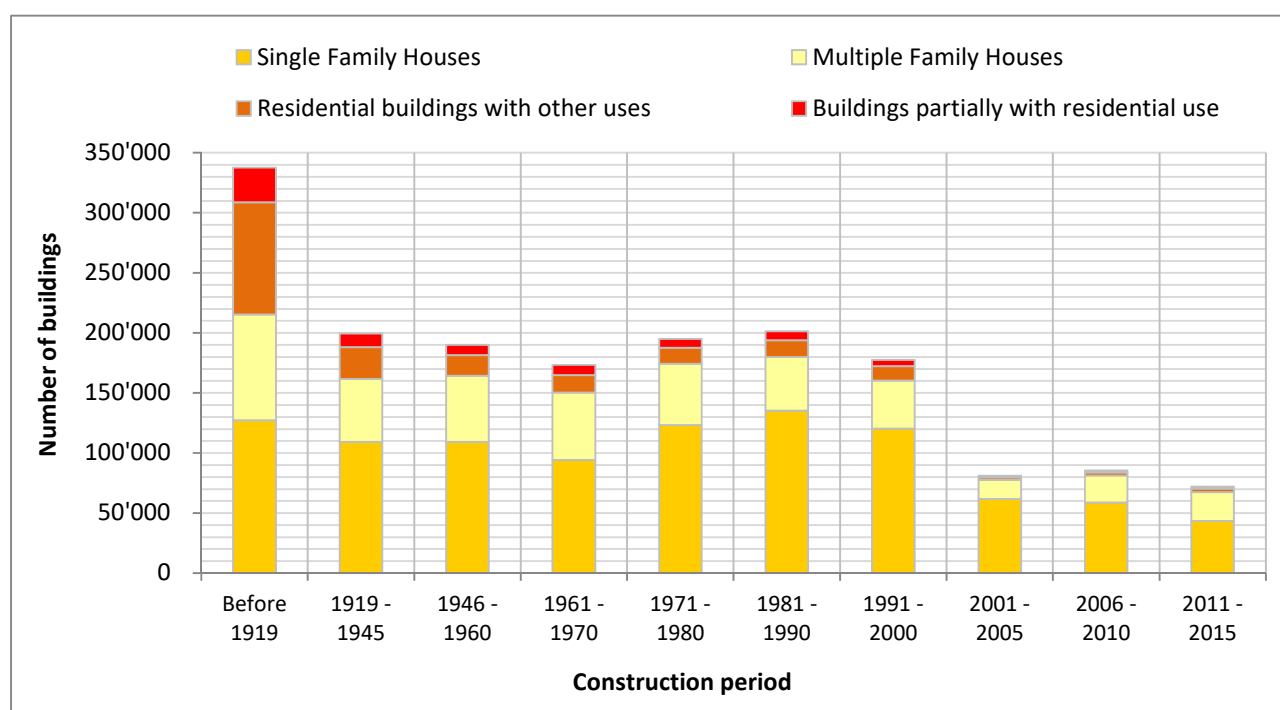
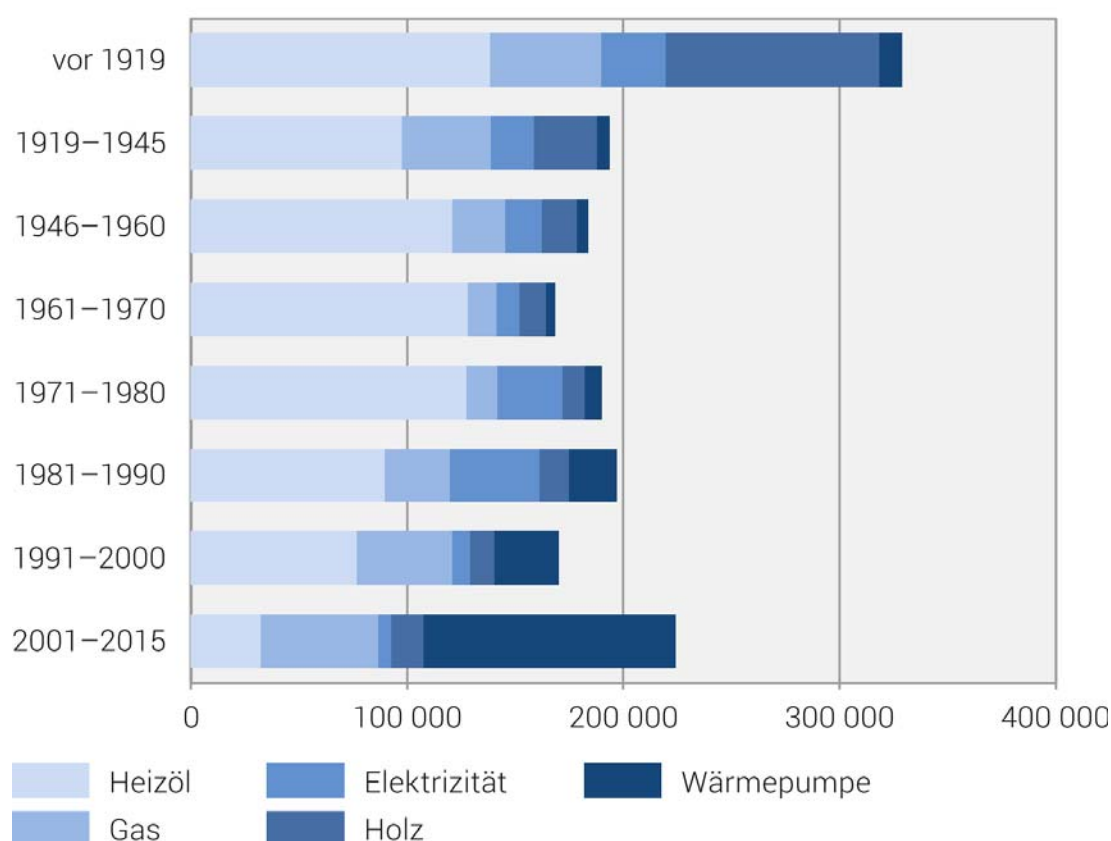


FIGURE 3: NUMBER OF RESIDENTIAL BUILDINGS (SINGLE FAMILY HOUSES, MULTIPLE FAMILY HOUSES, RESIDENTIAL BUILDINGS WITH OTHER USE, BUILDINGS PARTIALLY WITH RESIDENTIAL USE) ACCORDING TO THE CONSTRUCTION PERIOD. DATA FROM [7], OWN REPRESENTATION.

ENERGY CARRIERS

Figure 4 shows the energy carriers for heating purposes of the residential buildings according to the building period. Most of the buildings built before the year 2000 are heated with oil, gas or directly with electricity. A high share of buildings built before 1919 have wood as energy carrier, meaning that a biomass fueled district heating system has been put into operation. Most of the buildings built after the year 2000 have a heat pump as a heating system.





Quelle: BFS – Gebäude- und Wohnungsstatistik

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FIGURE 4: ENERGY CARRIERS FOR HEATING PURPOSES OF THE RESIDENTIAL BUILDINGS ACCORDING TO THE BUILDING PERIOD. [7]

ENERGY DEMAND

The average energy consumption for supplying space heating and domestic hot water of the total 1.7 million buildings in Switzerland is about 160 kWh/m²a [8]. The buildings built before 1975 have the highest energy consumption of about 200 kWh/m²a, corresponding to 20 Litres of oil equivalent. These buildings show also the largest energy saving potential. The lower consumption of the buildings built before 1919 is due to the fact that historical buildings are attached to each other and thus have less thermal losses through the envelope. The goal is to reach values of about 30 to 50 kWh/m²a for a sustainable retrofit of the building park, as for example the Minergie® standard foresees for new constructions.

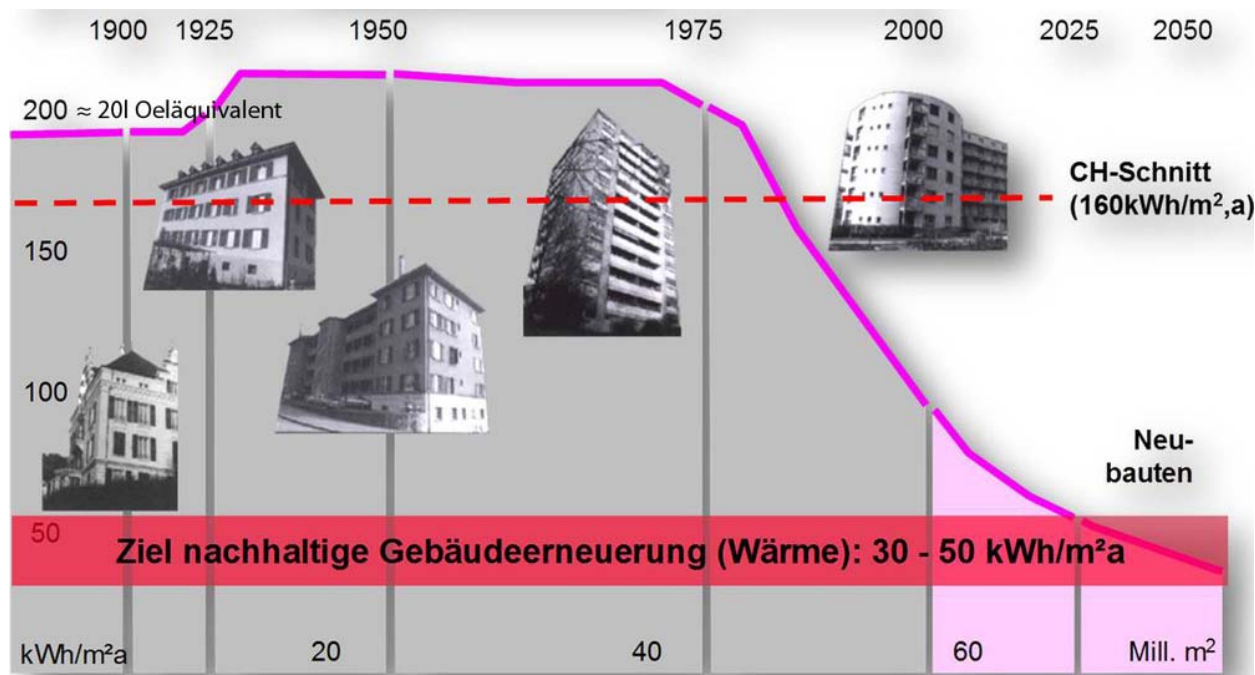


FIGURE 5: ENERGY CONSUMPTION DURING VARIOUS THE CONSTRUCTION PERIOD. [8]

FINAL ENERGY DEMAND

Projections of the energy demand of the Swiss building parks have been made according to a bottom-up model [9]. Assumptions for the surface increase, the retrofit rates, the U-Values of the envelope and the efficiency of new? technologies have been made to predict the final energy demand in 2050. Two scenarios were calculated, a reference scenario and an "efficiency" scenario. If we assume, that the Swiss politics follows the efficiency path, then the final energy demand will decrease by about 20% (Figure 6).

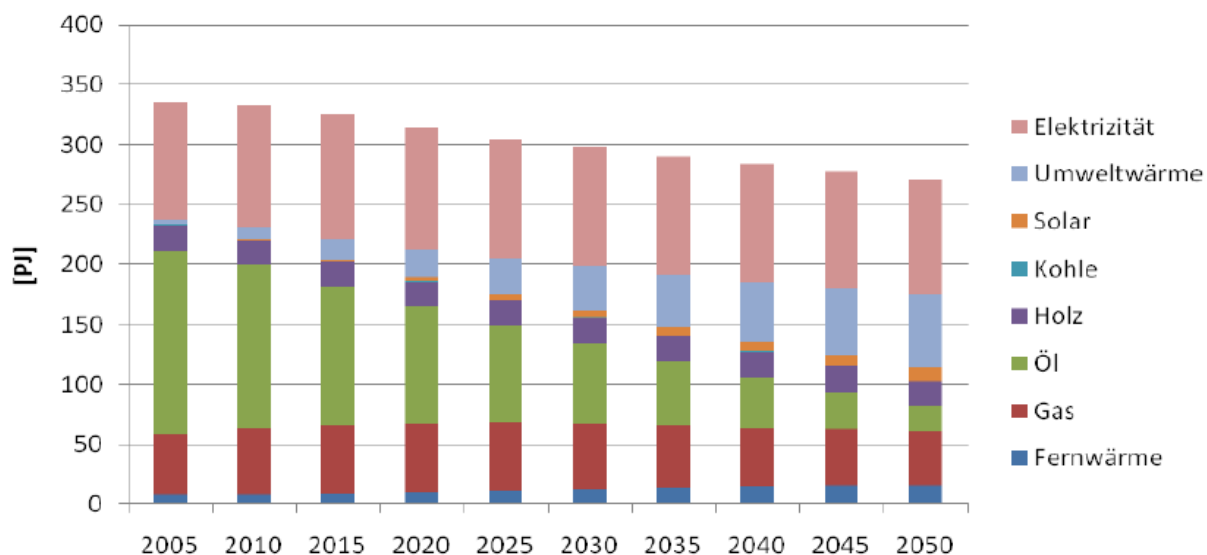
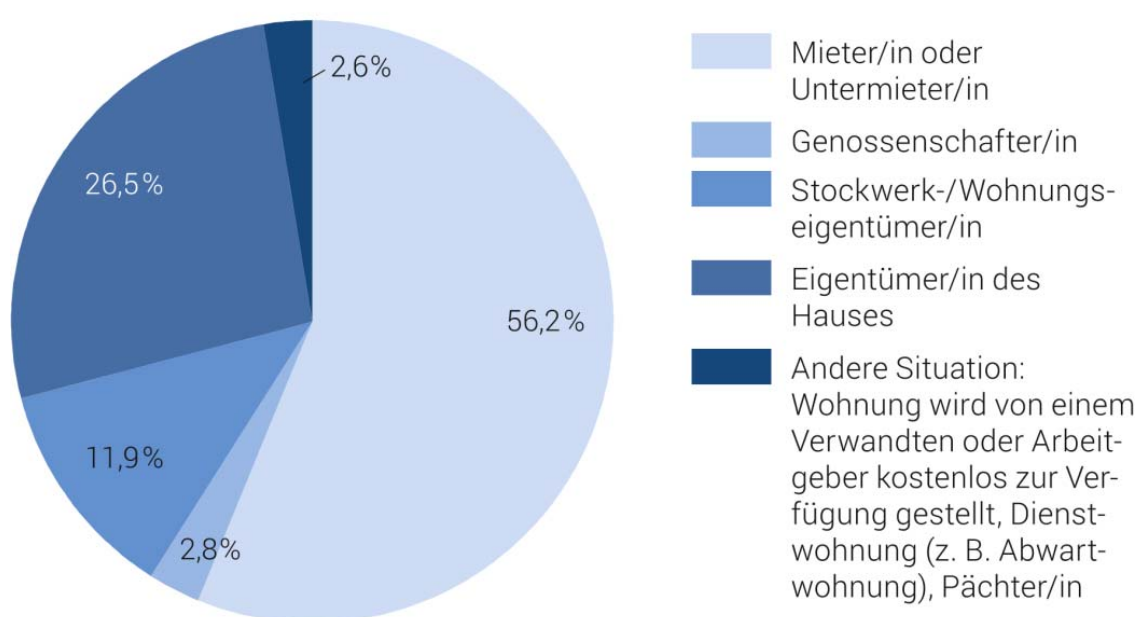


FIGURE 6: FINAL ENERGY DEMAND OF THE BUILDING PARK FOR AN EFFICIENT SCENARIO. [9]

In the energy mix oil consumption will significantly decrease. District heating and solar energy will slightly increase, whereas wood and gas remain rather constant. In this study, district heating systems are defined as large district heating plants (waste incineration) and do not take into account small district heating systems, which leads to a biased projection of the potential of district heating systems (see Chapter 3). The share of ambient heat will increase three times from the value projected in 2020 until 2050, which leads to the conclusion that more heat pumps will be used for heating purposes. Heat pumps will partly substitute oil heating systems and electrical heating systems, which explains why the electricity consumption will stabilize to a constant level of about 100 PJ/a. Heat pumps have a higher efficiency than electrical heatings.

TYPE AND OWNERSHIP

Figure 7 shows the type and ownership of the residential buildings in Switzerland for the year 2017.



Quellen: BFS – Strukturerhebung (SE), GWS

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FIGURE 7: TYPE AND OWNERSHIP OF THE RESIDENTIAL BUILDINGS. [7]

More than half of the population (56.2%) in Switzerland lives in rented apartments, whereas 38.0% of the population is owner, either of an apartment (11.9%) or a house (26.5%). A small share of the population lives in so-called "Genossenschaften", building cooperatives. The basic principles of a cooperative are self-help, self-administration and self-responsibility. The cooperative consists of its members and is a democratic form of enterprise. A cooperative is especially well suited for the implementation of a district heating systems, since usually there is a centralized administration and decisions are made for the whole neighborhood.

2.4 Energy Infrastructure in the country

2.4.1 District Heating/Cooling Networks

According to the last statistically recorded data based on a survey carried out in 1978, about 18,300 TJ/a heat is provided by district heating systems, which accounts for a share of 6 % [10] of the total heating supply. These data only comprise the large networks such as waste incineration plants. Smaller grids supplied with oil, gas, wood and other renewable energies are not included in the statistics, and therefore, the actual importance of the district heating is significantly larger. Compared to other countries in Europe, this share is small though. With the increase of local resources, this share is likely to increase in the future.

2.4.2 Electrical and Gas grid

THE SWISS ELECTRICITY GRID

Figure 8 illustrates the Swiss electricity grid.

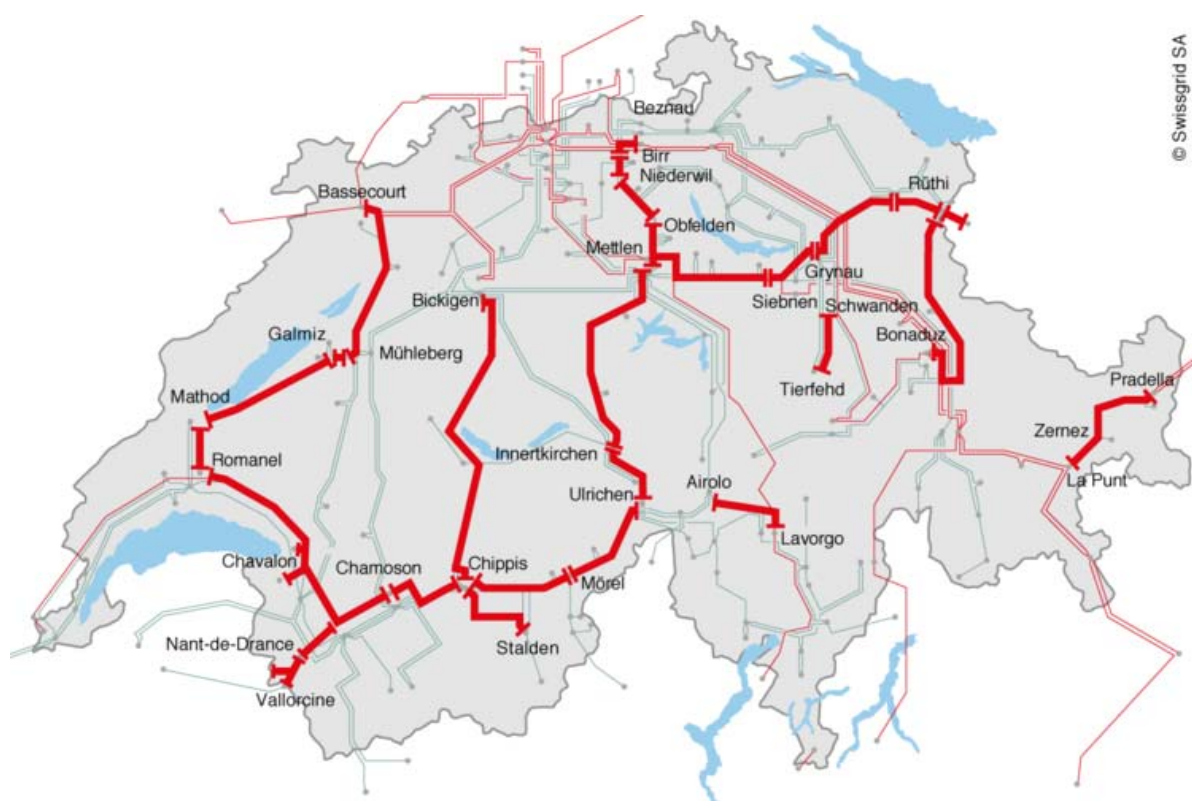


FIGURE 8 OVERVIEW OF THE SWISS ELECTRICITY GRID. [11]

The entire Swiss electricity grid comprises over 250,000 kilometers of lines and consists of a transmission and a distribution grid. On its way to consumers, electrical voltage is reduced

incrementally from 380,000 volts (380 kV) or 220,000 volts (220 kV) of extra-high voltage in the transmission grid to 400/230 V in households and businesses.

The Swiss electricity grid is divided into seven grid levels. Apart from the extra-high, high, medium and low-voltage power grid, there are also three transformation levels.

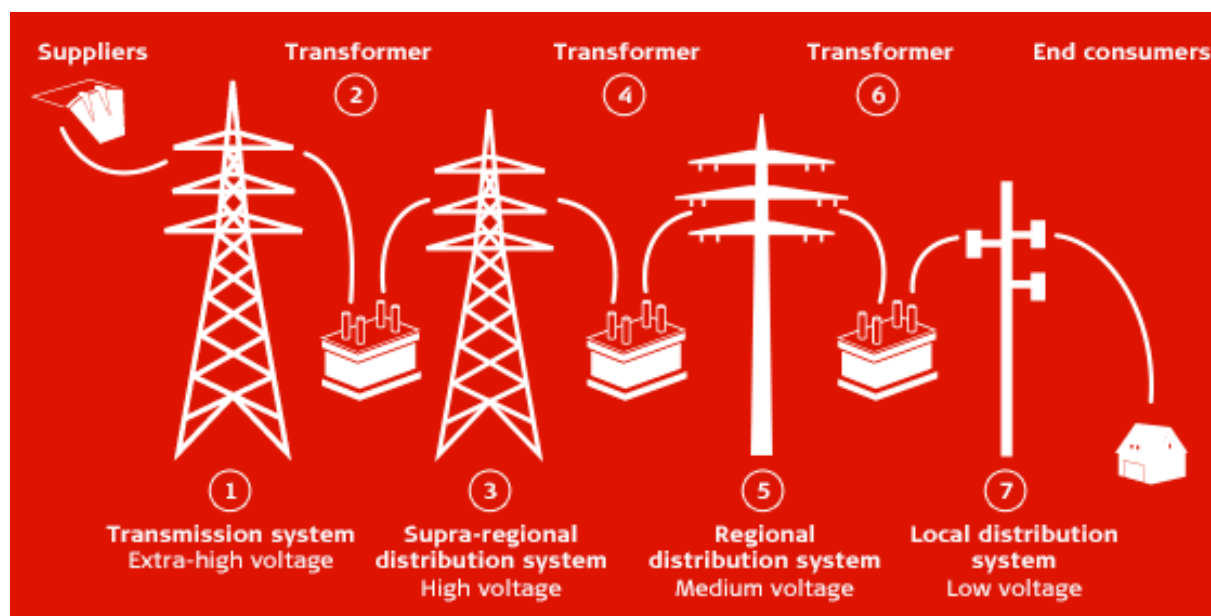


FIGURE 9: GRID LEVELS OF THE SWISS ELECTRICITY GRID. [11]

Extra-high voltage in the transmission system (level 1)

The transmission grid absorbs the electricity produced by the big power plants or in neighboring countries. The electricity is transported at a voltage of 380 kV or 220 kV to the vicinity of the consumer. There, it is fed into lower grid levels, the distribution grids. The Swiss transmission grid is the property of “Swissgrid”, the national network company, which is mainly owned by different electricity producers and has a public mandate.

High voltage in the supra-regional distribution system (level 3)

In the high voltage level (36 kV to 150 kV) electricity is distributed for supra-regional supply to cantonal, regional and municipal distribution grid operators and to major industrial plants.

Medium voltage in the regional distribution system (level 5)

Medium voltage (1 kV to 36 kV) is used for the regional distribution of electricity. Local distribution grids supply individual suburbs or villages and small and medium-sized industrial enterprises.

Low voltage in the local distribution system (level 7)

The electricity arrives as low voltage (< 1 kV) in homes and agricultural and commercial businesses.

Substations

The substation connects two voltage levels. The core of a substation is the transformer, which converts the voltage from one voltage level to another: from extra-high voltage to high voltage and from high voltage to medium voltage.

Transformer stations

Medium voltage is converted to the low voltages of 400 V required in homes and businesses in the transformer station.

THE SWISS GAS GRID

Swissgas, the Swiss joint-stock company for natural gas with headquarters in Zurich, is a natural gas trading and transport company. The company was founded in 1971 and began natural gas procurement in 1974. It procures and transports natural gas on a non-profit basis on behalf of the four Swiss regional gas distribution companies Erdgas Ostschweiz, Gasverbund Mittelland, Gaznat and Erdgas Zentralschweiz, and is entirely owned by these four regional companies as well as the Association of the Swiss Gas Industry (Figure 10). [13]

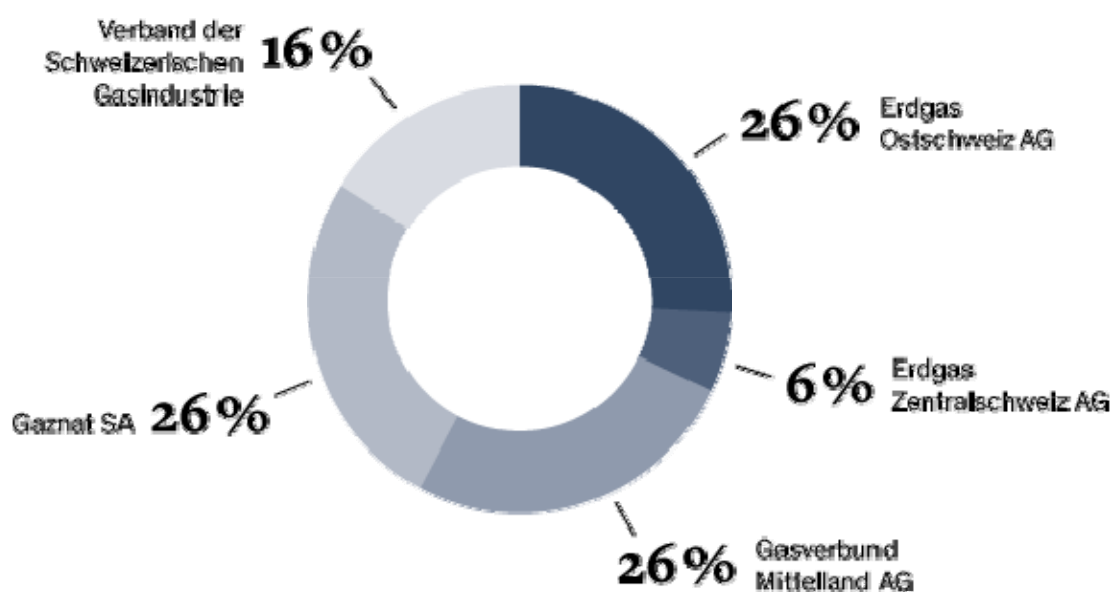


FIGURE 10: DISTRIBUTION SHARE OF THE GAS COMPANIES IN SWITZERLAND. [14]

Swissgas operates its own 258-kilometre-long high-pressure pipeline network in Switzerland (See Figure 11). It is also involved in the transit pipeline through the country and holds transport rights abroad. In 2007, the company procured around 24,300 GWh of natural gas and generated sales of CHF 1.136 billion.

Map of Swissgas grid

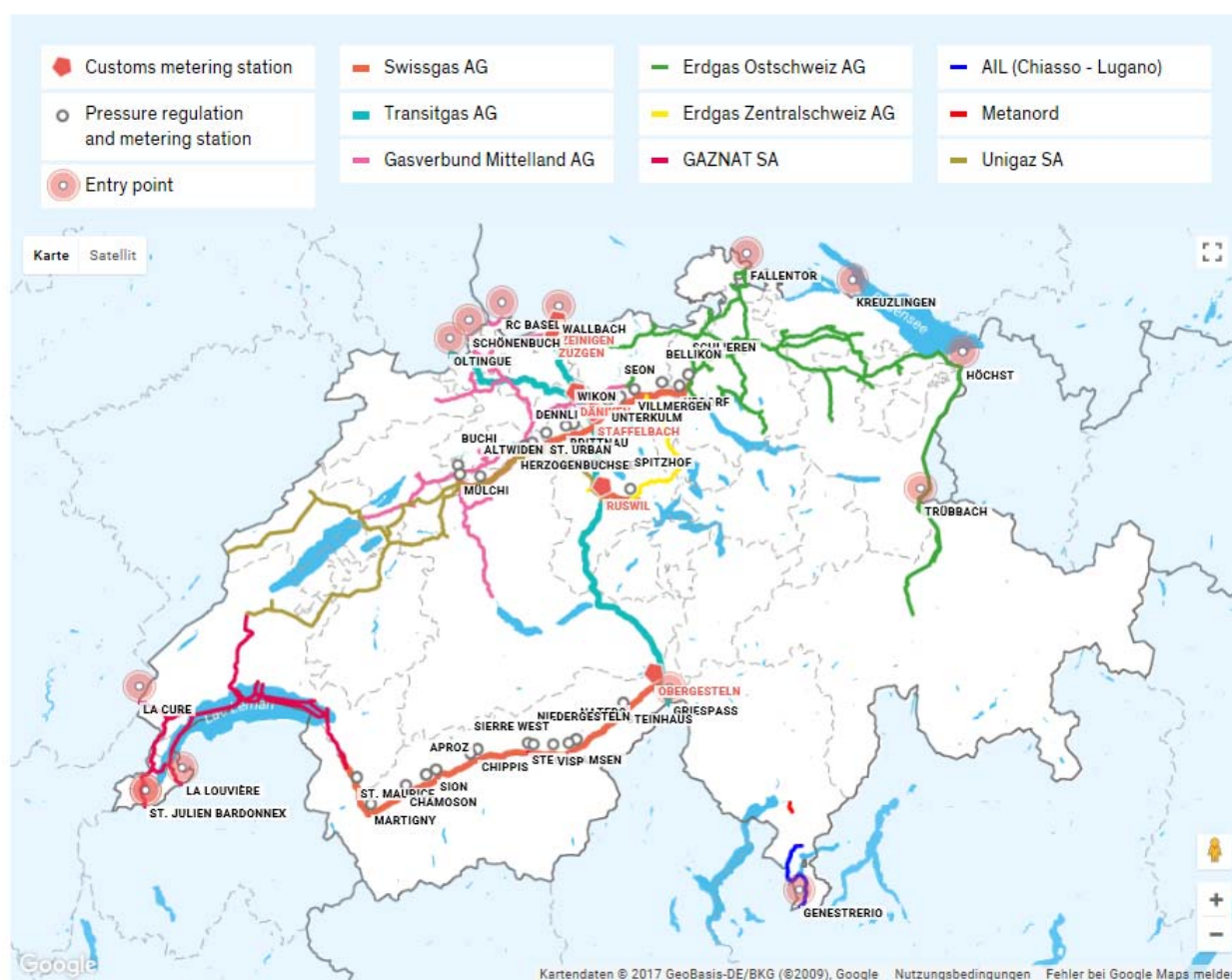


FIGURE 11 MAP OF GAS DISTRIBUTION NETWORK IN SWITZERLAND. [15]

WASTE HEAT RECOVERY FROM THE GAS GRID

The compression station of Transitgas AG is in visual contact with the Wolhusen Tropical House. This plant pumps natural gas from the North Sea to Italy in a pipeline that crosses Switzerland. In Ruswil, the pressure of the gas is increased by additional compressors to ensure the flow over the Alps. Waste heat is released from the compression process. The tropical house in Wolhusen¹ uses this waste heat for heating up its greenhouses, and the cantonal hospital in Wolhusen is heated by the same district heating system. [13]

¹ www.tropenhaus-wolhusen.ch/deu/abwaermenutzung_29974.shtml



FIGURE 12: TROPICAL HOUSE WOHLHUSEN IN THE FRONT AND WASTE HEAT USE FROM THE PRESSURIZED GAS STATION IN THE BACKGROUND. [14]

2.5 Swiss Energy Policy

INSTITUTIONS

Energy policy is a split responsibility between the federal state and the twenty-six cantons. Federal energy policy making has been strengthened in recent years (in matters such as product requirements and labels, traffic regulations etc.), mainly by means of the 1998 Energy Law and its subsequent amendments. Other domains such as buildings are in the responsibility of the cantons and are to some extent consented to harmonised regulations. [2]

The **Department of the Environment, Transport, Energy and Communications (DETEC)** is the leading ministry in charge of Switzerland's energy policy, both in its formulation and implementation. The concentration of the energy and environmental portfolios under one single ministry is intentional to strengthen sustainability concerns in energy policy making. Within DETEC, the **Swiss Federal Office of Energy (SFOE)** is responsible for the management of the energy policy. [2]

The **Federal Council** (federal government) is the collective executive body. It comprises representatives from five political parties. The six Departments (ministries) other than DETEC are in close exchange, particularly if an energy policy proposal affects their remit. This is mostly the case for the Department of Economic Affairs, the Department of Finance (for fiscal issues), the Federal Office for Agriculture (for biofuels), the Federal Office of the Environment (FOEN), the Federal Office for Transport and the Federal Office for Spatial Development (the last three under DETEC). The Federal Council therefore adopts draft laws collectively before being submitted to parliament. The cantons are consulted during the federal energy policy and law making processes. As a result, there is a diversity of cantonal policies and measures. [2]

2.6 Energy prices, Tariffs and structure

ENERGY PRICE

The main energy carriers used for heating purposes in Switzerland are gas, electricity, oil and wood (Figure 13).

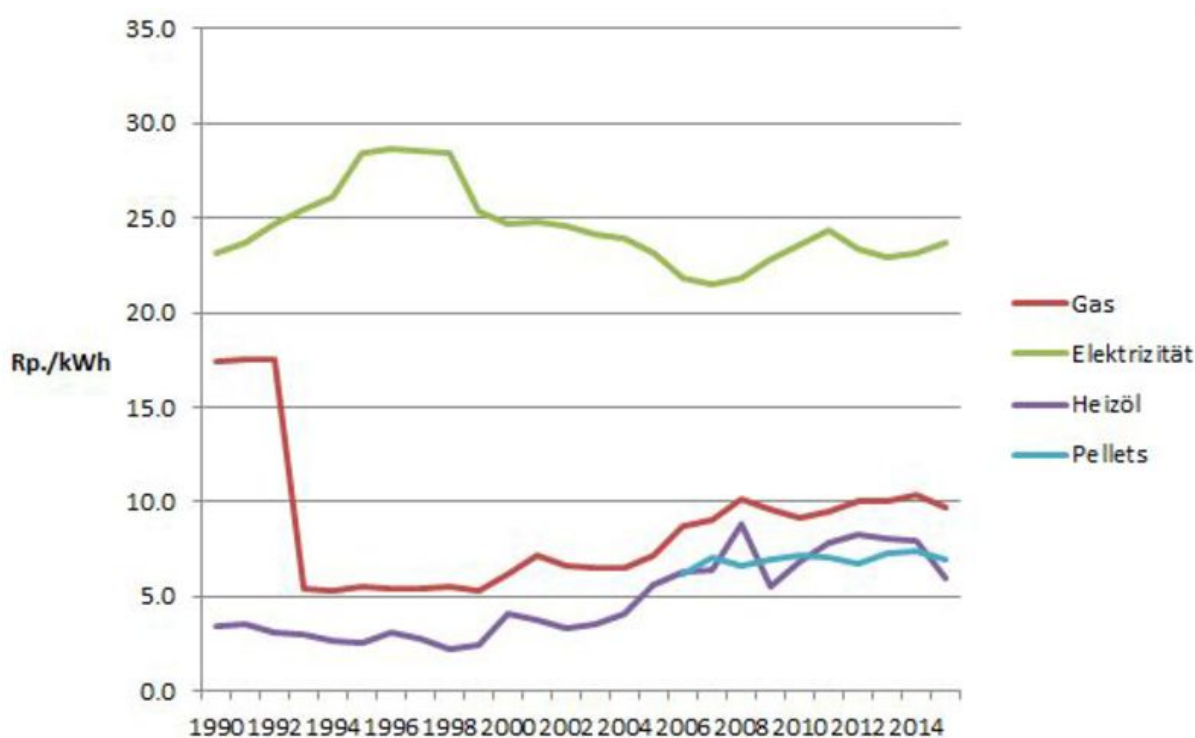


FIGURE 13: EVOLUTION OF THE ENERGY PRICES OF GAS (RED), ELECTRICITY (GREEN), OIL (LILA) AND PELLETS (BLUE). [16]

The gas price has dropped down from 17 cts/kWh to 6 cts/kWh between 1990 to 1995 and has stabilized at 10 cts./kWh nowadays. The oil price is presently rather low and makes profitable investments in renewable technologies difficult. The electricity price in Switzerland has remained more or less constant over the last decades and is between 20 and 25 cts/kWh. Wood is, at present, very competitive with gas and oil and is considered as a CO₂-neutral energy source and alternative to fossil fuels, since the Swiss forests are currently underexploited by a factor of roughly two.

TARIFF AND STRUCTURE

A study was carried out [17] on the structure and prices of Switzerland's largest district heating suppliers. The analysis has shown that the tariff structures are quite different. The tariff models often consist of three components: the service price is based on the infrastructure required for the supply of district heating and is charged annually. The service price is usually linked to the national consumer price index. The energy price is used to compensate the amount of energy purchased. Finally, the connection fee, which is used to finance the connection costs, is charged once. The price of energy is in some cases linked to a competitive energy source such as heating oil and in some cases linked to the national consumer price index. [17]

3. Market potential for district heating/cooling

3.1 Potential for district heating and cooling

The graph underneath shows the heat density map of Switzerland in MJ/m². The potential for district heating starts at around 200 MJ/m² (= 500 MWh/ha), so from the yellow pixels.

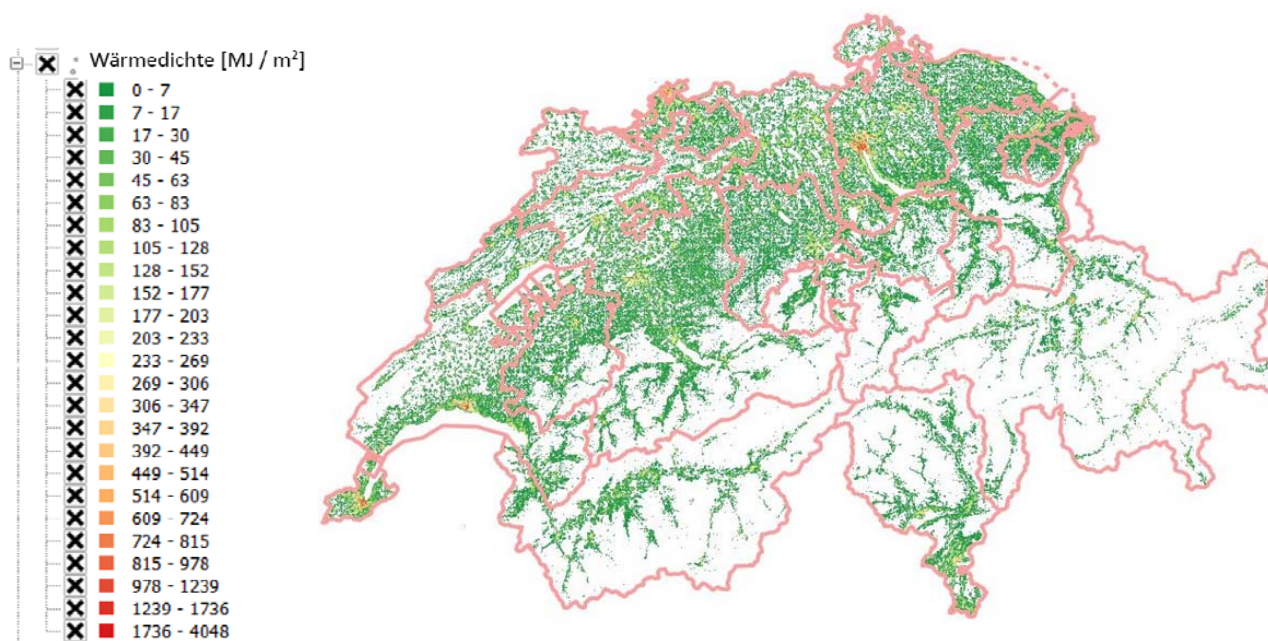


FIGURE 14: HEAT DENSITY MAP OF SWITZERLAND [18]

It can be seen, that the potential for district heating in Switzerland is concentrated in the big cities like Zurich, Geneva, Basel or Lausanne. Although the district heating potential is geographically small, it represents a high share of the overall heating demand.

The heating demand of the building park in Switzerland is about 85 TWh. According to assumptions underlying the energy strategy 2050, space heating and domestic hot water demand will decrease to about 45 TWh by 2050, due to retrofit measures of the buildings. (Figure 15)

Entwicklung Komfortwärmebedarf Schweiz 2010 - 2050

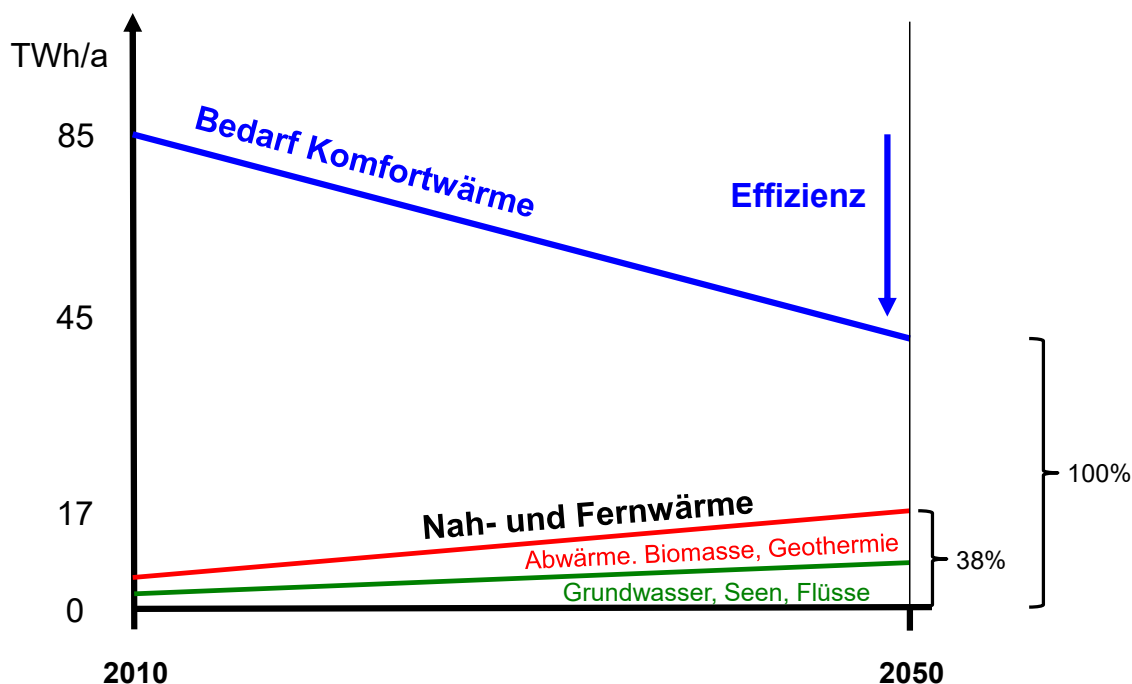


FIGURE 15: DEVELOPMENT OF DOMESTIC HEAT DEMAND IN SWITZERLAND BETWEEN 2010 AND 2050 AND THE POTENTIAL OF COVERAGE THROUGH THERMAL NETWORKS. [19]

Out of these 45 TWh, a potential of 17.3 TWh/a for district heating networks has been assessed, which means that 38% of space heating demand and domestic hot water could be covered by thermal networks in 2050. These numbers have been well-documented in the White Book of district heating systems (Weissbuch Fernwärme)[20].

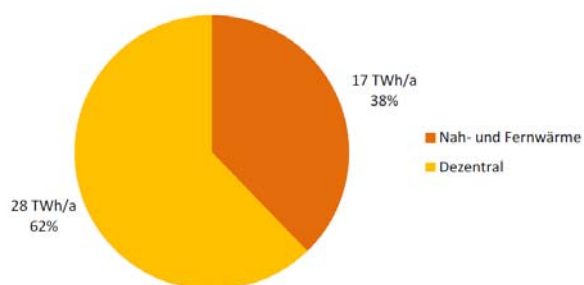


Bild 10 Möglicher Anteil Nah- und Fernwärme in der Schweiz 2050.

Wärmequelle	Wärmpotential [TWh/a]	Zugeordnet [TWh/a]
KVA	5.7	3.6
Direkte AWN Industrie	3.6	Nicht zugeordnet
Grundwasser	12.2	1.9
ARA	7.7	1.9
Seen	97.0	5.1
Flüsse	21.3	1.8
Holz	20.5	1.7
Geothermie	70.0	1.3
Total	238.0	17.3

Tabelle 11 Wärmepotential und resultierende Zuordnung.

FIGURE 16: POSSIBLE SHARE OF DISTRICT HEATING BASED SUPPLY VS. DECENTRALIZED SUPPLY (LEFT) AND ALLOCATED ENERGY POTENTIAL OF THE DIFFERENT RENEWABLE ENERGY CARRIERS (RIGHT). [20]

The potential for district cooling is often linked with the potential of district heating and is not well defined yet [21]. There are ideas to extend the existing GIS-Tool from the VFS and implement the cooling demand [22], but this has not yet been implemented.

3.2 Description of energy and CO₂ reduction potential

After the climate summit in Paris, a revision of the law on greenhouse gas emissions has been implemented. The greenhouse gas emissions have to be reduced by 50% until 2030 and around 75% in 2050 compared to the level of 1990, when 53,7 Mt CO₂ were emitted. After 2050, the country should reach zero emissions. [22] A new wide spread national research program has been implemented, comprising the foundation of 7 SCCERs (Swiss Competence Centers for Energy Research).. The vision of the Swiss Competence Center for Energy Research on Future Energy Efficient Buildings & Districts (SCCER FEEB&D) is to develop solutions for the Swiss building stock. The SCCER FEEB&D is addressing this challenge in a combined effort by leading Swiss and international partners from academia, industry and the public sector. Within the program, the goal is to decrease greenhouse gas emissions by a factor of three by the year 2035. The research program is divided into four work packages. Work package one deals with the energy efficiency of buildings, so reducing the energy consumption of buildings by using better insulating materials. Work package 2 addresses the substitution of fossil fuels with renewable energies, thus reducing the carbon footprint. District heating systems with heat pumps are addressed in WP 3 dealing with urban decentralized energy systems. WP 4 deals with the market diffusion and implementation of technologies. The goal of WP 1, 2 and 3 is to reduce the GHG emissions per square meter. This quantity is calculated by multiplying the x and y axis of the NSE diagram (Figure 17). The red lines in Figure 17 indicate constant CO₂ emissions per square meter. Green arrows indicate a reduction of CO₂ emissions per square meter, which can be either achieved by reducing CO₂ emissions per kWh consumed or by increasing the efficiency, thus reducing the kWh needed per square meter. District heating systems with heat pumps belong to WP3 and lead both to a reduction in final energy demand (higher efficiency of the heat pumps compared to conventional heaters) and a reduction in greenhouse gas emissions (decarbonization of existing district heating systems by substituting the energy carrier).

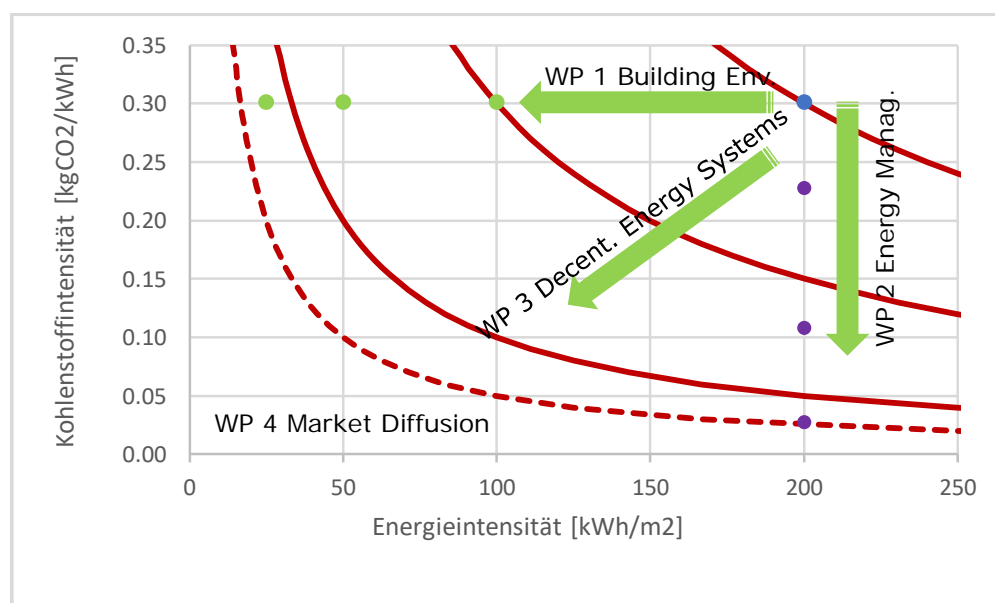


FIGURE 17: NSE-DIAGRAMM WITH THE REPRESENTATION OF THE WORK PACKAGES WITHIN THE RESEARCH PROGRAM SCCER-FEEBD AND THE CO₂-TARGETS.

4. Role of Heat Pumps in district heating/cooling

Heat pumps can be integrated in district heating systems in different ways and for different purposes (see Report on task 3). Heat pumps have to deal with different heat sources at different temperature levels and are dimensioned based on the temperature lift (See Table 1).

TABLE 1: DIFFERENT APPLICATION POSSIBILITIES OF HEAT PUMPS IN DISTRICT HEATING SYSTEMS. (OWN GRAPH)

Source	Role of heat pumps in district heating	Temperature lift
Ambient heat 4 – 7 °C (Lake water)	Temperature lift of primary network	2 – 8 K
Waste heat > 20°C (Data center)	Providing space heating for new buildings (35 °C)	5 – 15 K
Waste heat > 20°C (Data center)	Providing domestic hot water 60 °C	40 K
Waste heat > 35°C (Industrial waste)	Providing heat at 50 °C	5 – 15 K
District heating system	Reducing return temperatures of DHS	5 – 25 K
District heating system	Increase temperature difference flow/return of DHS	5 – 30 K

The main role of heat pumps in district heating systems is:

- To decarbonize the heat supply system

Throughout the use of electricity and hopefully an electricity mix going towards more renewable energy sources from photovoltaics, heat pumps in district heating systems will help decarbonized the energy system.

- Increase efficiency of the heat supply system

Heat pumps have a better efficiency than existing oil, gas or wood burners.

- Increase the capacity of existing networks

Heat pumps can reduce the return flow temperature of networks and thus increase their capacity.



4.1 When is it economically beneficial to implement heat pumps in district heating/cooling?

The question is very difficult to answer since few economic analyses have been performed on heat pumps in district heating systems. Basically, heat pumps are economically beneficial, if the annual costs of the systems are lower than the costs of a competitive system with energy carriers like oil, gas or wood. Heat pumps are most competitive when they supply space heating to new buildings, with low energy consumption and low space heating temperatures required (35 °C). Coefficients of performance can reach up to 6.2 for space heating (35 °C) with a source temperature of 10 °C. [10] Bivalent heating systems considering heat pumps as a base load and fossil fuel to cover the peak load has shown to be the most profitable systems, since about 85 % of the energy demand can be covered at high efficiency rates with 50 % of the installed heating capacity. The fossil fuel covers the remaining 15 % energy with 50 % of the installed heating capacity. The heat pump works in a constant range of delta T and is more efficient.

4.2 An overview of the market potential for heat pumps in district heating/cooling systems

According to Figure 15, the heating demand for buildings in Switzerland is currently 85 TWh/a, of which 6 TWh/a are covered by district heating networks. By 2050, the overall heat requirement has to be reduced from 85 TWh/a to 45 TWh/a according to the energy strategy 2050 by increasing efficiency (e. g. through insulation). At the same time, demand for district heating is estimated to increase from 6 TWh/a to 17 TWh/a. This increase of 11 TWh/a in the district heating sector is expected to be covered for the major part (estimated at 10 TWh/a) by heat pumps and thermal networks, and to a lesser extent (1 TWh/a) by high-temperature networks operated by biomass. An increase of 10 TWh/a for low-temperature networks at 2000 full load hours per year results in a power of 5 GW to be provided. With an average power of about 50 kW per building (equivalent to approx. 10 residential units), an additional 100,000 buildings will be supplied with energy from thermal networks and heat pumps in 2050. This corresponds approximately twice to the building stock of the City of Zurich.

5. Description of thermal storage options

Depending on the application and boundary conditions, different storage options can be used. Four types of storage tanks have been developed for seasonal heat storage in heating networks, each of which is operated in at least one pilot plant.

In tank thermal energy storages (TTES), water is used as a medium. In pit thermal energy storages (PTES), waster, a mixture of water and gravel or a mixture of water and earth serves as storage medium. Borehole thermal energy storages (BTES) and aquifer thermal energy storages (ATES) directly use the underground as storage medium. The specific heat capacity is significantly higher when water is used compared to water mixtures or substrates (Figure 18).

In the heat storage tanks, which are operated directly with water, the dynamics are so distictive that they can be used both as short-term storage tanks for balancing the daily cycle and for seasonal fluctuations. When rock or gravel is used as the main heat storage medium, a separate, small water based "buffer storage facility" usually needs to be included in the design for short-term fluctuations. [24]

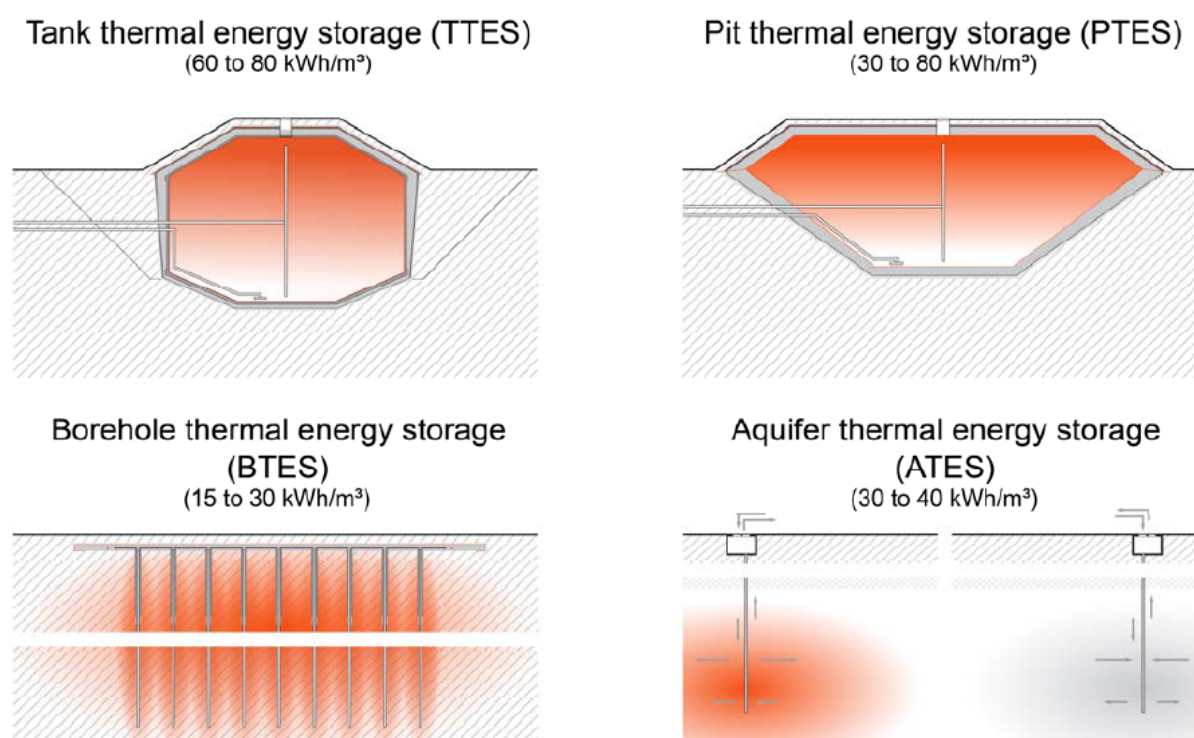


Figure 2: The four sensible seasonal thermal energy storage technologies (source: Solites)

FIGURE 18: SCHEMATIC ILLUSTRATION OF THE FOUR SEASONAL HEAT STORAGE TYPES [25]

In Switzerland, the BTES are the most used saisonal storage systems for building applications. They are often used in combination with low-temperatur networks providing heat during winter time and cooling in the summer, for example at the Suurstoffi-Areal in Rotkreuz. [26]

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