National report on the Swiss Energy regime

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by

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1. Introduction

1.1. Short history of the energy system in Switzerland

During industrialisation, coal was the main energy source in Switzerland. After the Second World War the fossil oil consumption increased significantly. Therewith the total energy consumption increased enormously (Fig. 1). In the 1970s transportation fuels became the most dominant energy source. Approximately at the same time the use of natural gas began. Today, the share of fossil energy sources amounts to about 60% (Fig. 2). Whereas the Swiss consumption of heating oil and coal is decreasing, the consumption of natural gas and transportation fuels is still increasing (Fig. 3).

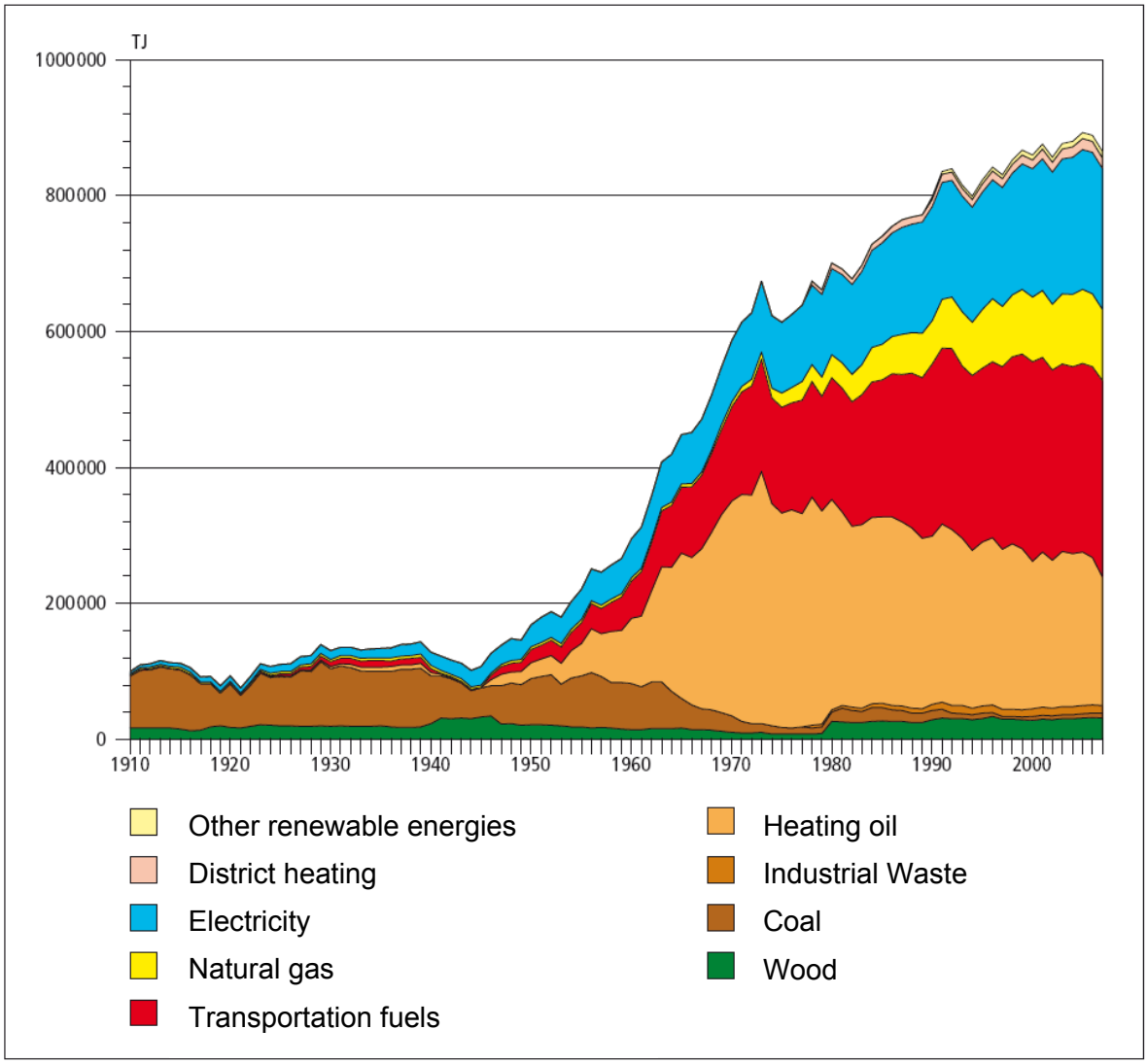

Fig. 1: End energy use 1910-2007 by energy sources **(Source: SFOE, 2008a)**

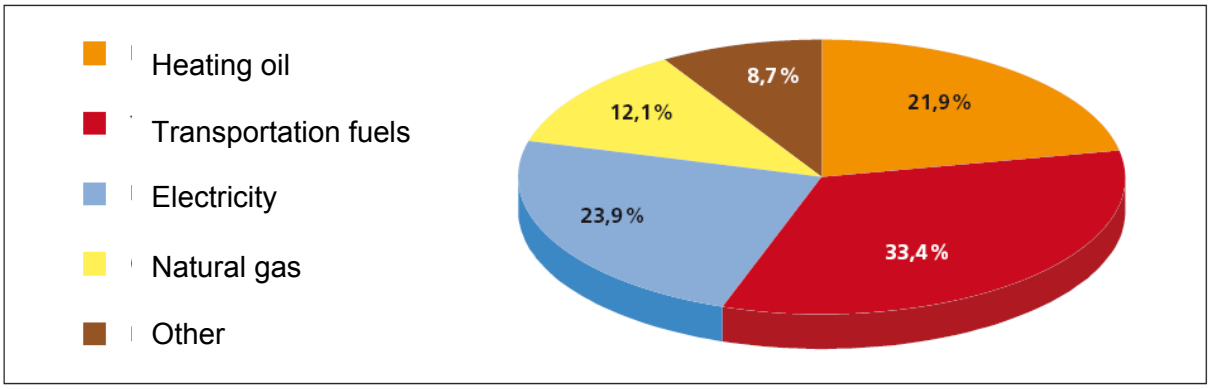

Fig. 2: Sharing of the end use by energy sources (2007) **(Source: SFOE, 2008a)**

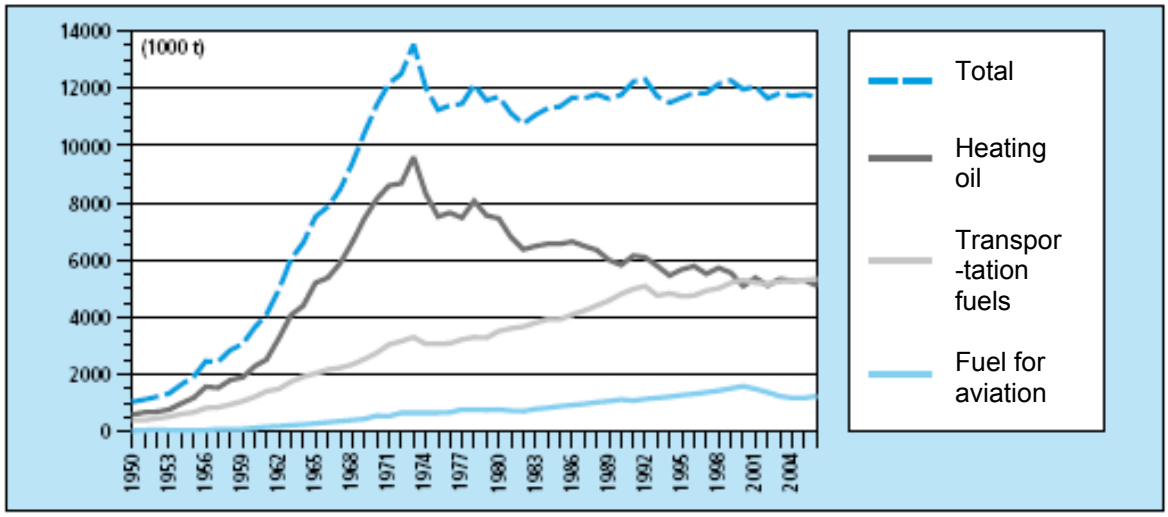

Fig. 3: Development of the use of fossil energy sources **(Adapted: BFS, 2008a)**

Regarding electricity production, Switzerland has good conditions for the utilisation of hydropower thanks to its topography and high levels of annual rainfall. Towards the end of the nineteenth century, hydropower underwent an initial period of expansion, and between 1945 and 1970 it experienced a boom during which numerous new power plants were built. At the beginning of the 1970s, hydropower still accounted for almost 90% of domestic electricity production, but this figure fell to around 60% by 1985 following the increase of electricity consumption and the introduction nuclear power, and is now around 57%.
As a result, Switzerland's most important source of renewable energy is hydropower. Today, the "new" renewables including solar, wood, biomass, wind, geothermal and ambient heat still play a minor role, but they are becoming more important. Renewables currently contribute around 16.9% towards Switzerland's energy production (including hydropower up to 10 MW) (Fig. 4). Renewable power production amounts at 11.32%. Regarding heat production, the biggest share (3.59%) comes from wood. Smaller contributions come from use of ambient heat (0.71%), district heating (0.50%), waste incineration plants (0.46%), biogas (0.18%) and solar energy (0.12%).

non renewable
energy

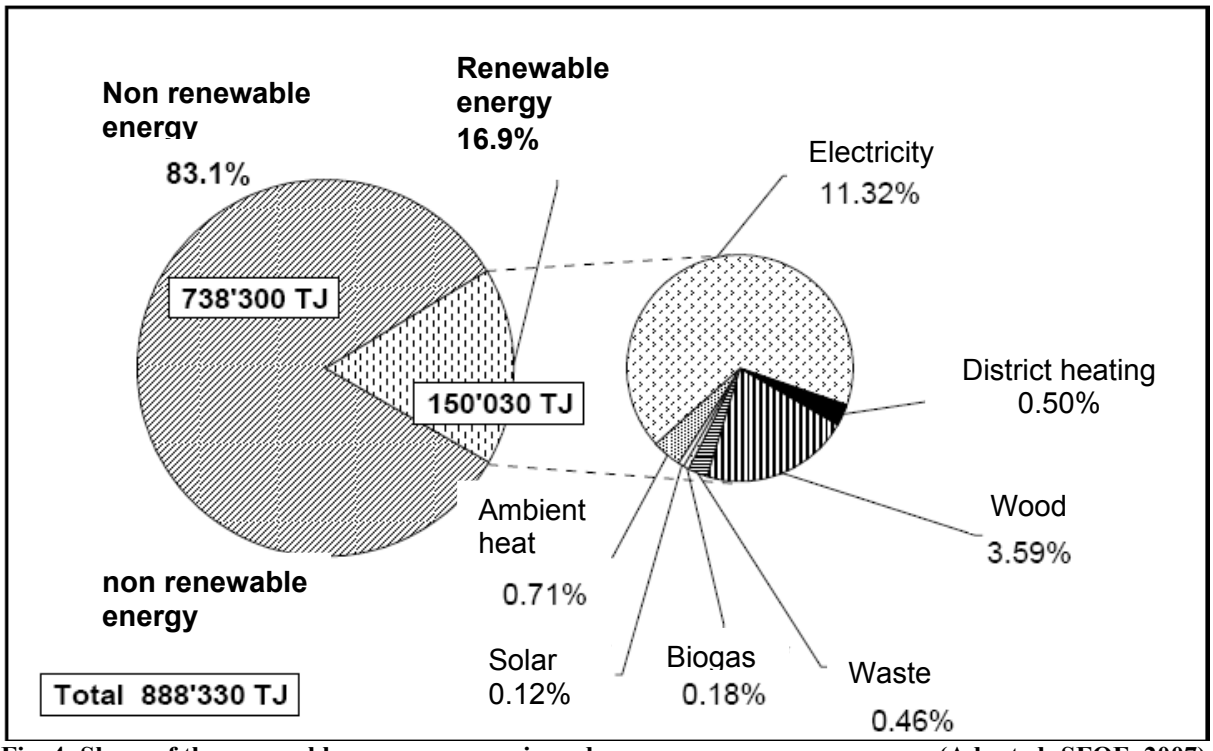

Fig. 4: Share of the renewable energy sources in end energy use **(Adapted: SFOE, 2007)**

In households, heating consumes with 72.1% by far the most energy (Fig. 5). Because of weather variations there are considerable annual differences. Energy used for hot water production comes second with 12.4%.

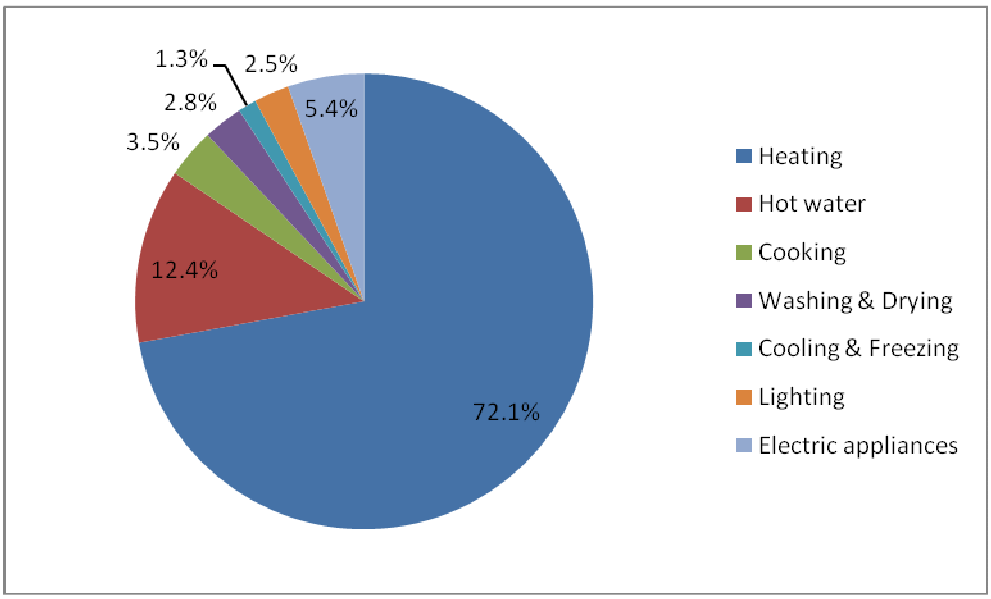

Fig. 5: Energy consumption of households following purpose (2006) **(Data source: SFOE, 2008b)**

The three main issues regarding the Swiss energy regime are:

1. High environmental pollution, especially greenhouse gas emissions, as most of the energy comes from fossil sources
2. High import dependence for oil, natural gas, uranium and coal
3. Controversial debate about renewal of existing nuclear power plants

1.2 Policies – overall targets and policies

The Energy Article (Article 89) in the Swiss Federal Constitution, the Energy Act, the CO_2 Act, the Nuclear Energy Act and the Electricity Supply Act are the main instruments of Swiss energy policy.
The **Energy Article** was added to the Swiss Federal Constitution only in 1990. Since then, all cantons have drawn up their own energy legislation and regulations. With the enactment of the **Energy Act** and the **Energy Ordinance** on 1 January 1999, the Federal Council fulfilled the mandate it had received following the approval of the Energy Article in 1990.
The **CO_2 Act** entered into effect on 1 May 2000. Its objective is to reduce the emission of climate-relevant carbon dioxide (CO_2) arising from the combustion of fossil oil by 10% versus the 1990 level by 2010. This means that the consumption of heating oil must be reduced by a total of 15% and of transportation fuels by 8%. The targeted reduction of CO_2 emissions is primarily to be achieved through voluntary measures by companies and private individuals. The relevant legislation provides that the federal government may introduce a steering tax on fossil fuels (CO_2 tax), if the voluntary measures fail to produce the desired effect. The CO_2 Act provides that high-consumption companies, large-scale consumers and consumer groups can be exempted from the CO_2 tax if they undertake to restrict their CO_2 emissions to a certain level and subsequently meet their declared target.
Because the voluntary measures have not led to a sufficient decrease of CO_2 emissions, a CO_2 tax for heating oil has been introduced in January 2008. Regarding transportation fuels, trade and industry have committed themselves to reducing 9 Mio tonnes of CO_2 over the period 2008-2012 by the "climate cent". As a consequence, all petrol and diesel imports are charged at a rate of 1.5 cents per litre. The revenue from the "climate cent" is to be invested in emission trading and climate protection projects in other countries, while another portion will be used for climate protection measures within Switzerland where at least 1 Mio tonnes CO_2 needs to be reduced. If the "climate cent" does not have the desired effect by 2012, the Federal Council has the option of introducing a CO_2 tax also on transportation fuels.
Currently the revision of the CO_2 Act for the time after 2012 is discussed. Thereby Switzerland is probably orientating oneself by the EU who decided to reduce greenhouse gases by at least 20% by 2020 (UVEK, 2008).
The revised **Electricity Supply Act** (in force since January 2008) regulates the bases for a reliable and sustainable electricity supply. It calls for an opening of the market in two stages: in the first 5 years, end-consumers with an annual consumption of more than 100 MWh have free access to the market. After 5 years, all end-consumers can freely choose their electricity supplier. The high-voltage transmission network (220/380 kV) is operated by the national transmission company "swissgrid".
With the revision, the Electricity Supply Act also contains a package of regulations governing the promotion of renewable energy and the introduction of measures to promote efficient electricity use. The most important measure concerns the cost-covering feed-in tariff for electricity from renewable energy sources (from 2009 on). The goal of this measure is to increase the proportion of electricity produced from renewable energy by 5.400 GWh, or 10% of the country's actual electricity consumption, by 2030.

In 2001 the Federal Council launched the **SwissEnergy programme** on the basis of the Energy Act and the CO_2 Act. This programme is the successor to Energy 2000 which was launched in 1990 following the acceptance of the Energy Article. SwissEnergy intends to contribute towards the realisation of Switzerland's energy and climate objectives, slow down the increase in energy consumption, promote the use of new renewable forms of energy and

lessen the degree of dependence on fuels by means of voluntary agreements with trade and industry, and with the aid of information campaigns.

Regarding international Energy policy, Switzerland signed the **Kyoto Protocol** and undertook therewith a commitment to reduce its emissions of greenhouse gases (especially CO_2). The Kyoto Protocol entered into effect on 6 February 2005. Switzerland's commitment would be met through the fulfilment of the CO_2 Act (cf. Fig. 6).

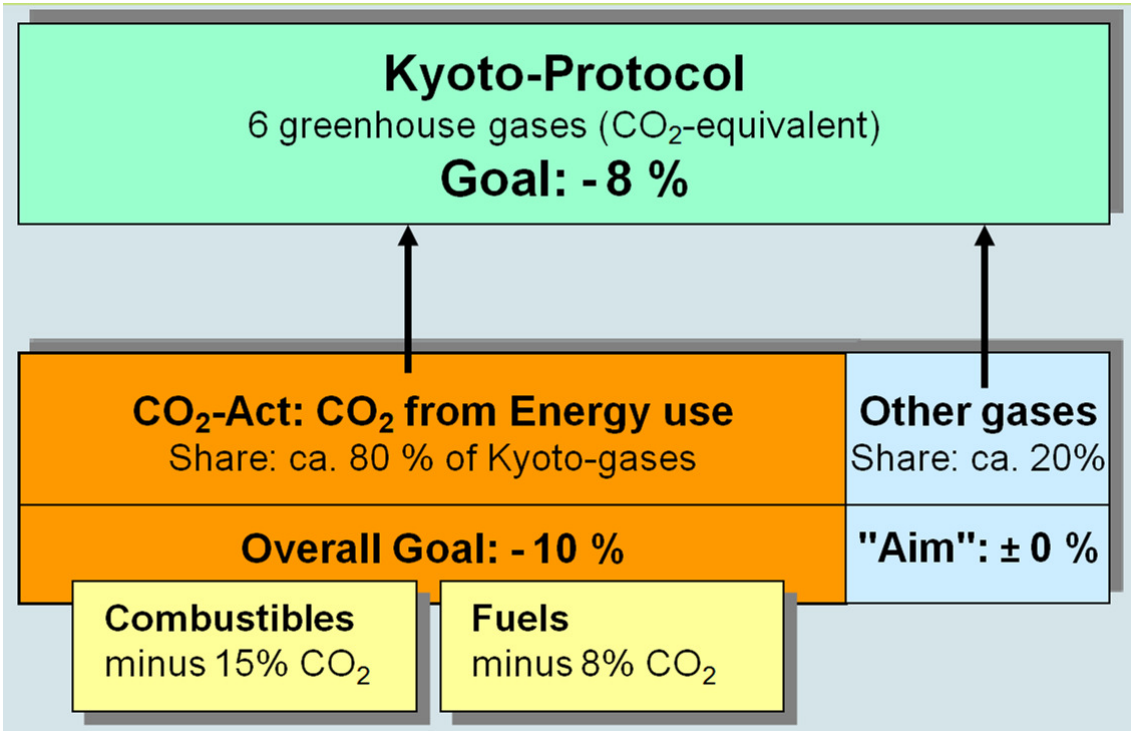

Fig. 6: Swiss instruments to fulfil the Kyoto-Protocol **(Adapted: Ruff, 2007)**

2. Energy for heating

The use of fossil combustible has decreased slightly in the last 5 years (cf Fig.3). A large part of the households is heated by heating oil (60.1%), followed by gas (18.4%) (Fig. 7). Central heating systems are dominating with 93.9% towards single-oven systems with 6.1%. The heated living space has been increasing since 2000 by 32.8 Mio. m^2, what corresponds to a mean yearly rate of 1.4%. The increase was strongest in gas heated space with 16.4 Mio. m^2 (+24.9%), followed by heating pumps with an increase of 9.6 Mio. m^2 (+67.2%) (SFOE, 2008b).

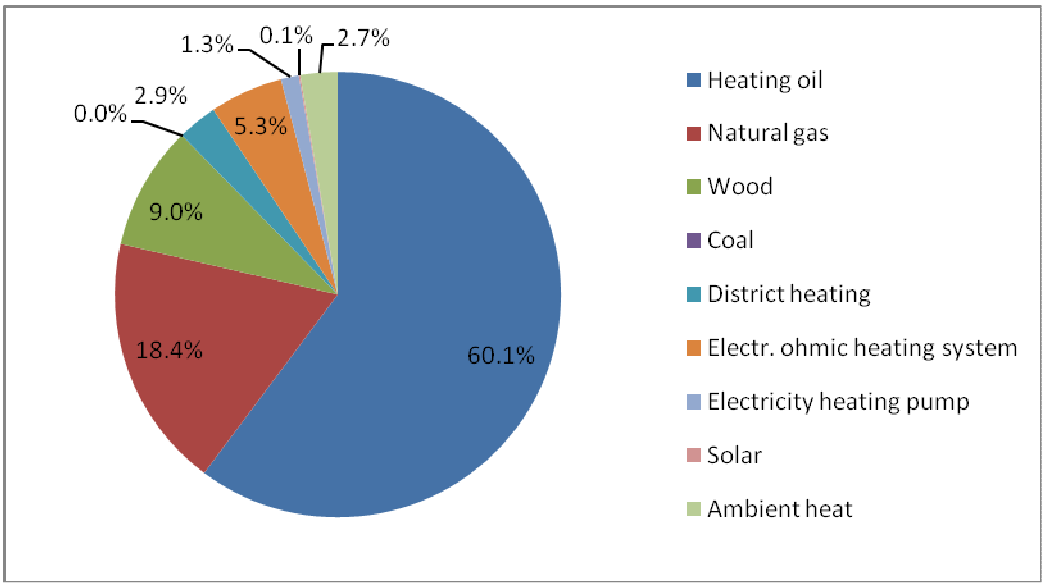

Fig. 7: Energy sources for heating of households (2006) (Data source: SFOE, 2008b)

For hot water production, in contrast to heating, electricity is besides heating oil and natural gas of high importance (Fig. 8). Thus, almost 30% of the population consumes hot water of electricity based systems (SFOE, 2008b).

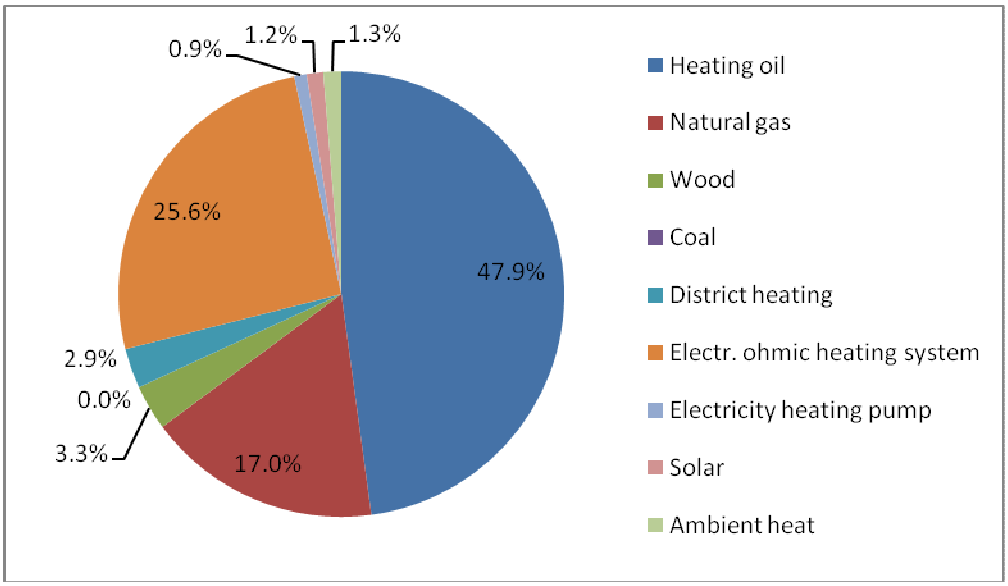

Fig. 8: Energy sources for hot water production of households (2006) (Data source: SFOE, 2008b)

The existing building stock (blue bars in Fig. 9) will also strongly influence the future energy use for heating and hot water of domestic buildings whereas future constructions (red bars in Fig. 9) will have a relatively small impact on total residential energy use (Jochem, 2004).

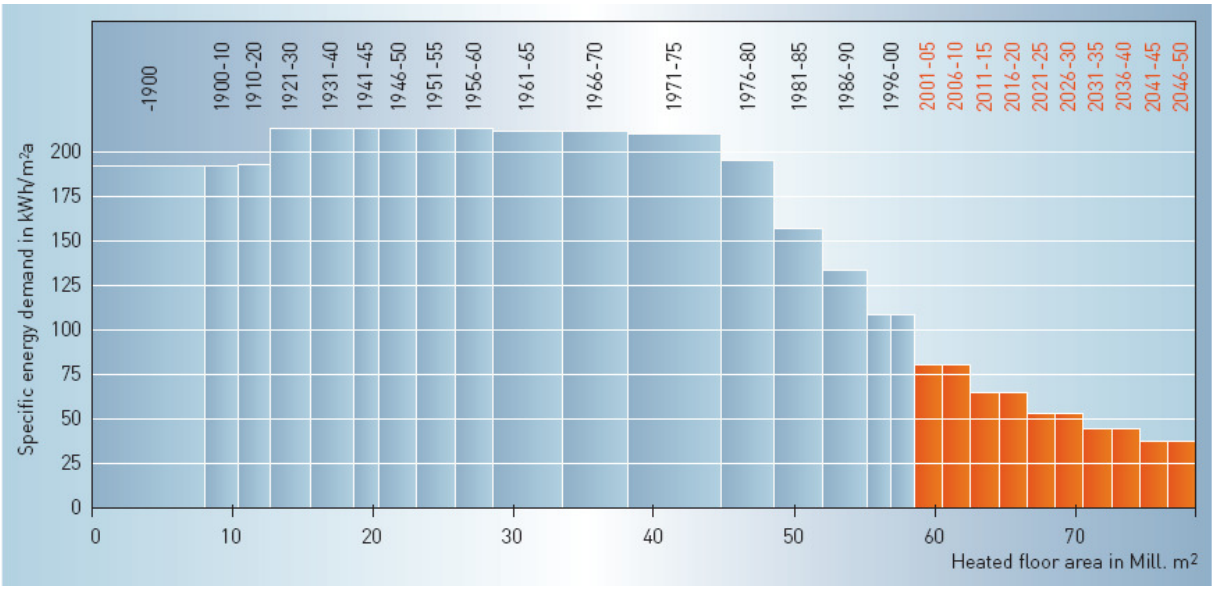

Fig. 9: Increase in heated floor area and development of specific energy demand for heating and hot water of domestic buildings by periods of construction, data from Canton Zurich

(Source: Jochem, 2004)

2.1. Policies to curb consumption/Increase production

One of the main objective of Swiss energy policy is to promote measures that reduce energy consumption in the building sector. Over the long term it would be possible to reduce the energy requirements of all residential and commercial buildings in Switzerland by 50-70% (SFOE, 2008d). To accomplish this, however, it would be necessary to consistently incorporate energy-efficiency aspects into both the construction of new buildings and the renovation of existing ones.

In Switzerland, building regulations are the responsiblitiy of the cantons. Since 2000, cantons have been harmoising their building regulations according to **MuKEn** (Model Cantonal Building Prescriptions). MuKEn describes the requirements for new buildings after which maximal 80% of the heat consumption for heating and warm water can be provided by non-renewable energies (Schwer and Kornmann-Wimmer 2007). The cantons have decided on this common strategy for energy efficiency in buildings with the following priority areas:

- The improvement of the energy properties of building shells (walls, floors, roofs, windows) is of highest priority for joint measures, along with the optimisation of installations and systems.
- The second priority is to increasingly sensitise users of buildings to energy-efficient behaviour.
- Thirdly, the utilisation of waste heat and renewable forms of energy is promoted to meet the remaining energy demand after the efficiency measures have been implemented.

The cantons and the federal state, together with the private sector, support a voluntary labelling system for high-efficiency buildings, namely the **Minergie** label. The Minergie label comprises the design and construction of buildings with low energy consumption and a high level of comfort (air-tight shell, excellent heat insulation, mechanical air-flow, efficient heat production). The label is applicable for new and renovated buildings and comes in several levels of standards (Minergie, Minergie-P, Minergie-Eco) (cf. Tab. 1 and Fig. 10).

	insulation	heat consumption	heating oil consumption
conventional new construction	10 cm	70 kWh/m^2	7 l/m^2
Minergie	20 cm	30 kWh/m^2	3 l/m^2
Minergie-P/ passive house	30 cm	10 kWh/m^2	1 l/m^2

Tab. 1: Comparison of construction norms **(Source: AUE, 2007)**

The Minergie standard for buildings requires that general energy consumption must not to be higher than 75 % and fossil-fuel consumption must not to be higher than 50 % of the average consumption of "normal" buildings. The Minergie-P standard defines building with very low energy consumption, it is especially demanding in regard to heating energy demand. This standard corresponds to the internationally-known passive house standard. Further, in the Minergie-P buildings the best conditions for low power consumption should be created, meaning energy efficiency lighting and appliances of energy class A (refrigerator A$^+$). The Minergie-Eco standard adds ecological requirements such as recyclability, indoor air quality, noise protection etc. to the regular Minergie requirements.
Actually, there are discussions on the cantonal level about making the limit value of heat consumption in new building as low as that of the Minergie standard. The only difference between new buildings and today's Minergie houses would then be the controlled aeration.

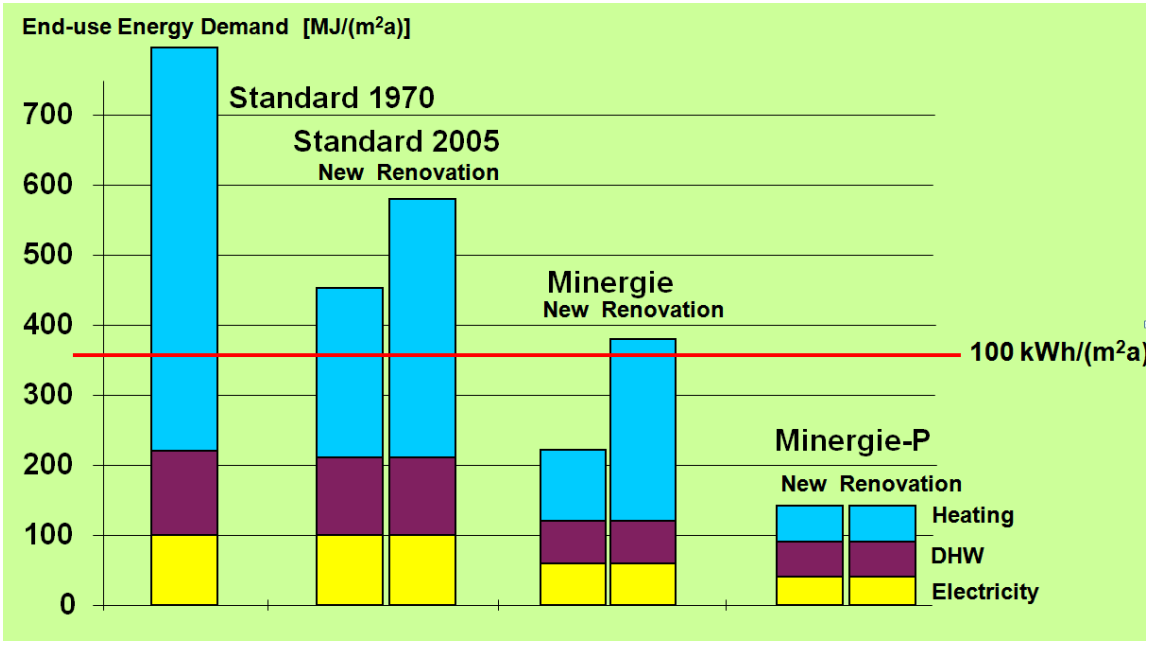

Fig. 10: Limit values for end-use energy demand for new residential buidlings and renovations **(Source: Minergie, 2008)**

bau-schlau (intelligent building) is a campaign of SwissEnergy to promote rational energy use in buildings. Developers and property owners can obtain information and useful hints on energy-efficient construction and renovation from cantonal energy offices and advisory centres, and at www.bau-schlau.ch.

3. Electricity

Switzerland's electricity market is to a great extent fragmented. The supply of electricity is secured by about 900 companies, including 7 generation and transmission companies and approximately 80 producers (SFOE, 2008d). Many plants are operated by municipalities and also supply water and natural gas. Partly, a single vertically-integrated company is responsible for the entire supply chain; partly supplies are secured by a variety of local distribution companies.
Cross-border electricity trading is of major importance for Switzerland, both economically and in terms of supply. Firstly, the trading is economically profitable because storage and pumped storage hydropower plants can sell expensive peak current to foreign countries. In pump storage plants, the water is pumped back to the storage during night, when power is very cheap. Secondly, in terms of supply, the trading is important to balance the electricity surplus in the summer and the shortcut during the winter season (Fig. 11). The surplus in summer results of the melting snow and glacier water as well as the lower power demand.

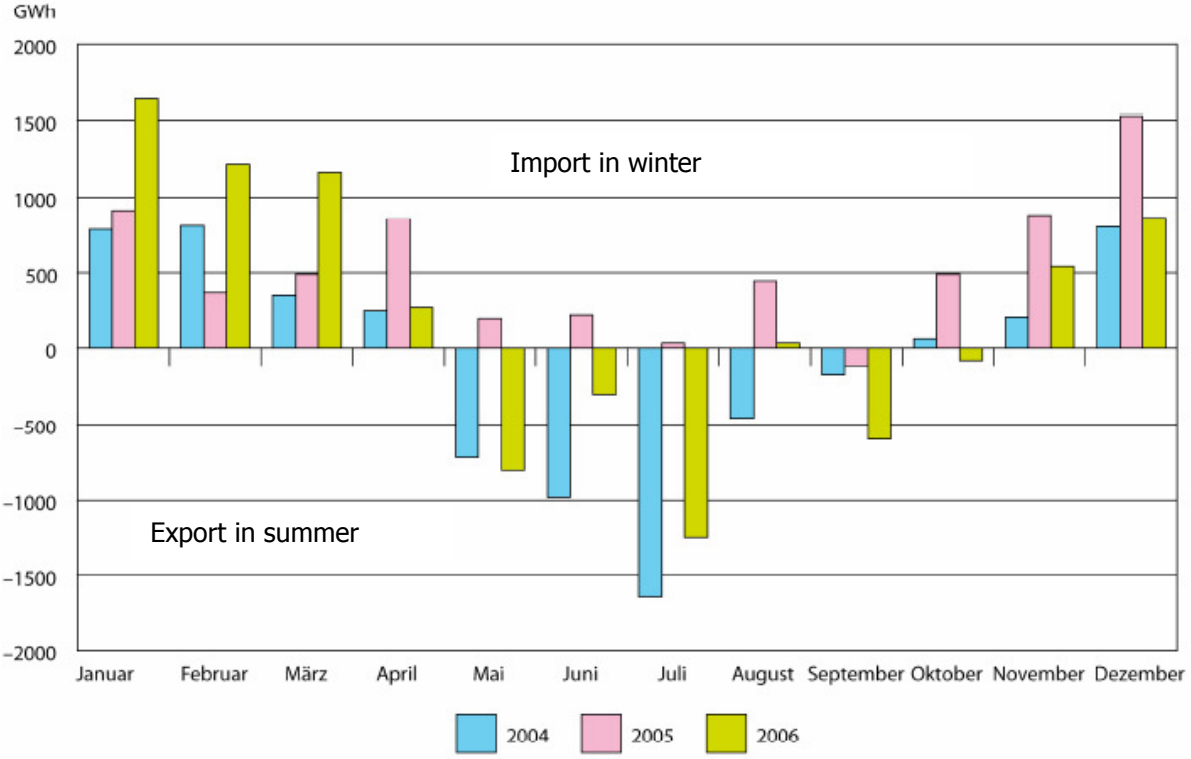

Fig. 11: Swiss power import and export surpluses **(Source: VSE, 2007)**

Hydropower production accounts for about 60% of the total domestic electricity production (Fig. 12). The electricity production is dependent on weather conditions as precipitation level and temperature. There are about 1200 hydropower plants (513 of these ≥ 300 kW) in Switzerland which produce an average of around 35.076 GWh per year (Laufer *et al.*, 2004). Large-scale hydropower plants (capacity greater than 10 MW) account for around 90% of Switzerland's total hydropower production. 47% is produced in run-of-river power plants, 49% in storage power plants and approximately 4% in pumped storage power plants. Two-thirds of hydroelectricity is generated in the Alpine region.

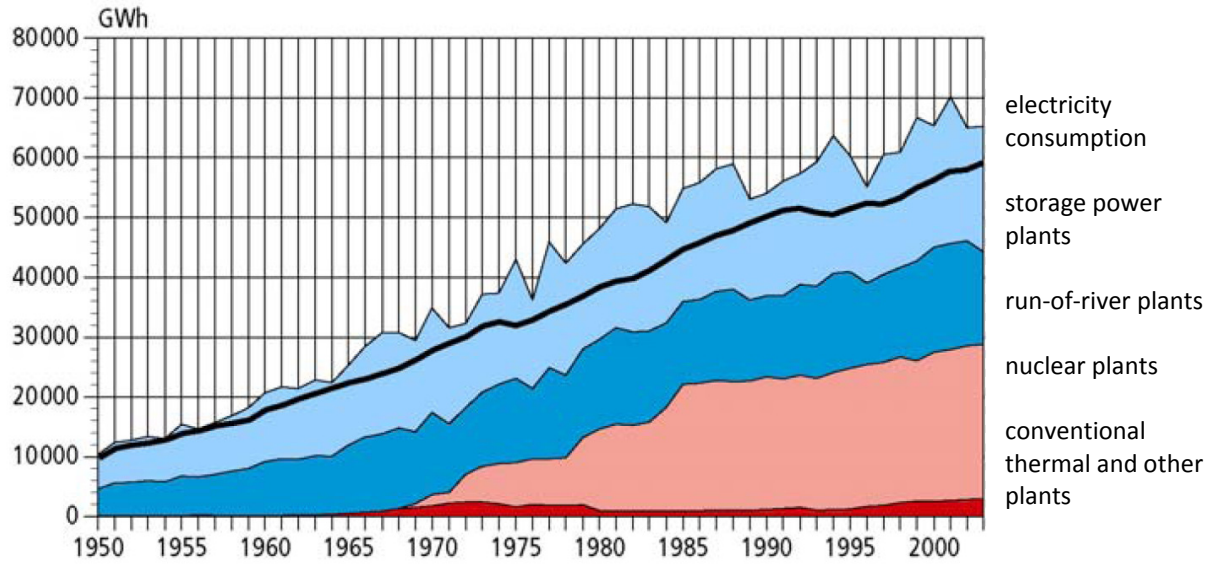

Fig. 12: Electricity production by energy sources and electricity end use in Switzerland since 1950
(Source: Laufer *et al.*, 2004)

The second main electricity source in Switzerland is nuclear power. Five nuclear power plants have a total capacity of 3.2 GW, and provide about 22.02 Mio. GWh respectively 39% of Swiss electricity production.
Renewable energy sources provide only about 2% of the Swiss power, most of which is produced by waste (Fig. 13)

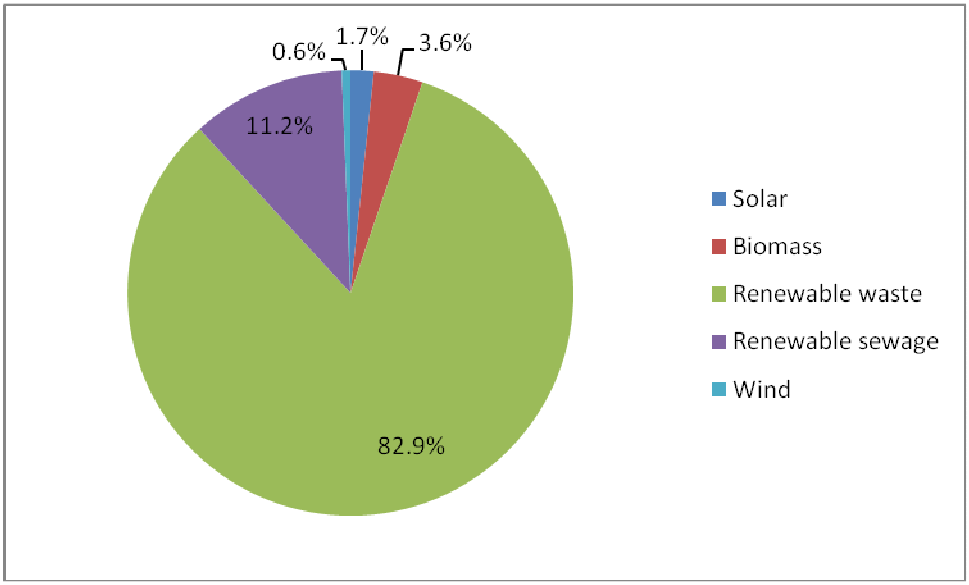

Fig. 13: Renewable energy power production (without hydropower) 2004
(Data source: Ruff, 2006)

Whereas the electricity mix produced in Switzerland consists of about 60% hydropower, this energy source contributes only about 34% to the consumed electricity in Switzerland (Fig. 14). The remaining Swiss hydropower is exported (mostly as expensive peak power). About 41% of the consumed electricity is nuclear power (of which about ⅓ is produced in foreign countries) and 21% remain unknown This electricity is bought at the international market.

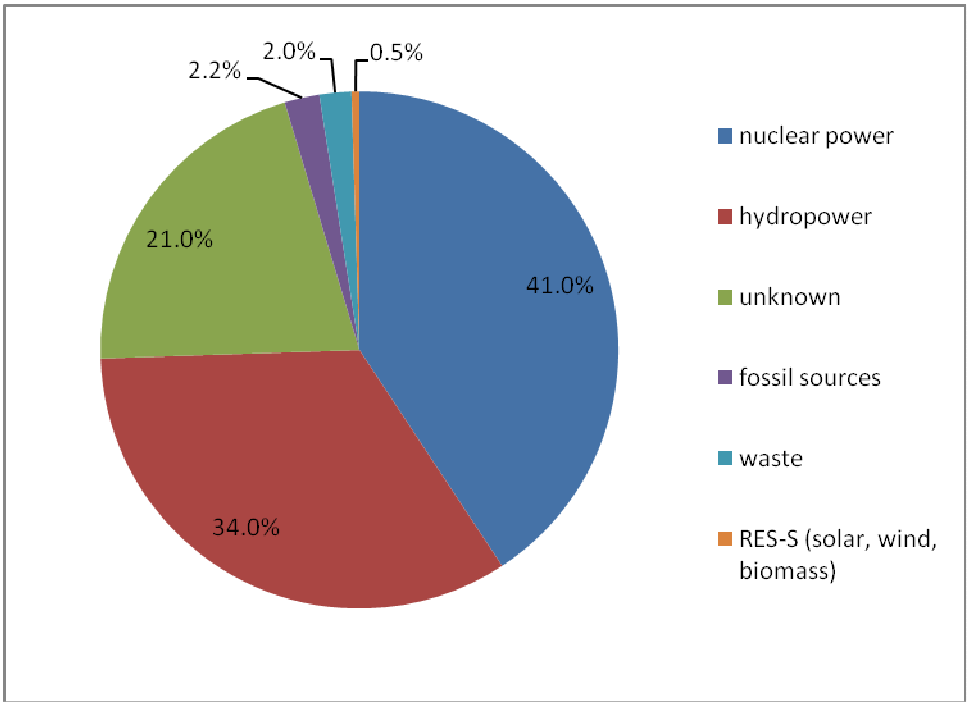

Fig. 14: Consumed power mix in Switzerland (Data source: Brunner and Farago, 2007)

3.1. Policies to curb consumption/Increase production

The federal government wants to promote the future use of renewable energy sources to a greater extent through a variety of measures. The instruments to be used include **cost-covering feed-in tariff** for renewable electricity including hydroelectricity up to 10 MW, photovoltaic, wind, geothermal, biomass and waste from biomass. From 1 January 2009, an annual charge of up to 0.36 €cts per kWh will be levied on high-voltage grid transmission costs, resulting in up to 200.36 mio € per year (SFOE, 2008d). The feed-in tariff is determined by the actual cost of the reference plants in the construction year of the promoted plant. It varies among technologies, category and performance of the plant and is paid over 20-25 years.

Electrical appliances account for around 60% of Switzerland's electricity consumption, and SwissEnergy wants to at least offset additional electricity demand by promoting the use of energy-efficient appliances. For this purpose it aims to:

- promote the energy label for appliances (compatible with those of the EU),
- prevent an increase in consumption in the area of household appliances, Information Technology equipment and electronic devices,
- increase the market share of new energy efficient motors,
- conclude agreements with the appliances industry concerning more stringent criteria for the approval of models,
- introduce the "Energy Star" label for electronic consumer and office equipment in Switzerland.

The minimum **label requirements** for new appliances are gradually being tightened. From 2009, category A will be required for new household appliances, such as ovens, freezers, refrigerators, dishwashers and washing machines. Stand-by use in consumer electronics and information technology equipment must be reduced, as a first step, to 0.3 watt (mobile

phones) to 8 watt (set-top boxes). For household lamps, the minimum category is E from 2008, D from 2012 and B from 2015, if similar obligations are enforced in the EU.
The two key organisations for promoting energy-efficient appliances are the Swiss Agency for Electric Appliances (EAE) and the Swiss Agency for Efficient Energy Use (SAFE). The EAE maintains a database on labelled appliances, including non-labelled ones, in each appliance category.

4. Transportation fuels

Mobility accounts for around 35% of Switzerland's energy consumption. The passenger transport performance is increasing since 1970. Especially in the motorized road transport sector the increase is uninterrupted (Fig. 15). So it is not surprising that the transportation fuel is still increasing whereas the use of fossil energy is actually stagnating (cf. Fig.3).

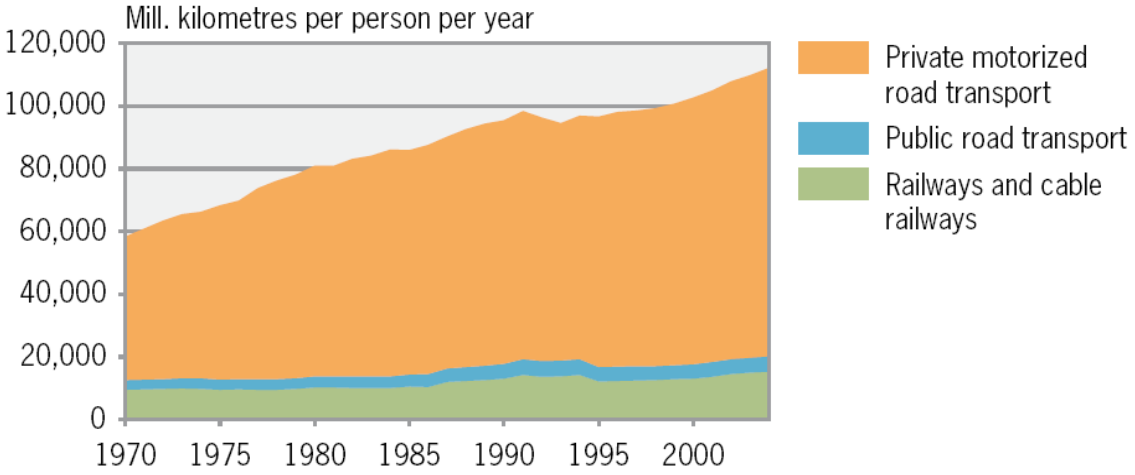

Fig. 15: Passenger Performance Capacity in Switzerland from 1970 to 2005 **(Source: SFSO, 2007)**

Besides the increasing number of vehicles, the fossil fuel rise is also due to the increase of driving performances, the average vehicle weight, air conditioner as well as stronger engines, especially SUV (Sport Utility Vehicles) (Fig. 16).

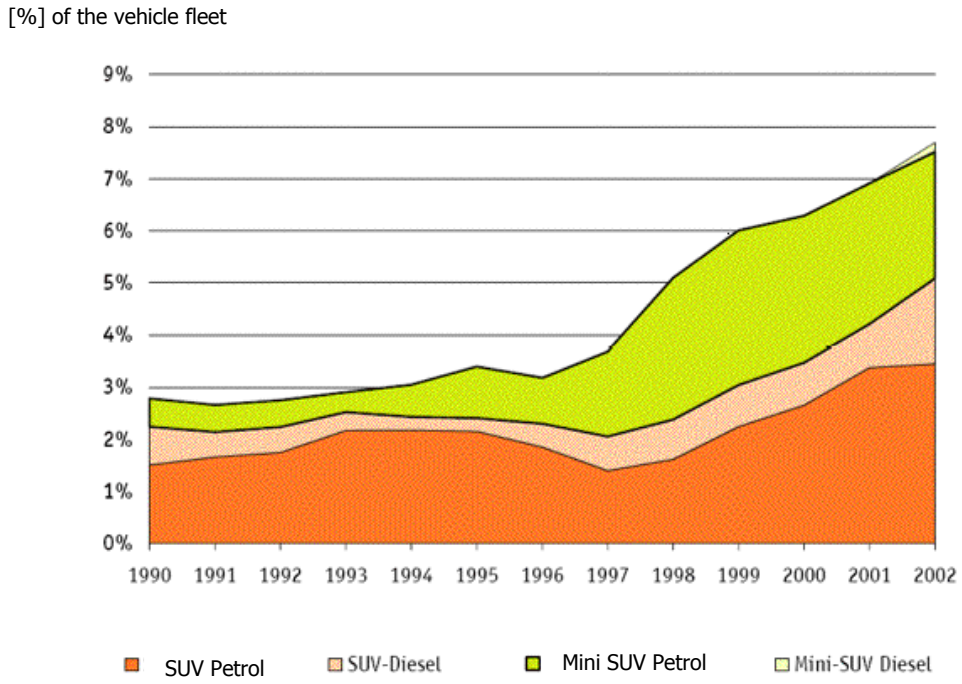

Fig. 16: Development of SUV (Sport Utility Vehicles) in Switzerland from 1990 to 2000 (adapted: INFRAS, 2003)

More energy efficient cars and cars powered by renewable transportation fuel are gaining importance only slowly (cf. Tab. 2 & 3 and Fig. 17). Switzerland has a large, well-maintained network of two-lane national roads. The paved road network has a total length of about 71.000 km (including 1.758,2 km of motorway) (FEDRO, 2007). The Swiss motorway system requires the purchase of a vignette (toll sticker) - which costs about 25.60 € - for one calendar year.

The public transport system is well developed in Switzerland. It has the most densely developed railway network worldwide (5.063 km; 122 m/km^2). Villages not connected to the railway are usually connected to public service vehicles or post office vans.

SBB (the Swiss Railway) consumed an average of around 9.2 kWh of end-use energy to transport one passenger a hundred kilometers in 2007 (SBB, 2008). This is equivalent to petrol consumption of 1.1 liters per 100 km. In freight traffic, SBB required an average of around 6.9 kWh of end-use energy to transport one tonne a hundred kilometers, i.e. the equivalent of 0.7 liters of diesel. A large amount of the consumed power comes from hydroelectric sources. In 2007, 70% of the energy consumed by SBB came from hydroelectric facilities run either solely or jointly by SBB (SBB, 2008). The remaining power is provided by French nuclear power stations and the free market.

Year	Transportation fuel		Electricity		Natural gas	Coal		Biofuel	Total (=100%)
	TJ	%	TJ	%	TJ	TJ	%	TJ	TJ
1950	19070	73,4	3990	15,4	–	2930	11,3	–	25990
1960	55310	89,0	5360	8,6	–	1470	2,4	–	62140
1970	138060	95,0	7310	5,0	–	–	–	–	145370
1980	178820	96,0	7520	4,0	–	–	–	–	186340
1990	253220	96,5	9260	3,5	–	–	–	0	262480
2000	293250	96,8	9500	3,1	0	–	–	70	302820
2001	285680	96,7	9710	3,3	0	–	–	70	295460
2002	279570	96,5	10070	3,5	0	–	–	70	289710
2003	276330	96,2	10740	3,7	10	–	–	90	287170

2004	275060	96,2	10580	3,7	30	–	–	130	285800
2005	277060	96,1	10740	3,7	90	–	–	290	288180
2006	280790	96,0	10130	3,8	120	–	–	350	292390
2007	288740	96,1	10070	3,7	240	–	–	480	300530

Tab. 2: Energy sources for transportation **(Data source: SFOE, 2007)**

		2003	2005	2006	2007
Number of vehicles		730	1900	2400	3600
Number of upgranding plants		4	7	6	7
Number of pump stations		35	60	65	78
Share of biogas [%]		45	37		n.k.
Price at pump station in €/l petrol eq.	Biogas		0.62	0.64	0.81
	Natural Gas		1.32	1.32	0.82-1.20

Tab. 3: Biogas fuel in Switzerland **(Data source: Wellinger, 2007)**

Fig. 14: Development of gas use as transportation fuel and numbers of vehicles in Switzerland from 1990 to 2007 **(Source: Wellinger, 2007)**

Non-motorized traffic includes hiking, cycling, mountain biking, skating and canoeing.
In Switzerland, cantons and communities are responsible for the non-motorized traffic infrastructure. The FEDRO (Federal Roads Office) supports them in providing recommendations, standards and norms for the design, construction, signalization and maintenance of hiking, biking and skating paths (FEDRO, 2008).
SwitzerlandMobility is the national network for non-motorized traffic and coordinates an official and standard signalized route of 6.300 km footpaths, 8.500 km cycle, 3.300 km of mountain-bike routes, 1.100 km skating trails and 250 km of lakes and rivers for canoeing.

The network also integrates non-motorized traffic and public transport, providing ideal conditions for combined mobility (SwitzerlandMobility, 2008).

The yearly infrastructures expenditures for individual transport/ streets amount to 3.500 to 4.500 Mio CHF (about 2243 to 2884 Mio €) and stayed more or less constant since 1991 (cf. Fig. 18) (ARE, 2007). In contrast in the public transport, there is a clear trend rupture recognizable from 1997 on. Since then, yearly expenditures in public transport doubled. Main reasons for this strong increase are investments in large-scale railway projects.

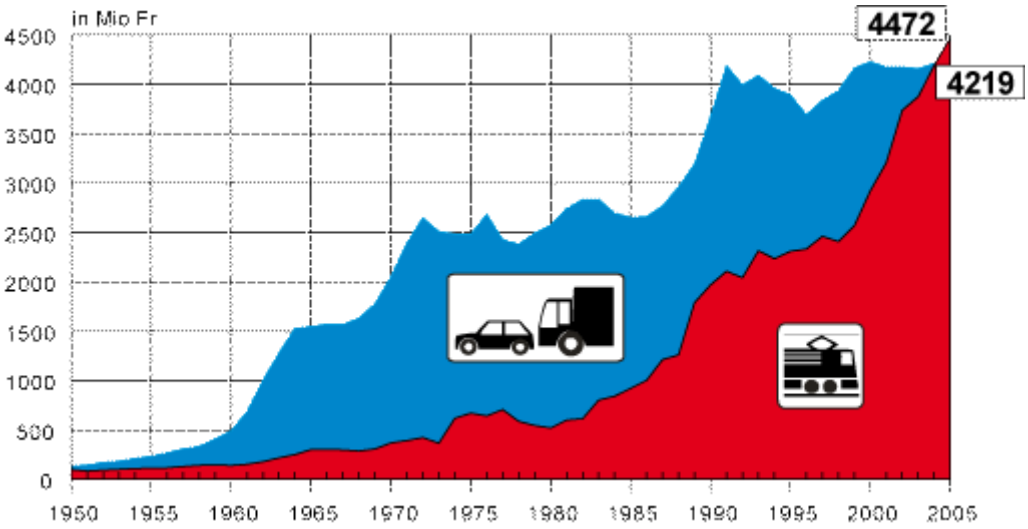

Fig. 18: Public infrastructure expenditures, public and private transport (Source: LITRA, 2008)

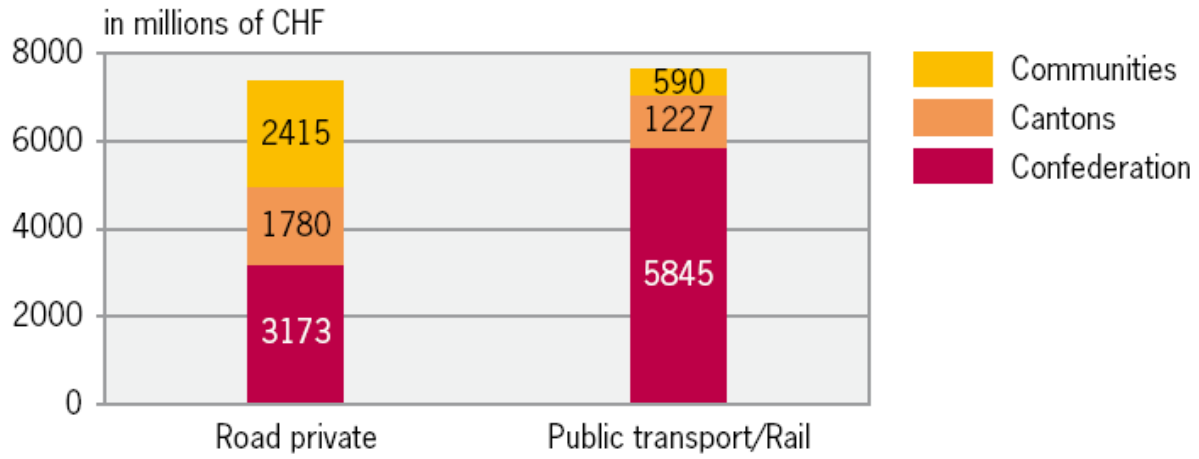

Fig. 19: Public expenditure on transport (Source: SFSO, 2007)

4.1. Policies to curb consumption/Increase production

Sustainable mobility requires a coordinated spatial development and transport policy. Therefore, both the expert knowledge of the individual transport offices (Federal Road Office (FEDRO), Federal Office of Transport (FOT), Federal Office of Civil Aviation (FOCA)) and a cross-disciplinary office (Federal Office for Spatial Development (ARE)) need to work

together. The ARE handles the overall transport aspect and the coordination function. It also contributes its expertise in the field of spatial development.
Energy efficiency of vehicles is promoted by legally binding as well as voluntary measures. Legally binding measures include harmonising annual **registration fees** on motor vehicles across cantons, and in 2009, establishing a **bonus-malus system** on the purchase of new cars to favour fuel-efficient vehicles at the expense of the inefficient ones (IEA, 2007).
A voluntary measure is the **agreement of DETEC** (Department of the Environment, Transport, Energy and Communications) **and car importers** to reduce the average fuel consumption of new cars from 8.4 litres per 100 km in 2000 to 6.4 litres per 100 km in 2007. Measures to achieve this target include the introduction of a compulsory energy label for new passenger cars and the promotion the Eco-Drive courses which enhance energy-efficient driving and which are meanwhile a prerequisite for obtaining a driver's licence. The courses are expected to reduce fuel consumption by 10-15% among the course participants (IEA, 2007). As a result, the consumption indeed decreased by 2.5%, but only to 7.43 litres per 100 km. The target was missed because the increase in car weight offset improvements in fuel efficiency (SFOE, 2008c).
DETEC is actually considering a new agreement with the car importers' association. The new objective is a reduction of CO_2 emissions from new vehicles to 140 g/km by 2010 (same as EU targets; in 2006 the whole fleet averaged 200 g/km), together with reduction of energy consumption and air pollutants (e.g. particulate matter from diesel engines) (SFOE, 2008d). Also, DETEC plans to increase the gas-powered fleet to 30,000 vehicles, hybrid/electric car fleet to 20,000 vehicles, and electric bikes to 30,000 by 2010. For this purpose and among other measures, renewable fuels are completely or partly exempted of the mineral oil tax.
In 2008, the **infrastructure fund** was created to support the growing traffic problems in agglomerations and the national motorway network. It also makes it possible to maintain the main roads in mountain and peripheral regions. The infrastructure fund is financed with a portion of the revenues from the mineral oil tax and the vignette badge that vehicles must display in order to use the Swiss motorway.
Regarding the freight transport, the government's principal policy is the shifting from road to rail. The **Federal Modal Shift Law** of 1999 aims to cut the number of lorries crossing the Swiss Alps by half from 1999 to 2010. Since 2001, vehicles weighing more than 3.5 tonnes are subject to the **HVF** (heavy vehicle fee). The HVF is vehicle-specific and based on weight, mileage and pollutant emissions. One-third of the revenue will be spent on infrastructure projects in the cantons and two-thirds on improving transalpine railways, mainly to finance the construction of two major tunnels, namely Lötschberg (34 km) and Gotthard (57 km, due to open in 2015). Energy efficiency was further raised by increasing the weight limit for lorries from 34 tonnes (2001) to 40 tonnes (2004), triggering fleet renewal and better logistics (IEA, 2007).

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