SWITZERLAND

SWITZERLAND

1. ENERGY, ECONOMIC AND ELECTRICITY INFORMATION

1.1. General Overview

Switzerland is one of the most mountainous countries of Europe, with more than 70 per cent of its area covered by the Alps, in the central and southern sections, and the Jura, in the north-west. Between the two mountain systems lies the Swiss plateau, about 400 m above sea level and some 50 km wide; it extends from Lake Geneva in the south-west to Lake Constance in the north-east. The principal river system is formed by the Rhine and its tributaries. Other important rivers are the Rhône, Ticino, and Inn, and other important lakes are the Lake Maggiore and the lakes of Lugano, Neuchâtel, Lucerne, Zurich, Thun and Brienz. Switzerland is bounded on the north by France and Germany, on the east by Austria and Liechtenstein, on the south by Italy, and on the west by France. About 29 per cent of Switzerland is covered by forest. Protected land makes up about 18 per cent of the country.

On the plateau and lower valleys of Switzerland a temperate climate prevails, with a mean annual temperature of about 10°C. Precipitation varies considerably according to elevation: precipitation on the plateau and in the lower valleys is about 915 mm annually; the higher regions generally receive much more. Much of the precipitation occurs during the winter in the form of snow; the peaks of most mountains higher than 2700 m are snow-covered throughout the year. There are also large glaciers at higher elevations, especially in the Alps. Predominant winds come from the north-east (cold), and from the south-east (warm).

Switzerland has a population of 7,318,638 (2003 estimate) yielding an overall population density of about 177 people per sq km. The population is unevenly distributed, with the principal concentrations occurring in the Swiss plateau. Approximately 68 per cent of the population is classified as urban, but most live in small towns. The major language communities are: German, French, Italian, and Romansch (Rhaeto-Romanic). Foreigners and their families represent about 15 per cent of the population.

TABLE 1. POPULATION INFORMATION

								Growth rate (%yr)
	1970	1980	1990	2000	2001	2002	2003	1990 To 2003
Population (millions)	6.2	6.3	6.8	7.2	7.2	7.2	7.3	0.7
Population density (inhabitants/km²)	149.8	153.0	165.5	173.5	174.5	175.8	177.2	

Predicted population growth rate (%) 2002 to 2010	-1.4
Area (1000 km²)	41.3
Urban population in 2002 as percent of total	67.8

Source: IAEA Energy and Economic Database.

Switzerland is a confederation of 23 states, called cantons, under a Constitution adopted in 1874 and amended several times since. The Swiss political system combines direct and indirect democracy with the principles of sovereignty of the people, separation of powers, and proportional representation. The electorate chooses its representatives, and also decides important issues by means of referenda, an integral part of Swiss government. Executive power is vested in the Federal Council (Bundesrat/Conseil Fédéral) of seven members who are elected to four-year terms by a joint session

of the parliament. The legislature elects a president from among the members of the council for a one-year term. The Swiss parliament, called the Federal Assembly, consists of two houses: the Council of States (Ständerat/Conseil des États), with 46 members (2 for each canton), and the National Council (Nationalrat/Conseil National), with 200 members. All powers not delegated to the Confederation by the Constitution are reserved to the Cantons. Each of the 20 Cantons and 6 half Cantons has an elected legislative council and an executive council.

1.1.1. Economic Indicators

Switzerland has a highly developed industrialized economy and one of the highest standards of living in the world. Trade and services, including banking and finance, pharmaceuticals, and tourism, are the dominant sectors of the Swiss economy. Agriculture accounts for less than 4% of the national output. The natural resources are essentially limited to the hydro electric potential.

The historical Gross Domestic Product (GDP) data are shown in Table 2.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

						Growth rate (%/yr)
	1980	1990	2000	2001	2002	1990 To 2002
GDP (millions of current US$)	107,474	228,414	239,449	244,577	250,072	0.8
GDP (millions of constant 1990 US$)	186,446	228,414	248,453	248,950	249,198	1
GDP per capita (current US$/capita)	17,008	33,423	33,384	34,098	34,871	0.4

Source: IAEA Energy and Economic Database

1.1.2. Energy Situation

Switzerland has great potential hydroelectric-power resources, which reserves amount to about 14 Exajoules according the IAEA Energy and Economic Data Base (Table 3). Some 60 per cent of its electricity is produced in hydroelectric facilities. Around 40 per cent is generated in nuclear power plants, produced at four sites. Small amounts of geothermal and thermal energy are also produced. The Swiss energy statistics are shown in Tables 4.1 and 4.2.

TABLE 3. ESTIMATED ENERGY RESERVES

	Estimated energy reserves in (Exajoule)					
	Solid	Liquid	Gas	Uranium (1)	Hydro (2)	Total
Total amount in place					13.88	13.88

(1) This total represents essentially recoverable reserves.

(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 2002) by a factor of 10.

Source: IAEA Energy and Economic Database.

TABLE 4.1. ENERGY STATISTICS(*)

	1970	1980	1990	2000	2001	2002	Average annual growth rate (%) 1970 To 1990	Average annual growth rate (%) 1990 To 2002
Energy consumption								
- Total (1)	0.80	0.92	1.10	1.15	1.19	1.21	1.60	0.76
- Solids (2)	0.03	0.02	0.03	0.03	0.03	0.03	-1.22	1.00
- Liquids	0.51	0.51	0.51	0.45	0.46	0.46	-0.06	-0.74
- Gases		0.04	0.08	0.11	0.11	0.12	20.89	3.57
- Primary electricity (3)	0.25	0.35	0.49	0.55	0.59	0.60	3.36	1.62
Energy production								
- Total	0.31	0.45	0.52	0.64	0.68	0.70	2.67	2.50
- Solids	0.01	0.01	0.01	0.02	0.03	0.04	0.35	13.16
- Liquids								
- Gases								
- Primary electricity (3)	0.30	0.44	0.51	0.62	0.65	0.66	2.72	2.17
Net import (Import - Export)								
- Total	0.58	0.61	0.64	0.62	0.62	0.62	0.52	-0.32
- Solids	0.02	0.02	0.02	0.01	0.01	0.02	-1.41	0.68
- Liquids	0.55	0.55	0.55	0.50	0.49	0.48	-0.06	-1.06
- Gases	0.00	0.04	0.08	0.11	0.11	0.12	20.88	3.60

(1) Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.

(2) Solid fuels include coal, lignite and commercial wood.

(3) Primary electricity = Hydro + Geothermal + Nuclear + Wind.

(*) Energy values are in Exajoule except where indicated.

Source: IAEA Energy and Economic Database.

Switzerland depends on imported energy for 80% of its primary energy supplies (2001), having no oil or gas resources of its own. Electricity's share of total final energy consumption in 2001 was 22%, and much of this was local production. Hydropower's share of total electricity production was 60.2%, nuclear power contributed 38.5%. Renewables' share of final energy consumption was 16.8%. This share was composed of 12.6% electricity from renewable resources, wood contributed 2.4%, waste 0.6% and other renewable energy sources 1.2%. The Swiss government promotes the use of new renewable energy sources.

TABLE 4.2. NATIONAL ENERGY STATISTICS

	1998		1999		2000		2001	
	TJ	TJ	TJ	TJ	TJ	%	TJ	%
Coal	3 810	0.3	3 980	0.4	5 850	0.5	6 170	0.5
Oil	547 860	49.0	547 200	48.5	532 370	47.0	548 610	47.0
Gas	98 880	8.8	102 450	9.1	101 880	9.0	106 040	9.1
Nuclear	256 830	23.8	256 610	22.7	272 170	24.0	275 920	23.6
Hydro	154 330	13.8	182 770	16.2	170 330	15.0	190 180	16.3
Other	69 610	6.2	71 880	6.4	75 200	6.5	79 050	6.6
Total*	1 140 320	101.9	1 164 890	103.3	1 157 800	102.2	1 205 970	130.2
Electricity trade	-21 430	-1.9	-36 820	-3.3	-25 450	-2.2	-37 600	-3.2

* Includes electricity trade

Source: Swiss Energy Statistics (Swiss Federal Office of Energy).

Total final energy consumption fell by 2.1% in 2002 compared to the year 2001 due to the warmer weather, the stagnating economic situation, the declining industrial production, the decline in travel activities and the increasing impact of the energy policy program "SwissEnergy ".

1.2. Energy Policy

The CO_2 Law is the central pillar of Swiss climate policy, with which it responds to global warming of the atmosphere. The Law entered into force on 1 May, 2000. In this law, Switzerland has laid down binding objectives for the reduction of the greenhouse gas CO_2. It also serves to fulfill international obligations under the International Climate Convention into which Switzerland has entered in concert with 180 other nations.

The intention of the CO_2 Law is to reduce emission of this climate-relevant gas by 2010 by 10 per cent below the 1990 level. The targets for heating and motor fuels differ. Thus the consumption of heating fuels is to be reduced by 15 percent and that of motor fuels by a total of 8 percent. Aviation fuels for international flights are excluded.

SwissEnergy, the follow-up program to the "Energy 2000" action plan, was adopted by the Federal Council and launched in January 2001 in collaboration with the cantons, the municipalities, industry and the environmental organizations. The program has clear quantitative objectives and comprehensive strategies for energy efficiency and utilization of renewable energy in industry, buildings and transport, and is based on a broad partnership. The task of SwissEnergy is to fulfill the national energy and climate policy objectives, and to initiate a sustainable energy supply based on innovation and new technologies.

With the help of the agencies laid down in the Energy Law, together with target agreements and binding undertakings under the CO_2 Law, the voluntary measures already adopted under Energy 2000 by industry will be significantly reinforced. The main instruments for this are the guideline on voluntary measures in industry, the trades and services, and performance contracts with the Energy Agency for Industry (EnAW) and the Agency for Renewable Energies and Energy Efficiency (AEE). The main task of the AEE is to ensure that the renewable energy objectives of SwissEnergy are achieved.

The basic norm for an ecological tax reform (which would have involved an environmental tax) was rejected by the electorate in September 2000.

In a nationwide referendum on 22 September 2002 Swiss voters rejected an electricity market liberalization law, which had been proposed by the Government and accepted by Parliament. Following rejection of this law, several parliamentary initiatives were submitted on the subject of the electricity market. The Federal Department of Environment, Transport, Energy and Communications appointed an expert commission in March 2003. Its purpose is to lay down the basic form of the new electricity industry structure with the help of the support groups by early 2004. The draft legislation is intended to be submitted for formal consultation in spring 2004.

1.3. The Electricity System

1.3.1. Structure of the Electricity Sector

The electricity industry consists of about 900 production and distribution utilities. The number decreased from about 1'200 in the 1990s as a consequence of mergers.

There are six vertically integrated supra-national companies operating in the Swiss market, which supply about 80 percent of the wholesale market. Three are private companies and three are owned mainly by the cantons and public utilities. All the companies generate and transmit electricity but most of them also import and export electricity and are involved in electricity distribution.

The bulk of the Swiss electric companies are distributors, operating at cantonal or municipal level. Most of them are also owned by cantons or municipalities. Local distribution companies account for about 70 percent of electricity distributed to final consumers. They are often involved in other activities such as gas and water distribution and district heating.

The influence of the cantons and local authorities in the power utilities varies significantly, and, except for nuclear energy, the Federal Government's influence is relatively low on the electricity sector.

VSE (Swiss Association of Electricity Supply Undertakings) and Swisselectric are the major organizations in the electricity sector. VSE represents the interests of 460 electricity companies that supply 90 percent of electricity. Swisselectric is an industrial association formed by the six supra-regional companies in order to promote their common interests.

The upgrading of existing plants is more common than the construction of new installations. Hydroelectric output capacity is thus set to rise by just 0.01 GW and electricity production by 17 GWh in the next few years.

Electricity prices are subject to substantial regional variations. Prices for large industries are set by utilities and are not subject to price controls or monitoring. Electricity prices for other consumers are set by the utilities or local authorities. When prices are set by utilities, formal approval by local authorities is needed in most cases. In some municipalities, electricity prices are approved by popular referendum. Municipalities and cantons also influence price setting through their shareholding.

Since individual electricity undertakings apply tariffs on an independent basis, there are no binding federal regulations for the establishment of these tariffs. Even the Swiss Association of Electricity Supply Undertakings (VSE) has no authority in this area. However, the VSE tariffs committee prepares regular guidelines and recommendations for the use of member companies. These recommendations are generally incorporated into tariffs applied by electricity utilities.

Charges for construction costs are levied by electricity distributors when new electric power plants are installed or when existing plants are enlarged. In general, a distinction is drawn between system costs and connecting costs, with many electricity companies incorporating these two cost elements into a single charge. These construction charges are generally levied on a one-off basis when the customer is connected to the electricity supply system, with a variety of procedures being applied by individual companies. A small number of companies increase the energy rate (and/or the demand rate) in the area, which they supply, rather than charging newly connected customers for construction costs. In some cases, prices fixed by the utilities are subject to formal approval by the local authority concerned. The recommendations published by the Federal Department of Environment, Transport, Energy and Communication in 1989 cover the principles of tariff setting in networks.

1.3.2. Decision Making Process

The Swiss Federal Government has adopted the program "SwissEnergy" which concern the energy as a whole. This action program defines also the objectives in the electricity sector. The Federal Department of Environment, Transport, Energy and Communication is the Swiss regulatory body for this program, in co-operation with the authorities of the Cantons. It supports R&D programs, elaborates recommendations and regulations, but not the policy. The policy and decision making is in the hands of the electricity generation industry within the regulatory framework. Because electricity in Switzerland is decentralized and the electric utility industry and non-utility generators are, for the most part, privately owned, policy and decision making in the electricity generation industry is decentralized, subject to Federal and Cantonal laws and regulations. The regulatory body examines the submitted projects, eventually proposes some modifications and prepares a proposition to the

cantonal or federal concerned political organization for a decision. By the way of an initiative or referendum the electorate may make the final decision.

1.3.3. Main Indicators

On an annual basis, Switzerland is still a net exporter of electricity. The year 2002 saw an export surplus of 4.5 TWh, i.e. 6.9 % of the electricity produced. Total imports were 47.1 TWh and total exports 51.6 TWh. In the winter 2001/2002, imports exceeded exports by 1.9 TWh after an export surplus of 2.3 TWh in the winter of 2000/2001. Table 5.1 shows the electricity generation and Table 5.2 the electricity use based on national data. Table 5.3 shows the electricity statistics from EEDB. Table 6 shows the energy related ratios.

TABLE 5.1. ELECTRICITY GENERATION

	1998		1999		2000		2001		2002	
	TW·h	%	TW·h	%	TW·h	%	TW·h	%	TW·h	%
Hydro	34.3	56.3	40.6	60.9	37.9	57.9	42.3	60.2	36.5	56.2
Nuclear	24.3	40.0	23.5	35.3	24.9	38.2	25.3	36.1	25.7	39.5
Fossil	2.3	3.7	2.6	3.8	2.5	3.9	2.6	3.7	2.8	4.3
Total	60.9	100.0	66.7	100.0	65.3	100.0	70.2	100.0	65.0	100.0

Source: Country Information.

TABLE 5.2. ELECTRICITY USE

	1997		1998		1999		2000		2001	
	TW·h	%	TW·h	%	TW·h	%	TW·h	%	TW·h	%
Households	14.9	30.6	15.1	30.5	15.6	30.4	15.7	30.0	16.1	29.9
Agriculture	0.9	1.9	0.9	1.9	0.9	1.9	1.0	1.9	1.0	1.9
Industry+Craft	16.2	33.4	16.7	33.5	17.0	33.2	18.1	34.5	18.3	34.1
Services	12.7	26.1	12.9	26.1	13.6	26.6	13.4	25.6	14.0	26.1
Transportation	3.9	8.0	4.0	8.0	4.1	7.9	4.1	8.0	4.3	8.0
- Railways only	(2.4)	(5.0)	(2.5)	(5.0)	(2.5)	(5.0)	(2.6)	(5.0)	(2.7)	(5.0)
Total	48.6	100.0	49.6	100.0	51.2	100.0	52.4	100.0	53.7	100.0

Source: Country Information.

TABLE 5.3. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

							Average annual growth rate (%)	
	1970	**1980**	**1990**	**2000**	**2001**	**2002**	**1970 To 1990**	**1990 To 2002**
Electricity production (TW.h)								
- Total (1)	32.57	47.06	55.80	67.21	70.30	71.67	2.73	2.11
- Thermal	1.39	0.96	2.51	2.66	2.67	2.75	3.00	0.74
- Hydro	28.72	32.44	30.98	39.60	42.34	43.23	0.38	2.81
- Nuclear	2.45	13.66	22.30	24.95	25.29	25.69	11.68	1.19
- Geothermal								
Capacity of electrical plants (GWe)								
- Total	10.54	13.99	16.30	17.99	18.18	18.27	2.20	0.96
- Thermal	0.57	0.60	0.76	0.87	0.88	0.89	1.44	1.36
- Hydro	9.62	11.45	12.35	13.92	14.09	14.17	1.26	1.15
- Nuclear	0.35	1.94	3.19	3.20	3.20	3.20	11.69	0.02
- Geothermal								
- Wind				0.01	0.01	0.01		

(1) Electricity losses are not deducted.

(*) Energy values are in Exajoule except where indicated.

Source: IAEA Energy and Economic Database.

TABLE 6. ENERGY RELATED RATIOS

	1970	1980	1990	2000	2001	2002
Energy consumption per capita (GJ/capita)	130	146	161	160	166	168
Electricity per capita (kW.h/capita)	4,494	5,878	7,604	8,106	8,851	8,109
Electricity production/Energy production (%)	102	100	103	101	100	98
Nuclear/Total electricity (%)	8	29	40	37	36	36
Ratio of external dependency (%) (1)	72	66	58	54	52	51
Load factor of electricity plants						
- Total (%)	35	38	39	43	44	45
- Thermal	28	18	38	35	34	35
- Hydro	34	32	29	32	34	35
- Nuclear	80	80	80	89	90	92

(1) Net import / Total energy consumption.

Source: IAEA Energy and Economic Database.

2. NUCLEAR POWER SITUATION

2.1. Historical Development and current nuclear power organizational structure

2.1.1. Overview

In November 1945, the Swiss Government established the independent Atomic Energy Committee with the mandate to advise the Government in all civilian and military matters dealing with nuclear energy. In 1946, the Swiss Government mandated the Atomic Energy Committee to investigate all aspects dealing with nuclear weapons, i.e. to prepare the necessary measures for protecting army and population against their impact and also to study what would be required to develop such weapons. On 18 March 1957, the Swiss Parliament ratified the IAEA Statute which has been brought into force on 29 July 1957. In 1969, Switzerland signed the Non-Proliferation Treaty and the Parliament ratified it on 9 March 1977.

As early as 1946, Brown Boveri & Cie (BBC), now Asea Brown Boveri AG (ABB), took the first steps to build up a team of physicists and to launch a development program. BBC was later joined by Sulzer Brothers and Escher-Wyss. Initial studies dealt with graphite-carbon dioxide reactor concepts, but from 1952 on, the development concentrated on heavy water moderated reactors with the subsequent planning of the research reactor DIORIT. In 1955, more than 150 private companies joined forces and formed the company "Reactor Ltd" to build and operate the new privately-owned research center, in Würenlingen, with two reactors on the site: SAPHIR and DIORIT. In 1960, the Swiss Government took over the research center, well known under its abbreviation EIR (Eidgenössisches Institut für Reaktorforschung). In 1988, the fusion of EIR and SIN (Schweizerisches Institut für Nuklearphysik) led to the creation of the Paul Scherrer Institute.

In Switzerland, the nuclear age began on 30 April 1957, when the SAPHIR research reactor went critical under the responsibility of Swiss scientists and engineers. This swimming pool reactor had been purchased in 1955 from the American Government, after being exhibited in Geneva during the First International Conference on the Peaceful Uses of Atomic Energy. SAPHIR has been definitely shut down at the end of 1993. Decommissioning work, based on a license granted in 2000, was still underway in the year 2003.

DIORIT, the first reactor designed and constructed in Switzerland, reached criticality on 15 August 1960. It was moderated and cooled by heavy water; the fuel was initially natural uranium; a special loop allowed testing of power reactor fuel elements. DIORIT has been definitely shut down in 1977. At the end of 2003 all radioactive material has been removed from the reactor building.

In 1962 began the construction of the experimental nuclear power reactor in Lucens, a 30 MW(th), 6 MW(e), heavy-water moderated, carbon dioxide cooled reactor located in an underground cavern. Criticality was reached in late 1966 and commissioning in early 1968. In spite of numerous difficulties, the supply consortium led by Sulzer Brothers had demonstrated that Swiss industry was capable of building nuclear plants. Goal was the development of a small to medium-sized power reactor fuelled with natural uranium within a massive containment system. As during the mid sixty years enriched uranium became easily available, the unit size of commercially offered LWR nuclear power plants increased drastically and Swiss utilities started construction of such plants very early, the interest in the Lucens reactor type decreased and further large expenses for such a development could not be justified. It was decided to operate the reactor until the end of 1969; unfortunately, on 21 January 1969, the plant was abruptly put out of service by a partial core meltdown that destroyed the integrity of the primary system and released radioactivity into the cavern. After decontamination, decommissioning and termination of intermediate storage of radioactive material the whole site got ready for unrestricted reuse in 2003.

A turnkey contract was awarded, by Nordostschweizerische Kraftwerke AG (NOK), in August 1965 to a consortium made up of Westinghouse International Atomic Power Co, Ltd. and Brown Bovery & Cie for the supply of a 350 MW(e) plant equipped with a pressurized water reactor and two turbo-generators (Beznau). In late 1967, NOK took the option to order a duplicate of the first unit. Beznau I reached criticality by the end of June 1969, and Beznau II in October 1972.

In 1965 too, Bernische Kraftwerke AG (BKW) chose a 306 MW(e) plant equipped with a boiling water reactor manufactured by General Electric (GE) and twin turbo-generators from BBC (Mühleberg). In July 1971, full power was achieved, but on 28 July a turbine fire broke up. Sixteen months later the plant was officially handed to the owner.

In 1973, a supply contract was signed by a consortium of Swiss utilities with Kraftwerk Union (Siemens) for the delivery of a 900 MW(e) pressurized water reactor and turbo-generator (Gösgen). Construction of the plant went very smoothly until the first connection to the grid in February and 80% power test in March 1979. However, the accident at Three Mile Island on 29 March 1979 led to an 8 month delay in commissioning.

In December 1973, a consortium of Swiss utilities and one German utility awarded a turnkey contract to General Electric Technical Services Overseas (GETSCO) and BBC for the supply of a 940 MW(e) nuclear power plant equipped with a boiling water reactor (Leibstadt). Construction began in 1974 and the plant was commissioned in December 1984.

In the course of time all Swiss nuclear power plants have upgraded their power capacity. At the end of 2002, the nominal net powers were twice 365 MW(e) for Beznau-, 355 MW(e) for Mühleberg-, 970 MW(e) for Gösgen- and 1165 MW(e) for Leibstadt-NPP.

The nuclear controversy began in Switzerland in 1969 with the first signs of local opposition to a nuclear plant project at Kaiseraugst, near Basel. For 20 years, the Kaiseraugst project was to remain center stage in the nuclear controversy: Site permit, local referenda, legal battles, site occupation by opponents in 1975, parliamentary vote in favor of construction in 1985, and finally parliamentary decision in 1989 to end the project definitively. The Chernobyl accident of spring 1986 had drastically affected the political climate. Another project, less advanced than Kaiseraugst, Graben has also been cancelled.

The nuclear controversy led to several anti-nuclear initiatives on the federal level:

i) an attempt to forbid all nuclear plants, both new and those already in operation - rejected by 51.2 % of the voters in February 1979;

ii) aimed at forbidding future nuclear plants, leaving untouched the plants in operation, two initiatives differing only in the treatment to be applied to Leibstadt, then under construction - rejected by 55 % of the voters in September 1984;

iii) nuclear phase-out - rejected by 52.9 % of the voters in September 1990;

iv) 10-year moratorium - accepted by 54.6 % of the voters in September 1990;

v) In 1999, two new initiatives were organized aiming at the ban of the construction of new NPPs until 2010 and the closure of all NPPs after a 30 year live-span. Both initiatives were rejected in May 2003 by 58.4 % and 66.3 % of the voters respectively.

In 1972, specific steps toward the realization of Swiss disposal facilities were initiated through the formation of the national co-operative for the disposal of radioactive wastes (NAGRA), which brings together the operators of nuclear power plants and the Federal Government. NAGRA must ensure that in the near future (about 2000) low and medium level radioactive wastes could begin to be stored in a final repository, and that at a later stage (about 2020) a separate deep disposal site will be ready to receive the high-level radioactive wastes to be returned by the fuel reprocessing plants abroad. Two interim storages for low and medium level radioactive waste are operative since 1993:

- "ZWIBEZ" on the site of BEZNAU
- "BZL" on the site of the Paul Scherrer Institute

A third one, "ZWILAG" (Central interim storage for radioactive wastes from all Swiss nuclear power plants), by the side of the Paul Scherrer Institute, is operative since 2001.

The continuation of project work for a final storage for low and medium level radioactive wastes at the Wellenberg, in central Switzerland, has been stopped by the negative outcome of a cantonal referendum in 2002. The search for a suitable storage site has to start again.

The appointment of nuclear safety authorities in Switzerland has been based on the nuclear law of 1959. The Federal Nuclear Safety Commission has been set up in 1960; it consisted initially of 9 members and 1 scientific secretary, today 13 members and 3 scientific secretaries. The first secretary's office has been developed in the course of time to the Federal Nuclear Safety Inspectorate, comprising 39 persons in 1980 and about 90 persons today.

2.1.2. Current Organizational Chart

The institutional structure of the Swiss regulatory nuclear sector and the relationship among different organizations are shown in Figure 1. The Federal Department of Environment, Transport, Energy and Communication (UVEK) reports to the Federal Council. The Federal Office of Energy (BFE), a regulatory body, reports to the Federal Department of Environment, Transports, Energy and Communication. The Swiss Federal Nuclear Safety Inspectorate (HSK) is part of the Federal Office of Energy. The Commission for the Safety of Atomic Installation reports to the Federal Council via the Federal Office of Energy.

(updated organizational chart not available at the present time)

2.2. Nuclear Power Plants: Status and Operations

The five nuclear units in operation in Switzerland contribute more than 35% of the electricity generation in the country. In December 1994, Beznau-II, a 365 MW(e) PWR unit in operation since 1971, was issued a license for operation until the end of 2004. Similarly, the 355 MW(e) BWR unit in operation at Mühleberg was issued a ten year operation license after refurbishment and 10% capacity

upgrade in 1992. In both cases, the operating utilities intend to seek for an extension of the license before it expires. The three other units in operation have unlimited operating licenses. Table 7 shows the status of the Swiss nuclear power plants.

TABLE 7. STATUS AND TRENDS OF NUCLEAR POWER PLANTS

Station	Type	Capacity	Operator	Status	Reactor Supplier
BEZNAU-1	PWR	365	NOK	Operational	WEST
BEZNAU-2	PWR	365	NOK	Operational	WEST
GOESGEN	PWR	970	KKG	Operational	KWU
LEIBSTADT	BWR	1165	KKL	Operational	GETSCO
MUEHLEBERG	BWR	355	BKW	Operational	GETSCO

Station	Construction Date	Criticality Date	Grid Date	Commercial Date	Shutdown Date
BEZNAU-1	01-Sep-65	30-Jun-69	17-Jul-69	01-Sep-69	
BEZNAU-2	01-Jan-68	16-Oct-71	23-Oct-71	01-Dec-71	
GOESGEN	01-Dec-73	20-Jan-79	02-Feb-79	01-Nov-79	
LEIBSTADT	01-Jan-74	09-Mar-84	24-May-84	15-Dec-84	
MUEHLEBERG	01-Mar-67	08-Mar-71	01-Jul-71	06-Nov-72	

Source: Country Information.

2.3. Supply of NPPs

- ABB, Asea Brown Boveri AG
  (Nuclear power plants, nuclear wastes facilities, LWR fuel, fuel channels, BWR control rods, fuel management services, nuclear services, engineering services)

- Colenco Power Consulting Ltd
  (Nuclear technology surveys, bid process, contractual advice, procurement of nuclear systems, radioactive waste conditioning/disposal, emergency training)

- Elektrowatt Engineering Services Ltd
  (Nuclear system engineering and design, containment protection features for severe accidents, probabilistic safety analysis, conditioning of radioactive solids, treatment of radioactive liquids, plasma incineration of radioactive waste.)

- GE Nuclear Energy (GETSCO)
  (Integrated, full scope services including upgrades, modifications and outage support, BWR reload fuel, control rods, fuel channels, advanced reactors 600-1300 MW(e))

2.4. Operation of NPPs

2.4.1. Owners/Operators

- Bernische Kraftwerke AG, Kernkraftwerk Mühleberg.
  (BWR, 355 MW(e) (net); NSSS supplied by GETSCO; turbine island supplied by BBC)
- Nordostschweizerische Kraftwerke AG, Kernkraftwerk Beznau I & II.
  (PWR, 2 x 365 MW(e) (net); NSSS by Westinghouse, turbine island by BBC)
- Kernkraftwerk Gösgen-Däniken AG.
  (PWR, 970 MW(e) (net), NSSS by KWU, turbine island by KWU)
- Kernkraftwerk Leibstadt AG.
  (BWR, 1165 MW(e) (net); NSSS by GESTSCO, turbine island by BBC)

2.4.2. Operation and maintenance service suppliers

- ABB, Asea Brown Boveri AG
- ARC Machines, Inc.
  (Automatic orbital TIG welding/equipment. For heavy wall piping, fuel pins, instrumentation tubing, process piping. Remote control systems)
- GE Nuclear Energy (GETSCO)
- ICT Inter Control Technology AG
  (Installations and equipment for examination of spent fuel elements and fuel rods, remote handling systems, MS manipulators, nuclear robots)
- Pedi AG
  (Systems for protection of persons for production, supervision, maintenance and emergencies; Remote handling tools, lead shielding, working tents)
- Sulzer Thermtec Ltd, Nuclear services and valves

2.4.3. Operator training

- Reaktorschule PSI
  (Theoretical formation of operation personal for nuclear facilities at all levels and of engineers involved in maintenance works in nuclear facilities)

2.5. Fuel Cycle and Waste Management [1]

2.5.1. General Survey

The owners and operators of NPPs are responsible for the planning and decision making relative to the fuel cycle. They conclude contracts within the framework of the law and international agreements. The activities of the Government and its administration are of a subsidiary nature, e.g. accounting and controlling nuclear materials as required by the Non Proliferation Treaty, import/export licenses in accordance with bilateral agreements and the guidelines of the Nuclear Suppliers Group (NSG) as well as negotiating bilateral agreements.

2.5.2. Uranium Supply, Enrichment and Reprocessing

Natural uranium is currently procured from three sources: Partnership or joint-venture production, long term contracts and spot market contracts.

Enrichment is provided by the U.S., Russia and the European Community (France, Germany, United Kingdom, and the Netherlands). The fuel elements are manufactured in the U.S., the European Community (Belgium, Germany, United Kingdom, Spain, and Sweden) and Russia.

Reprocessing contracts with COGEMA and BNFL cover about one third of total nuclear fuel to be irradiated. MOX elements with recycled plutonium have been used in the Beznau I power plant since 1978. Today, the use of MOX is a standard operational procedure in both Beznau plants. The Gösgen NPP uses MOX elements since June 1997.

2.5.3. Waste Management and Storage

According to Swiss law, radioactive waste generated in Switzerland has to be disposed off domestically, although exceptions may be granted by the Government. All radioactive waste has to undergo geological disposal. The generators of radioactive waste, i.e. the operators of the nuclear power plants and the Federal State for the radioactive waste from medicine, industry and research, are responsible for the management including disposal. No disposal facility is yet in operation, thus all

radioactive waste is kept in storage facilities. Each nuclear power plant has sufficient storage capacity for its own wastes. Radioactive waste from medicine, industry and research is stored at the Federal Storage Facility operated by the research institute PSI.

Centralized interim storage of radioactive wastes

The utility-owned organization ZWILAG is responsible for storing spent fuel, HLW and other wastes, for conditioning specific L/ILW waste streams and for incinerating LLW wastes. Construction of the facility has been finalized and the operational license was issued in March 2000. Operation of the storage part started in 2001. By the end of 2003, 8 transport and storage castes with spent fuel and 4 casks with vitrified high level waste are stored. The conditioning and incineration installations are in various stages of commissioning. The realization of this interim storage facility relieves the time-pressure for establishing final disposal routes.

Program for disposal of L/ILW

In 1994, the application for the federal general license for a L/ILW repository at the Wellenberg site was submitted and a request for a mining concession for the repository was made to the Canton of Nidwald, where the proposed repository should be sited. A public referendum in June 1995 refused to grant the mining concession by a narrow margin (52 to 48 %). Within the framework of the general license application, the safety authority's review came to positive conclusions. However, because the project was blocked on the political level, the general license procedure has been suspended since 1997.

On request by the federal energy minister, a working group discussed technical and socio-economical aspects of the Wellenberg project. In September 1998 the work of the technical group came to an end with positive results. From mid 1999 until early 2000 a new governmental working group EKRA (Expertengruppe Entsorgungskonzepte Radioaktive Abfälle) evaluated different waste management concepts and reviewed the Wellenberg project. Their report issued in February 2000 recommends continuing with the site investigation process.

In order to take into account public concerns (mainly monitoring/retrievability and public involvement in decision-making), the strategy for repository implementation has been adapted by the implementers. They adopted a step-wise approach. In a first step, the concession will be restricted to an exploratory drift. The repository project has been modified to include a phase of long term monitoring and easier retrievability.

In March 2000, the federal government and the government of the Canton of Nidwald agreed to continue site investigations and defined the steps to be taken. A new application for a mining concession only for the exploratory drift was submitted in January 2001. The granting of this concession was rejected at a referendum in September 2002 by 57.5 % of the citizens. As a consequence of this rejection, the site of Wellenberg had to be abandoned. A new site selection has now to be carried out.

Program for disposal of HLW and long-lived ILW

Within the HLW/ILW repository program, two host rock options are considered: Crystalline Bedrock (for which a comprehensive evaluation has been performed in 1994) and Opalinus Clay. The next milestone of the HLW program is to demonstrate that safe disposal is feasible in Switzerland.

A corresponding project has been submitted to the federal Government in December 2002. It is based on a model repository in Opalinus Clay in Zurich Weinland region. The geological database is provided by the results of the deep exploratory drilling at Benken, a 3D-seismik survey over an area of about 50 km^2 around Benken and the experiments at the Mont Terri rock laboratory. The project is

currently reviewed by the competent authorities; this should be completed by the end of 2004. The decision of the Federal Government is expected in 2006; it will fix the next steps of the HLW program.

2.6. Research and Development

The basis of the Swiss federal energy RD&D (research, development and demonstration) policy has been set in the Concept of Swiss Federal Energy Research 2004-2007 in which **r**egulatory safety research is mentioned with respect to decommissioning of nuclear power plants and safe disposal of radioactive wastes. It is the sixth such document since 1984. The Concept is intended to serve as a guideline for decision-makers in the energy research field within the Swiss federal administration, and at the same time as an energy research "roadmap" for the Cantons and the local authorities. These energy research concepts have been applied and been proven to be sound guidelines. According to the concept, the aim of RD&D is to help the realization of the basic objectives of Swiss energy policy: To ensure an energy supply that is safe, environmentally sound and economically feasible in the long-term, to secure the production and distribution of a sufficient amount of energy under optimal economic and ecological conditions, and to contribute to the rational and efficient use of energy. Its long-term goal is a significant reduction of carbon dioxide emission, leading to what is known as the "2000 Watt Society". In the shorter term, this calls for serious efforts to reduce pollution through the development of improved energy technology as well as through a more efficient use of energy. Technical progress alone will not be sufficient to accomplish these objectives: significant socio-economic changes will also be required.

The co-ordination and monitoring of public sector energy RD&D programs is one of the tasks of the Swiss Federal Office of Energy (SFOE). It acts on advice from the Federal Energy Research Commission. The Office's duties include the updating of Swiss energy RD&D, putting research findings to good use, leasing with private sector energy RD&D programs and ensuring the links with international research projects.

In order to consider long-lasting effects in the policy of planning with respect to the energy supply concepts nuclear energy plays a significant role. Since almost 40 % of the energy produced in Switzerland is nuclear, its research budget actually is about half to that of the renewable energy.

For the operation of nuclear power plants, for the radiation protection and for the disposal of radioactive waste in Switzerland safety research plays a predominant role. The Paul Scherrer Institute (PSI) plays a significant role in regulatory research activities and additional guarantees that the scientific knowledge in nuclear technology be maintained in the future. It is of crucial importance that all safety related areas be covered in the monitoring of national and international documents in order to keep in touch with the actual state of the art (requirement of the Nuclear Energy Law). When prioritizing new research programs the Swiss Nuclear Safety Inspectorate (HSK) takes into account two goals, the promotion of areas required for the improvement of technical and operational aspects important for the review of nuclear power plants and the maintenance of competence itself making Switzerland attractive for research and industry. For the safety of the Swiss Nuclear Power plants it is important to have a minimum of scientists and technical experts within the own country, since by buying know-how from abroad national independence and trustworthiness in the inspection activities will decrease increasingly.

Paul Scherrer Institute (PSI)

The PSI is a multi-disciplinary research centre for natural sciences and technology. In national and international collaboration with universities, other research institutes and industry, PSI is active in solid state physics, materials sciences, elementary particle physics, life sciences, nuclear and non-nuclear energy research, and energy-related ecology.

The Institute's priorities lie in areas of basic and applied research, particularly in fields which are relevant for sustainable development, as well as of major importance for teaching and training, but which are beyond the possibilities of a single university department. PSI develops and operates complex research installations which call for especially high standards of know-how, experience and professionalism, and is one of the world's leading user laboratories for the national and international scientific community. Through its research, PSI acquires new basic knowledge and actively pursues its application in industry.

The mission of PSI is:

- To conceive, design, build and operate large, complex research facilities for the scientific community (User-Lab mission for universities, other research institutes and industry).
- To carry out fundamental and applied research in:
  - Solid state physics and materials sciences (investigation of the atomic structure of solid matter and liquids by means of particle beams and radiation; micro- and nano-technology).
  - Particle physics (study of fundamental interactions of matter; search for rare decays of elementary particles) and Astrophysics (study of stellar atmosphere, dark matter, solar spectroscopy; development of X-ray detectors).
  - Life sciences (cancer therapy and medical diagnosis using particle beams, effects of radiation on living organisms, structural biology).
  - Nuclear and non-nuclear energy and energy related environmental research (reactor safety, system analysis and scientific services, thermo hydraulics, material aging safe disposal of radioactive wastes; new methods for energy production and storage, energy systems analysis).

The Swiss Synchrotron Light Source (SLS) of the PSI started operating since August 2001. The investment costs for this facility are 159 million Swiss francs. The Spallation Neutron Source SINQ is in operation since 7 years and produces neutrons with a proton beam on the SINQ target of more then 1.7 mA. SINQ is a continuous Spallation Neutron Source with a flux of about 10E14 n s^{-1} cm^{-2}, the first of its kind in the world. SINQ and SLS initiated a strong shift of the research focus towards the study of the structure of materials and strengthen the national and international User-Lab mission of PSI for universities, other research institutions and for industrial laboratories. About 2/3 of the annual budget of PSI are dedicated to the user-lab mission.

Energy Research

Nuclear energy research at PSI will be reduced further and concentrate for the next planning period 2004-2007 on *reactor safety and safety-related operational problems of Swiss NPP* and on *nuclear waste disposal*. With a reduced effort, safety features of *advanced reactor concepts*, which rely on inherent safety mechanisms and on passive system layouts (to a greater extent than today's plants), will continue to be investigated.

Presently, PSI invests almost 180 personal years per year in nuclear energy related activities. One third of the overall costs of nuclear energy research are being externally funded by the Swiss Utilities and the NAGRA, the Safety Authority (HSK) and other research supporting agencies. Most of this support occurs in the framework of long-term research contracts, several projects have been approved under the EU Framework Programs.

The goals of nuclear energy research at PSI are

- To maintain and further develop the scientific competence on an internationally high level with the aim of a safe use of nuclear energy also in the future;
- To educate the next generation of scientists and technicians in the framework of attractive research, in a possibly close co-operation with the universities;

- To treat scientific issues up to expertises on specific questions and to provide scientific / technical services including the safe operation of plants needed hereto;
- To actively follow discernible evolutions in safety requirements and characteristics of future nuclear power plants and fuel cycles, primarily reflecting the sustainability potential of nuclear power.

The *LWR safety research* program is centered on transient analyses of Swiss NPPs and on NPP life extension (ageing and other material problems). Further effort is invested in safety related operational issues of existing NPPs (e.g. primary water contamination, PIE). Research on severe accidents and man-machine interaction is conducted in the framework of international co-operation (i.e. the PHEBUS program in France and the Halden Reactor Project in Norway).

The *waste management research* program mainly focuses on performance and safety assessment of waste repositories (i.e. characterization of waste forms, repository near-field and far-field studies). Emphasis is put on development of models of relevant mechanisms for nuclide transport in the geosphere and their validation by experiments, and on data acquisition for safety analysis. The work is done in close co-operation with NAGRA.

The research program on the safety of *advanced reactor systems* concentrates today mainly on topics of advanced LWRs. The investigation of passive decay heat removal and fission product retention in advanced LWRs is undertaken at PSI with a large experimental facility (PANDA), in close co-operation with the EPRI research program and with the financial support of the Swiss utilities. The aim of the program was to analyze passive safety features of advanced PWR and BWR concepts from industrial partners.

2.7. International Co-operation and Initiatives

Well established bilateral relations with French and German authorities in the nuclear field have been cultivated by the Swiss Government. Within this framework, French and Swiss regulatory authorities began with common inspections of their nuclear installations. Differences between the two inspection systems were mainly found in the formality of inspections, the extension of inspection programs and the formation of inspectors. Since these inspections have been very instructive for both parties, they will be repeated in the coming years.

Switzerland welcomes the efforts made by the OECD to enforce collaboration between the International Energy Agency (IEA) and the Nuclear Energy Agency (NEA). At the OECD/NEA, the Swiss Nuclear Safety Inspectorate (HSK) is represented on the committees Committee on Nuclear Regulatory Activities (CNRA), Committee on the Safety of Nuclear Installations (CSNI), Committee on Radiation Protection and Public Health (CRPPH) and Radioactive Waste Management Committee (RWMC). Besides, HSK is involved in the decision-making bodies and teams of the IAEA, in particular the commission for safety standards (CSS), the Nuclear Safety Standards Committee (NUSSC), the Radiation Safety Standards Committee (RASSC), the Transport Safety Standards Advisory Committee (TRANSCC) and the Waste Safety Standards Committee (WASSC). Further international unions in which HSK participates are the Western European Nuclear Regulators' Association (WENRA), the Nuclear Regulatory Working Group of the European Commission (NRWG) and the Network of Regulators of Countries with small Nuclear Programs (NERS).

In November 2003 the first review meeting with respect to the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" has taken place in Vienna. The Joint Convention is the first international instrument that deals with the safety of management and storage of radioactive waste and spent fuel in countries with and without nuclear programs. It also considerably elaborates on and expands the existing IAEA nuclear safety regime and promotes international standards in the area ensuring that there are effective defenses against potential hazards during all stages of management of such materials, and preventing accidents with radiological consequences. It has been recognized that within the framework of its national law Switzerland has taken all the necessary legislative, regulatory, and administrative measures for implementing its

obligations under this Convention. In addition to the above mentioned review process a group of international experts verified the safety aspects within the demonstration of the disposal feasibility.

With the start in 2002 of Project SWISS-UKRAINE the abilities, the experience and the effectiveness of the Ukrainian nuclear safety authorities should all improve. The work is concentrated on the training of personnel and on the transfer of knowledge in the field of the most important safety activities. The financing of the project is guaranteed by DEZA and IAEA.

The third and last stage of Project SWISRUS, in progress since 1994, was tackled in mid 2002. By means of a concrete safety analysis for the Russian pressurized water reactor Novovoronezh-5, employees of the Russian regulatory agency were trained in the handling of modern analysis tools. SWISRUS III has as its goals to carry out probabilistic safety analyses for the plant status of shut-down and reduced power, to build up an official quality management program, and to implement new guidelines for Russian nuclear power stations.

Nuclear safety is one of the major concerns worldwide. It goes without saying that risk coming from a malfunctioning nuclear power plant cannot be confined within the national borders of a country, and that a possible incident might have catastrophic consequences on all the neighbors. Therefore Switzerland supports Eastern European countries in maintaining and improving the safety of their nuclear installations. In this respect HSK participated substantially in the conception and introduced its experience for the establishment of the Centre for Nuclear Safety in Eastern European Europe (CENS). Opened in Bratislava (Slovakia) on September 2002 this new centre of competence (http://www.censee.org) focuses on training and further education of employees of the supervisory authorities. Being financially supported by the Swiss Agency for Development and Cooperation (DEZA) CENS helps nuclear safety authorities carry out the safety analyses in Eastern Europe in order to finally become independent and to elaborate networking among all involved stakeholders. It benefits from synergies and collaborations with international organizations in the field of nuclear safety. Very important partners are the IAEA, the Nuclear Safety Commission (NRC), the OECD Nuclear Energy Agency and the German “Gesellschaft für Anlagen und Reaktorsicherheit” (GRS).

In 2003, only one year after its inauguration, CENS is now financially independent to a degree of 50 %. On August 2003 it has been certified to be meeting the standards set out under ISO 9001:2000 which is primarily concerned with “quality management” and creates transparency. Several orders and contracts from IAEA and GRS, but also training courses such as “Severe accident analysis and MELCOR Code” and “Effective Inspection Training Course” helped make CENS to an internationally recognized competence centre. At the moment it is involved in the preparation of the Armenian authority to obtain an ISO-certified quality management system.

2.8. Human Resources Development

There is no university level nuclear engineering degree in Switzerland. However, nuclear technology related courses are offered at the Federal Institutes of Technology in Zurich (ETHZ) and Lausanne (EPFL). The EPFL operates a research reactor for educational purposes. At the canton level, the University of Basel offers courses in reactor physics and operates a research reactor for educational purposes. Nuclear education and training at the technical level is offered at a “reactor” school for nuclear plant operators at the Paul Scherrer Institute, which makes use of the reactors in Lausanne and Basel. Power plant operators also receive on-the-job training and continuing training at their facilities.

3. NATIONAL LAWS AND REGULATIONS

3.1. Safety Authority and the Licensing Process

After a two-year consultation phase, the new Nuclear Energy Act had been adopted by Parliament in March 2003, and will presumably be implemented by the Federal Council at the beginning of 2005. The revision process on the 1959 Federal Acts on Atomic Energy and on the 1978 Federal Decree on the atomic energy act, which lasted for the past 30 years, will thus be terminated.

The new Nuclear Energy Acts includes the following main points: the nuclear energy option is left open (possibility to build new nuclear power plants), with the possibility of a referendum against the construction of new nuclear installations, intensified say of the site cantons and neighbor cantons as well as of the neighbor states in the preparation of a general license decision for new nuclear installations, the introduction of a 10-year moratorium on the export of nuclear fuel for reprocessing (2006 - 2016), the abstention from a legal time limit on the operation period of nuclear power plants, provisions on the decommissioning of nuclear installations, a concept of monitored long-term geological disposal of radioactive waste (combines elements of final disposal and reversibility), a stronger role of the government in managing disposal issues, a funding system for decommissioning and waste management costs including solidarity of operators of nuclear power plants, the coordination of licensing procedures (pooling of all Federal and Cantonal licenses in one single license), the general possibility to appeal against license decisions.

The Federal Council will not be able to bring the new Act into effect before the beginning of 2005 since a variety of legislative tools still need to be prepared. Various provisions of the Nuclear Energy Act need to be fine-tuned in the Nuclear Energy Ordinance, and new regulations need to be incorporated. The current applicable law (Atomic Energy Act, 1959) provides only some basic principles of the requirements regarding nuclear safety and safeguards (nonproliferation and security). Important details are governed by the guidelines issued by the safety authorities. Parts of the comprehensive set of guidelines of the Swiss Federal Nuclear Safety Inspectorate (HSK / DSN) must be incorporated in the new ordinances.

The preparatory work has been going on since the beginning of 2001. An administerial working group has fundamentally redesigned the main Nuclear Energy Ordinance. However, the implementation of the Nuclear Energy Act will require further new ordinances. These are to be elaborated after completion of the Nuclear Energy Ordinance. Additionally, existing ordinances need to be modified. The following comments are based on the new Nuclear Energy Act:

As hitherto, the construction and operation of nuclear facilities and any changes in their purpose, nature or size require a general license prior to the granting of technical licenses. Nuclear facilities are installations designed for the use of nuclear power, for the extraction, production, use, processing or storage of nuclear material, and for the disposal of radioactive wastes. The general license determines the site and the main features of the project. It is essentially a political decision.

The application for a general license must be particularly accompanied by:

- A concept for the decommissioning of the installation or for the monitoring and the closure of the deep-geological depository;
- The demonstration of feasibility of disposal of the radioactive waste produced in this nuclear installation;
- The demonstration of the suitability of the site for deep-geological depositories.

The Federal Council transmits the application for consultation to the cantons, federal authorities and neighbor countries concerned. It also arranges for various expert reports to be prepared, mainly by the Swiss Federal Nuclear Safety Inspectorate. The application, the statements and experts' reports are made available to the public along with any supporting documents. Anyone

may then submit written objections to the Federal Chancellery concerning the granting of the general license.

The site canton, neighboring cantons and countries enjoy extended participation rights, as they must be involved in the general license granting procedure. Their concerns need to be considered as far as they do not unproportionally restrict the project. Finally, after having examined the application, the opinions given during the consultations, the experts' reports and any objection made, the Federal Council reaches a positive or negative decision; the granting of a general license must also be approved by the Federal Assembly. A referendum can be held against the approval by the Federal; 50 000 voters can demand a public vote on the project. If the Swiss electorate ratifies the project, the application for a construction license may be submitted.

Licenses for constructing, operating, modifying or decommissioning a nuclear installation as well as licenses for geological investigations with regard to the construction of a deep-geological depository are primarily of technical nature since the main requirements relate to nuclear safety. The new provision is that all other procedures for non-nuclear licenses necessary for the realization of the project, will be integrated in the same procedure (e.g. cantonal licenses concerning construction and land use planning, protection of workers). Thus, there will be only one single license granted by the Federal Department of Environment, Transport, Energy and Communication. The expropriation procedure will also be partly integrated in this procedure. The application for a license for constructing, operating or modifying a nuclear installation must be particularly accompanied by a technical report (safety analysis report). All further documentation must be submitted according to the respective non-nuclear laws.

The documents necessary for the license will be published for public consultation. The concerned parties according to the administrative procedure have the possibility to appeal. Also the canton where the installation is to be located will be consulted. If the canton rejects the application and if the Federal Department will nevertheless grant the license, the canton can appeal against this decision.

The Federal Department decides on the application and on the appeals. There is a possibility to appeal against this decision at the Appeals Commission of the Federal Department for Environment, Transport, Energy and Communication (Federal Administrative Court). The Appeals Commission’s decision can be appealed at the Federal Court.

The radiation protection regulations concerning the use of nuclear energy are regulated essentially in the Radiation Protection Act. This applies also to the fields of medicine, industry and research.

For the import, export, transit and transportation of nuclear fuel a license is required, which is granted by the Swiss Federal Office of Energy (BFE). The transport must satisfy the rules of the Safety Series Nr. 6 of the IAEA.

The liability of the operator is unlimited. At the present time, all operators of nuclear installations must take out insurance with a Swiss insurer for at least 1 000 million Swiss Francs for each installation, plus at least 100 million for interest payable and procedural costs. The same cover applies to transport operations for which the operator is liable. In the case of transit of nuclear material, insurance must amount to at least 50 million, plus at least 5 million for interest payable and procedural costs.

The 1983 Nuclear Energy Liability Act is currently undergoing a complete revision. The main amendment concerns a significant increase in the current liability coverage of 1 billion Swiss francs, and the creation of the prerequisites for ratification of international treaties on nuclear energy liability. Regarding a deep-geological depository, the liability will subrogate to the Confederation after the closure of the depository.

A Nuclear Damage Fund was set up by the Federal Council. The fund is independent and managed by the Federal Office of Energy. The task of the Fund is to cover nuclear operators up to 1 000 million Swiss francs for each nuclear installation or transport operation (plus 100 million for interest and procedural costs), in as much as the damage exceeds the amount covered by private insurance or if it is excluded from such cover. Operators and holders of transport licenses pay contributions into the Fund.

The costs of decommissioning the nuclear power plants are estimated at 1.5 billion Swiss francs. To cover this amount, a Decommissioning Fund was established in 1984. The fund is legally independent from the operators. The owners of the nuclear power plants are paying contributions to this public fund on an annual basis. At the end of 2002, the fund totaled about 844 million francs. The amount necessary for decommissioning has to be ready 40 years after operation started. The investment strategy aims at an optimal balance of risk and performance. Investments in companies controlled by the owners of the nuclear power plants are not allowed.

The total costs of radioactive waste management are estimated at 13.1 billion Swiss francs. This amount is backed by reserves of the owners of the nuclear power plants which reached 7.24 billion Swiss francs at the end of 1998. According to the new Ordinance on the waste management fund the plant owners have to transfer the accumulated reserves into the fund within several years. Additional yearly payments into the fund have to be made in order to cover the costs arising after the end of plant operation. Costs resulting while the plant is still operating continue to be paid for directly by the owners. At the end of 2002, the fund totaled about SFR 1432 million. Also this fund is legally independent from the operators.

3.2. Main National Laws and Regulations in Nuclear Power

Note: Reference to the original publication is given in parenthesis: (RO 732. 0).

The following data apply to the currently applicable, most important decrees. Some of them, as mentioned above, will gradually be replaced starting 1 January 2005.

General legislation

- Atomic energy act (RO 732.0)
- Federal decree on the atomic energy Act (RO 732.01)
- Atomic energy ordinance (RO 732.11)
- Act on the control of goods to be used for civil and military purposes, and of special military goods (RO 946.202)

Organization and structure

- Ordinance on the Swiss Federal Nuclear Safety Commission (RO 732.21)
- Ordinance on the Paul Scherrer Institute (RO 414.163.1)
- Ordinance on the National Alert Center (RO 732.34)

Protection against Radiation

- Radiological protection act (RO 814.50)
- Radiological protection ordinance (RO 814.501)
- Ordinance on interventions in case of increase of radioactivity levels (RO 732.32)
- Ordinance on measures to protect the vicinity of nuclear installations in case of emergencies (RO 732.33)

Regulatory regime for nuclear installations

- Atomic Energy Act (RO 732.0)
- Federal decree on the atomic energy act (RO 732.01)
- Ordinance on the decommissioning fund (RO 732.013)
- Ordinance on the waste management fund (RO 732.014)
- Ordinance on the surveillance of nuclear utilities (RO 732.22)

Radioactive waste management

- Ordinance on preparatory measures taken in respect of management of a radioactive repository (RO 732.11)
- Ordinance on the collection of radioactive waste (RO 814.557)

Civil liability

- Nuclear energy liability act (RO 732.441)
- Nuclear energy liability ordinance (RO 732.44)

4. CURRENT ISSUES AND DEVELOPMENTS ON NUCLEAR POWER

4.1. Energy Policy

In May 2003, the Swiss electorate rejected two popular initiatives on nuclear power ("Moratorium Plus" which aimed at the extension of the ban on the construction of new nuclear power plants for another ten years until 2010, and "Strom ohne Atom" which demanded the gradual closure of all existing Swiss nuclear power plants after a 30 year life-span, and the stop of any reprocessing of spent fuel).

The new Nuclear Energy Law which had been adopted by Parliament in March 2003 will enter into force on 1 January, 2005. The main points of the new law have been mentioned in chapter 3.

4.2. Privatization and deregulation

Current legislation does not prohibit competition in the Swiss power sector, but it is prevented in the absence of third-party access obligations. The cantonal legislation on public service obligations and monopolies is generally vague because it was established long before discussions about market reform. However, in most cases distributors do have an obligation to supply in their areas.

In December 2000, the Parliament passed the Electricity Market Law (EML) to liberalize the electricity market. The power industry and consumers welcomed the law, considering that it would reduce prices, provide a more stable energy investment climate, improve international competitiveness and harmonies the Swiss power market with the rest of Western Europe. Major opposition to the law came from labor unions that argued that the law would lead to privatization of the distribution companies and to job cuts in the electricity industry. They also argued that electricity prices would increase and that the electricity sector needs to remain regulated to avoid power shortages and speculative behavior. At the public referendum held in September 2002, the EML was rejected by a majority of the electorate.

Currently, most of the parties agree that efficiency needs to be increased in the electricity sector and that it would be detrimental for Switzerland to fall behind European development. Following

rejection of the EML, several parliamentary initiatives were submitted on the subject of the electricity market. The Federal Department of Environment, Transport, Energy and Communication appointed an expert commission in March 2003. Its purpose is to lay down the basic form the new electricity industry structure should take with the help of the support groups by early 2004. The draft legislation is intended to be submitted for formal consultation in spring 2004.

4.3. Role of the government in the nuclear R& D

The two topical areas for nuclear energy R&D are fission and fusion. The majority of funds within the fission area are directed at R&D to improve the safety of existing power plants. Only a small amount of funds is directed towards future fission energy systems. The government also spends a relatively minor amount of public money on R&D relating to radioactive waste, with the majority of funding coming from Nagra. Almost all R&D work related to fission is accomplished at the Paul Scherrer Institute (PSI). In February 2002, Switzerland became a member of the Generation IV International Forum, and is planning on participating in forthcoming research projects as a means of maintaining and using the technical competence of the PSI.

Participation in international fusion research (EURATOM) through experiments using facilities located in Switzerland remains the focus of fusion research. The main nuclear fusion areas of research relate to plasma physics with the bulk of activity occurring at the Federal Institute of Technology in Lausanne. Fusion is perceived as a long-term alternative and only basic research is being pursued at this time.

Publicly funded energy R&D decreased steadily and significantly, by about 30%, from 1992 through 2000. Both the public and private sectors fund energy R&D. In 2001, 10% (51 million Swiss Francs) of the totality of private and public funding was used for R&D on nuclear power.

Switzerland places emphasis on the importance of international collaboration given its limited R&D resources.

4.5. Safety and waste management issues

According to Swiss law, safe handling and disposal of radioactive waste are the responsibility of the waste producers. In 1972, the utilities operating nuclear power plants and the Confederation, which is responsible for radioactive waste from research activities and radioisotope production and uses, founded the National Cooperative for the Disposal of Radioactive Waste (Nagra). Nagra is responsible for the disposal of all categories of radioactive waste and for any R&D that may be required.

Expenditures associated with the management and disposal of radioactive waste from nuclear power plants are financed by waste producers (nuclear utilities), and charged to consumers as a component of electricity prices. The Confederation manages the Radioactive Waste Management Fund that which was established in 2000 to secure the costs of radioactive waste disposal after the decommissioning of a nuclear power plant.

Nuclear power plant owners are responsible for funding their decommissioning. The total estimated costs of decommissioning the five units currently in operation amount to 1 800 million Swiss Francs. The Confederation manages the Decommissioning that was established in 1984 to ensure that the necessary funds are available for decommissioning nuclear power plants after 40 years of operation. The nuclear utilities pay contributions to this fund on an annual basis.

Currently, Switzerland has no radioactive waste disposal facilities. Until final repositories become operational, all categories of radioactive waste are held in interim storage facilities either at the nuclear power plants or at a centralized facility. In 2001, a centralized interim storage facility, located on the site of the Paul Scherrer Institute (PSI) at Würenlingen, began to accept intermediate

and high-level waste. The facility is operated by Zwischenlager Würenlingen (ZWILAG), a utility-owned organization. A repository project for low and intermediate-level waste had been planned at Wellenberg in central Switzerland. However, the electorate rejected a bill that would have permitted the construction of an underground test facility.

A repository for high-level waste will not be required before 2020. Nagra is pursuing a program based on the concept of a deep geological repository and focusing on the crystalline bedrock of northern Aargau and the opalinus clay of the Zürcher Weinland in the northern part of the Swiss plateau. In 2002, Nagra submitted a report demonstrating how and where spent fuel, high-level and long-lived intermediate-level waste can be safely disposed of in Switzerland. The federal safety authorities are currently evaluating the report with a view to allowing the government to take a decision regarding the management of theses wastes around 2006. Identification of a site will be the subject of a later general license procedure.

4.6. Nuclear Energy and Climate Change

The government has analyzed the impacts of different scenarios on the electricity generation mix and on the CO_2 emissions up to the year 2030. These analyses (energy perspectives) are currently being revised and extended to the year 2050. The nuclear phase-out scenarios induce substantially higher CO_2 emissions than the reference scenario (with continuous use of nuclear power until the end of the operation periods of the existing nuclear power plants).

4.7. Other issues

None.

REFERENCES

[1] Geschichte der Kerntechnik in der Schweiz, Die ersten 30 Jahre 1939-1969, Published by the Swiss Society of Nuclear Engineers (SOSIN).

[2] Data & Statistics/The World Bank, www.worldbank.org/data.

[3] IAEA Power Reactor Information System (PRIS).

[4] IAEA Energy and Economic Data Base (EEDB).

Appendix 1

INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

AGREEMENTS WITH THE IAEA

• Membership of the International Atomic Energy Agency	Member	5 April 1957
• Amendments of Article VI & XIV.A of the IAEA Statute	Ratified	24 August 2000
• NPT related agreement INFCIRC/264	Entry into force:	6 September 1978
• Additional protocol	Signature	16 June 2000
• Improved procedures for designation of safeguards inspectors	Accepted on:	16 January 1989
• Supplementary agreement on provision of technical assistance by the IAEA	Not applicable	
• Agreement on privileges and immunities	Entry into force:	16 September 1969

OTHER RELEVANT INTERNATIONAL TREATIES etc.

• NPT	Entry into force:	9 March 1977
• EURATOM		Non-member
• Convention on the physical protection of nuclear material (INFCIRC/274)	Entry into force:	8 February 1987
• Convention on early notification of a nuclear accident	Entry into force:	1 July 1988
• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	1 July 1988
• Conventions on civil liability for nuclear damage	Non-party	
• Joint protocol	Signature:	21 September 1988
• Protocol to amend the Vienna convention on civil liability for nuclear damage	Not signed	
• Convention on supplementary compensation for nuclear damage	Not signed	

• Convention on nuclear safety	Entry into Force:	11 December 1996
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management	Entry into Force:	18 June 2001
• ZANGGER Committee	Member	
• Nuclear Export Guidelines	Adopted	
• Acceptance of NUSS Codes	Summary: Codes are appropriate safety principles and a basis for national requirements. National practice meets requirements though are some deviations.	
• Nuclear Suppliers Group		Member

BILATERAL AGREEMENTS

• Co-operation between the Government of Switzerland and the Government of Australia concerning peaceful uses of nuclear energy	1988
• Co-operation between the Government of Switzerland and the Government of Canada concerning peaceful uses of nuclear energy	1989
• Co-operation between the Government of Switzerland and the Government of China concerning peaceful uses of nuclear energy	1988
• Co-operation between the Government of Switzerland and the Government of France concerning peaceful uses of nuclear energy	1990
• Co-operation between the Government of Switzerland and the Government of Russia concerning peaceful uses of nuclear energy	1990
• Co-operation between the Government of Switzerland and the Government of Sweden concerning peaceful uses of nuclear energy	1968
• Co-operation between the Government of Switzerland and the Government of the United States of America concerning peaceful uses of nuclear energy	1966
• Agreement between the Government of Switzerland and the Government of France on information exchange in case of incidents or accidents with possible radiological consequences	1989
• Agreement between the Government of Switzerland and the Government of Germany on mutual information in case of construction and operation of nuclear facilities near the border	1983
• Agreement between the Government of Switzerland and the Government of Italy on quick information exchange in case of nuclear accidents	1989
• Agreement between the Government of Switzerland and the Government of Germany in the field of nuclear liability	1987
• Convention between the Government of Switzerland and the Government of Germany on the radioprotection in case of an alert	1978
• Exchange of letters between the Government of Switzerland and the Government of France for the creation of a mixed commission on nuclear safety	1989

Appendix 2

DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

NATIONAL ATOMIC ENERGY AUTHORITY

Bundesamt für Energie Worblentalstrasse 32 CH-3063 Ittigen (for visits) CH-3003 Berne (postal address)	Tel: +41-31-322 56 11 Fax: +41-31-323 25 00 http://www.admin.ch/bfe
Hauptabteilung für die Sicherheit der Kernanlagen (HSK) CH-5232 Villigen - HSK	Tel: +41-56-310 38 11 Fax: +41-56-310 39 07 http://www.hsk.ch

MAIN POWER UTILITIES

Kernkraftwerk Goesgen-Daeniken AG CH-4658 Daeniken	Tel: +41-62-288 20 00 Fax: +41-62-288 20 01
Kernkraftwerk Leibstadt AG CH-5325 Leibstadt	Tel: +41-56-267 71 11 Fax: +41-56-247 14 37
NOK Nordostschweizerische Kraftwerke AG Postfach CH-5401 Baden	Tel: +41-56-200 31 11 Fax: +41-56-200 37 55
NOK Nordostschweizerische Kraftwerke AG Kernkraftwerk Beznau CH-5312 Doettingen	Tel: +41-56-266 71 11 Fax: +41-56-266 77 01
BKW FMB Energie AG Viktoriaplatz 2 CH-3013 Bern	Tel: +41-31-330 51 11 Fax: +41-31-330 56 35
BKW FMB Energie AG Kernkraftwerk Mühleberg CH-3203 Mühleberg	Tel: +41-31-754 71 11 Fax: +41-31-754 71 20

OTHER NUCLEAR ORGANIZATIONS

NAGRA Hardstr. 73 CH-5430 Wettingen	Tel: +41-56-437 11 11 Fax: +41-56-437 12 07 http://www.nagra.ch
Verband Schweizerischer Elektrizitätsunternehmen (VSE) Postfach CH-8023 Zürich	Tel: +41-1-226 51 11 Fax: +41-1-226 51 91
Schweizerische Vereinigung für Atomenergie	http://www.atomenergie.ch/index.html
The European Nuclear Society (ENS)	http://nucnet.aey.ch/ens/

NucNet, The World's Nuclear News Agency	http://nucnet.aey.ch/nucnet/

NUCLEAR RESEARCH INSTITUTES

Paul Scherrer Institut CH-5232 Villigen-PSI	Tel: +41-56-310 21 11 Fax: +41-56-310 21 99 http://www.psi.ch/

OTHER RESEARCH INSTITUTES

CERN (European Laboratory for Particle Physics)	http://www.cern.ch/
Institute of High Energy Physics (University of Lausanne)	http://www-ipn.unil.ch/
Swiss Light Source (SLS)	http://www1.psi.ch/www_sls_hn/
CRPP (Plasma Physics Research Center) Lausanne	http://crppwww.epfl.ch/en/index.htm

UNIVERSITIES

Ecole Polytechnique Fédérale de Lausanne (EPFL)	http://www.epfl.ch/
Eidgenössische Technische Hochschule Zürich (ETH)	http://www.ethz.ch/
University of Basel	http://www.unibas.ch/
University of Bern	http://www.unibe.ch/
University of Fribourg	http://www.unifr.ch/home/welcome.html
University of Geneva	http://www.unige.ch/welcome.html
University of Lausanne	http://www.unil.ch/
University of Neuchâtel	http://www.unine.ch/
University of Zurich	http://www.unizh.ch/

INTERNATIONAL ORGANIZATIONS

Intergovernmental Panel on Climate Change (IPCC)	http://www.ipcc.ch/
United Nations Environment Program (UNEP)	http://www.unep.org/
United Nations Institute for Disarmament Research (UNIDIR)	http://www.unog.ch/unidir/
World Health Organization (WHO)	http://www.who.org/
World Meteorological Organization (WMO)	http://www.wmo.ch/

OTHER ORGANIZATIONS

Nuclear explosions recorded by the Swiss Seismological Service (ETH)	http://seismo.ethz.ch/bsv/nuclear_explosions.html
Energy efficiency in Switzerland	http://www.energie.ch/
European Physical Society (EPS)	http://epswww.epfl.ch/