SWITZERLAND

SWITZERLAND

1. GENERAL INFORMATION

1.1. General Overview

Switzerland is one of the most mountainous countries in Europe, with most of its area covered by the Alps and the Jura. Between these mountain systems lies the Swiss Plateau, about 400 m above sea level and about 50 km wide. The principal river system is formed by the Rhine and its tributaries: Aare, Limmat etc. Other important rivers are the Rhine, Ticino, Inn. The Swiss rivers are not navigable for any appreciable extent. The most important lakes are those of Geneva, Constance, Lugano, the Lago Maggiore, and the lakes of Neuchâtel, Lucerne, Zürich, Brienz and Thun.

On the Plateau and in the lower valleys a temperate climate prevails with a mean annual temperature of about 10 °C. Precipitation on the plateau is about 900 mm annually, higher regions generally receive more precipitation. Much of the precipitation occurs as snow during the winter. In the Alps are large glaciers and the peaks of most mountains are snow covered throughout the year. Predominant winds come from the north-east (cold) or from the west and in certain regions from the south (warm and dry).

The population of Switzerland, roughly 7 million people, is essentially concentrated in small towns of the Swiss Plateau (Table 1). The main languages are German, French, and Italian with a minority of Retho-romansch. Foreigners and their families represent some 15% of the population.

TABLE 1. POPULATION INFORMATION

	1960	1970	1980	1990	1997	1998	1999	2000	Growth rate (%) 1980 to 1998
Population (millions)	5.4	6.3	6.3	6.7	7.1	7.3	7.2	7.2	0.8
Population density (inhabitants/km²)	130	152	153	163	172	177.4	173.7	173.7	0.8
Urban population as percent of total	51	55	57	60	68	68	68		-
Area (1000 km²)	41. 3								

Source: IAEA Energy and Economic Data Base; Data & Statistics/The World Bank).

Switzerland has a highly developed industrialized economy and one of the highest standards of living in the world. Manufacturing, based on private enterprise, is the dominant economic sector, followed by trade, finance and services. Agriculture accounts for less than 4% of the national output. The natural resources are essentially limited to the hydro electric potential.

Switzerland is a Confederation of States governed under a Constitution adopted in 1874 and amended several times since. The Swiss political system combines direct and indirect democracy, the electorate chooses its representatives and decides on important issues by means of referenda, initiatives or petitions. The executive power is the Federal Council, seven members elected by the Swiss Parliament, one of them being elected President for one year. The Swiss Parliament consists of two houses: The Council of States (46 members) and the National Council (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.

1.2. Economic Indicators

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

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

	1970	1980	1990	1997 (3)	1998 (3)	1999 (3)	Growth rate (%) 1980 to 1998
GDP (1)	21,922	107,470	228,410	256,000	262,000	259,000	5.1
GDP (2) per capita	3,496	17,005	34,040	36,056	35,890	35,000	4.4

(1) Millions of current US$.
(3) Data & Statistics/The World Bank
(2) Current US$ per capita.
Source: IAEA Energy and Economic Data Base; Data & Statistics/The World Bank).

1.3. Energy Situation

Switzerland has no major energy resources except for hydro, which reserves amount to about 14 Exajoules according the IAEA Energy and Economic Data Base (Table 3). The Swiss energy statistics are shown in Tables 4.1 and 4.2.

TABLE 3. ESTIMATED ENERGY RESERVES

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 - 1998) by a factor of 10.
Source: IAEA Energy and Economic Data Base.

TABLE 4.1. ENERGY STATISTICS

Exajoule

	1960	1970	1980	1990	1999	2000	Average annual growth rate (%) 1960 to 1980	1980 to 2000
Energy consumption								
- Total (1)	0.40	0.80	0.92	1.10	1.13	1.16	4.31	1.13
- Solids (2)	0.08	0.03	0.02	0.03	0.01	0.01	-5.56	-4.62
- Liquids	0.15	0.51	0.51	0.51	0.50	0.51	6.21	-0.04
- Gases			0.04	0.08	0.11	0.12	-38.64	5.53
- Primary electricity (3)	0.17	0.25	0.35	0.49	0.51	0.52	3.70	2.05
Energy production								
- Total	0.18	0.31	0.45	0.52	0.56	0.57	4.69	1.16
- Solids		0.01	0.01	0.01	0.01	0.01		-0.89
- Primary electricity (3)	0.18	0.30	0.44	0.51	0.55	0.56	4.58	1.19
Net import (Import - Export)								
- Total	0.24	0.58	0.61	0.64	0.68	0.70	4.83	0.71
- Solids	0.08	0.02	0.02	0.02	0.00	0.00	-5.82	-13.00
- Liquids	0.16	0.55	0.55	0.55	0.57	0.58	6.28	0.32
- Gases	0.00	0.00	0.04	0.08	0.11	0.12	-38.64	5.53

(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.
Source: IAEA Energy and Economic Data Base.

Switzerland depends to 81 % (1999) on imported energy (in terms of primary energy supplies). There are no domestic oil and gas resources. The share of electricity - partially a domestic energy - in total final energy consumption was 21.4 % in 1999. The Government promotes the use of new renewable energies like solar energy and environmental heat. This helped the renewables, incl. hydropower, to reach 16.3 % of final energy consumption. The share of electricity from renewable sources was 12.3 %, wood contributed 2.4 %, waste 0.9 % and other renewable energy sources the remaining 0.7 %.

TABLE 4.2. NATIONAL ENERGY STATISTICS

	1996		1997		1998		1999	
	TJ	%	TJ	%	TJ	%	TJ	%
Coal	5 950	0.5	4 590	0.4	3 810	0.3	3 980	0.4
Oil	535 070	48.8	528 480	48.5	547 860	49.0	547 200	48.5
Gas	99 490	9.1	96 060	8.8	98 880	8.8	102 450	9.1
Nuclear	258 760	23.6	261 500	24.0	265 830	23.8	256 610	22.7
Hydro	133 640	12.2	156 570	14.4	154 330	13.8	182 770	16.2
Other	66 090	6.0	66 360	6.1	69 610	6.2	71 880	6.4
Total*	1 099 000	100.3	1 113 560	102.2	1 140 320	101.9	1 164 890	103.3
Electricity trade	-3 400	-0.3	-24 310	-2.2	-21 430	-1.9	-36 820	-3.3

* Includes electricity trade
Source: Swiss Energy Statistics (Swiss Federal Office of Energy).

Total final energy consumption fell 0.8 % in 2000 after rising 1.7 % in 1999. The warmer weather, a marked increase in the oil price and the activities within the scope of the energy policy programme "Energy 2000" led to energy savings in spite of rising economic activity and further population growth.

1.4. Energy Policy

In 1999, Parliament approved a law on the reduction of CO_2 emissions, which allows the government to introduce a CO_2 tax from 2004 if the national target cannot be achieved otherwise. The law was put into force on 1 May 2000. Furthermore, Parliament agreed to introduce an energy levy and an energy tax on non renewable energy. In the first case, the revenues will be used to lower the compulsory supplementary wage costs, in the second case to promote renewable energies, energy efficiency and hydroelectric power. A plebiscite about this package will take place on 24 September 2000.

The follow-up programme to the „Energy 2000 Action Plan“ has been launched in January 2001 under the name of "Swiss Energy". Its objectives are to reduce the consumption of fossil fuels, to stabilise the consumption of electricity and to increase the contribution of renewables to energy supply.

As the European Union opens the electricity market across the continent, the Swiss government is following suit. The draft of the Electricity Market Law takes a step-by-step approach to the opening of the Swiss market, which would be accessible to all consumers six years after the law takes effect. The proposed law will open Switzerland's electricity market on the basis of regulated third party access. The law has been accepted by Parliament on 15 December 2000. Due to a referendum, a popular ballot on the law will probably be held in March 2002.

2. ELECTRICITY SECTOR

2.1. Structure of the Electricity Sector

The electricity industry consists of 1 200 production and distribution utilities. Of these, 970 utilities account for 65 % of supply and are owned or controlled by local authorities. Many of these are also responsible for the provision of water services. The private sector companies account for 25 % of supply and the remaining 10 % comes from auto producers. There are six main regional suppliers and three large municipal suppliers in Basel, Bern and Zürich. Except for nuclear energy, the Federal Government's influence is relatively low on the electricity sector. Local authorities exert influence through their participation’s or through cantonal legislation.

A new law on water protection has taken effect on 1st November 1992, it places minimum flow requirements on all new hydro plants and on existing plants when present concessions are to be renewed. The Government estimates that this law will eventually reduce existing plant capacity by no more than 6 % by 2070 and that cantonal regulations will double this estimated loss; new plants and the expansion of existing ones should nonetheless more than offset the total loss of capacity.

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 Transport, Communication and Energy in 1989 cover the principles of tariff setting in networks.

2.2. Decision Making Process

The Swiss Federal Government has adopted the action programme "Energy 2000" which concern the energy as a whole (see Section 1. 4). This action programme defines also the objectives in the electricity sector. The Federal Department of Transports, Communications and Energy is the Swiss regulatory body for this action programme, in co-operation with the authorities of the Cantons. It supports R&D programmes, 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 prepare 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.

2.3. Main Indicators

On a yearly basis, Switzerland is still an electricity exporting country. The whole year of 2000 resulted in a positive export balance of 7.1 TW·h, i.e. 10.8 % of produced electricity. 39.9 TW·h had to be imported and 47.0 TW·h were exported. In the winter of 1999/2000, exports exceeded imports by 1.9 TW·h after a surplus of 0.02 TW·h in the winter of 1998/1999. 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

	1996		1997		1998		1999		2000	
	TW·h	%	TW·h	%	TW·h	%	TW·h	%	TW·h	%
Hydro	29.7	53.9	34.8	57.4	34.3	56.3	40.6	60.9	37.9	57.9
Nuclear	23.7	43.0	24.0	39.6	24.3	40.0	23.5	35.3	24.9	38.2
Fossil	1.7	3.1	1.8	3.0	2.3	3.7	2.6	3.8	2.5	3.9
Total	55.1	100.0	60.6	100.0	60.9	100.0	66.7	100.0	65.3	100.0

Source: Country Information.

TABLE 5.2. ELECTRICITY USE

	1996		1997		1998		1999		2000	
	TW·h	%	TW·h	%	TW·h	%	TW·h	%	TW·h	%
Households	15.3	31.4	14.9	30.6	15.1	30.5	15.6	30.4	15.7	30.0
Agriculture	0.9	1.9	0.9	1.9	0.9	1.9	0.9	1.9	1.0	1.9
Industry+Craft	16.0	32.9	16.2	33.4	16.7	33.5	17.0	33.2	18.1	34.5
Services	12.6	25.8	12.7	26.1	12.9	26.1	13.6	26.6	13.4	25.6
Transportation	3.9	8.0	3.9	8.0	4.0	8.0	4.1	7.9	4.1	8.0
- Railways only	(2.4)	(4.9)	(2.4)	(5.0)	(2.5)	(5.0)	(2.5)	(5.0)	(2.6)	(5.0)
Total	48.7	100.0	48.6	100.0	49.6	100.0	51.2	100.0	52.4	100.0

Source: Country Information.

TABLE 5.3. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

							Average annual growth rate (%)	
	1960	1970	1980	1990	1999	2000	1960 to 1980	1980 to 2000
Electricity production (TW·h)								
- Total [(1)]	19.07	32.57	47.06	55.80	62.20	62.13	4.62	1.40
- Thermal	0.25	1.39	0.96	2.51	4.95	3.72	7.03	7.02
- Hydro	18.83	28.72	32.44	30.98	33.72	33.46	2.76	0.15
- Nuclear		2.45	13.66	22.30	23.52	24.95		3.06
Capacity of electrical plants (GWe)								
- Total	5.84	10.54	13.99	16.30	16.78	16.81	4.46	0.92
- Thermal	0.20	0.57	0.60	0.77	0.97	1.00	5.65	2.56
- Hydro	5.64	9.62	11.45	12.35	12.61	12.62	3.60	0.49
- Nuclear		0.35	1.94	3.18	3.19	3.19		2.52

[(1)] Electricity losses are not included.
Source: IAEA Energy and Economic Data Base.

In order to ensure the supply for the coming decades, Swiss electricity companies signed contracts with foreign suppliers. Long-term agreements with the French Electricity Company (EDF), covering the years 1977 to 2040, give them access to a maximum power capacity of 2 455 GWe. Appropriate sites for profitable new hydroelectric power plants have become scarce in Switzerland. Upgrading of existing plants is more common than the construction of new facilities. Hydraulic power capacity will thereby rise by 0.02 GW (+0.2 %) and the electricity production by 54 GW·h (+0.1 %) in the next few years. 20 GW·h (+0.1 %) will be gained in winter production and 34 GW·h (+0.2 %) in the summer.

TABLE 6. ENERGY RELATED RATIOS

	1960	1970	1980	1990	1996	1998	1999	2000
Energy consumption per capita (GJ/capita)	74	130	146	161	160	152	157	161
Electricity per capita (kWh/capita)	3,311	4,494	5,878	7,604	7,585	7,510	7,756	7,818
Electricity production/Energy production (%)	101	102	100	100	102	102	104	102
Nuclear/Total electricity (%)	0	8	29	41	43	40	39	41
Ratio of external dependency (%)[(1)]	60	72	66	58	60	60	60	61
Load factor of electricity plants								
- Total (%)	37	35	38	39	39	43	42	42
- Thermal	14	28	18	33	42	45	58	43
- Hydro	38	34	32	29	27	32	31	30
- Nuclear	-	80	80	83	88	87	84	89

[(1)] Net import / Total energy consumption
Source: IAEA Energy and Economic Database.

3. NUCLEAR POWER SITUATION

3.1. Historical Development

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 programme. BBC was later joined by Sulzer Brothers and Escher-Wyss. Initial studies dealt with graphite-carbon dioxide reactor concepts, but from 1952 on, development was concentrated on heavy water 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 Wurenlingen, 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 (Eidgenoschisches Institut für Reaktorforschung). In 1988, the fusion of the 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 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. On 22 November 2000, the Government granted permission to the Paul Scherrer Institute (PSI) to decommission its SAPHIRE research reactor. Based on reports by the Swiss Federal Safety Inspectorate (HSK) and the Federal Commission for the Safety of Nuclear Installations (KSA), the Government accepted the PSI’s decommissioning concept. DIORIT, the first reactor designed and constructed by Swiss scientists, reached criticality on 15 August 1960. DIORIT has been definitely shut down in 1977.

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. Unfortunately, on 21 January 1969, the Lucens 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.

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.

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 favour of construction in 1985, and finally parliamentary decision in 1989 to kill the project definitively. The Chernobyl accident of spring 1986 had drastically affected the political climate. An other project, less advanced than Kaiseraugst, Graben has also been cancelled.

The nuclear controversy led to several anti-nuclear initiatives:

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 4.2 and 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 organised aiming at the ban of the construction of new NPPs until 2010 and the closure of all NPPs after a 30 year live-span.

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" (interim storage for radioactive wastes from nuclear power plants), on the site of the Paul Scherrer Institute, should be operative in 2000, and a final storage for low and medium level radioactive wastes should be erected at the Wellenberg, in central Switzerland, in the coming years.

3.2. Status and Trends of Nuclear Power

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 350 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 Muehleberg 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.

In September 1990, Switzerland voted by referendum to impose a ten year moratorium, which prevents any plan to undertake the construction of a new nuclear unit before the turn of the century.

TABLE 7.1. STATUS AND TRENDS OF NUCLEAR POWER PLANTS

Station	Type	Capacity	Operator	Status	Reactor Supplier
BEZNAU-1	PWR	365	NOK	Operational	WEST
BEZNAU-2	PWR	357	NOK	Operational	WEST
GOESGEN	PWR	970	KKG	Operational	KWU
LEIBSTADT	BWR	1145	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: IAEA Power Reactor Information System as of 31-Dec-2000.

TABLE 7.2. PERFORMANCE OF NUCLEAR POWER PLANTS

Power Plant	1999		2000	
	Production TW·h	Availability %	Production TW·h	Availability %
Beznau 1	2.81	88.4	2.50	78.5
Beznau 2	2.21	70.7	3.05	95.1
Mühleberg	2.71	87.2	2.83	90.7
Gösgen	7.47	88.6	7.74	91.7
Leibstadt	8.32	88.0	8.83	87.7
Total	23.52	86.2	24.95	89.1

Source: Country Information.

The performance of the Swiss NPPs has been good in 2000. Their load factors attained values between 79,4 % and 95.8 %. One unplanned scram had no consequences for installations, personnel or the environment. Among 7 events subject to notification, all were classified INES level 0. The Beznau and Gösgen plants also produced 1 100.9 TJ of process and district heat in 2000.

Once more, efficient radiation protection led to low values of collective occupational exposure accumulated by persons at the Swiss NPPs in 2000. The values of collective doses, in person-Sievert (person-Sv), at each plant in 2000 were as follows: 0.64 (NPP Beznau Unit 1 – KKB-1), 0.14 (NPP Beznau Unit 2 – KKB-2), 0.79 (NPP Mühleberg – KKM), 0.53 (NPP Gösgen – KKG) and 0.98 (NPP Leibstadt – KKL). At NPP Beznau 1, the reactor protection and control system was replaced in the summer of 2000 after 31 years of operation. The new system is computer based and has the same functions.

Due to contaminations, all authorisations for spent fuel transports from Swiss nuclear power plants were suspended in May 1998. The operators were asked to investigate the causes of contamination and to propose remedial actions to prevent them in the future. The results of the investigations performed were published in a report issued in March 1999 by the Swiss Federal Nuclear Safety Inspectorate (HSK). According to the causes identified, HSK defines technical, organisational and radiological measures to be taken in view of future spent fuel transports. These measures are expected to markedly reduce the frequency and degree of contamination, thus ensuring safe spent fuel transportation.

Based on this assessment and after implementation of the requested measures, new authorisations for the shipment of spent fuel to the reprocessing facility of COGEMA in La Hague (F) were granted to the nuclear power plants Gösgen and Beznau. At the occasion of the first transport in September 1999 from the Gösgen plant, the media was supplied with detailed information. By the end of 1999, four transports (three from Gösgen and one from Beznau) hade been carried out without any contamination exceeding the limit. It is expected that spent fuel transports from the other Swiss nuclear power plants Mühleberg and Leibstadt, and to the reprocessing facility of BNFL in Sellafield (GB), will resume in the year 2000.

3.3. Current Policy Issues

The opponents to nuclear energy handed in two propositions for national referendums demanding constitutional amendments. "MoratoriumPlus" aims at the extension of the ban on the construction of new NPPs for another ten years until 2010. To the difference of the first moratorium, even power upgrades in existing plants should be banned. Also, the voters would be enabled to decide if a NPP should be authorised to operate in excess of 40 years. "Strom ohne Atom" demands the gradual closure of all existing Swiss NPPs after a 30 year life-span. The plants of Mühleberg and Beznau would have to be shut down two years after the acceptance of the amendment by the voters, Gösgen in 2009 and Leibstadt in 2014. The referendum also wants to stop any reprocessing of spent fuel. To force a federal vote, the opponents to nuclear energy had to collect at least 100 000 signatures before the end of September 1999. They gathered 120 000 signatures. The Government will take a position on the proposal. Parliament will then discuss the matter and take a decision. Finally, there will be a public vote on both initiatives probably in 2003.

The Federal Act regarding the Atomic Energy Law has been extended to the end of 2010. Both the Federal Act and the Atomic Energy Law are incomplete. In the summer of 2000, the draft of a new Nuclear Energy Law was sent to the Cantons, political parties and interested associations for consultation. On 28 February 2001, the Federal Council (Government) sent his "message" on the new initiatives and the draft for the new Nuclear Energy Law to Parliament. The government decided to use the draft law to counter the two new initiatives. The main points of the draft are: the possibility to build new NPPs, the abstention from a legal time limit on the operation license of NPPs, the maintenance of the general license with the possibility of a referendum, the interdiction to reprocess nuclear fuel (existing contracts can be fulfilled), provisions on the decommissioning of nuclear installations, the concept of monitored long-term geological disposal (combines elements of final disposal and reversibility), a funding system for decommissioning and waste management costs, the simplification of licensing procedures, the general possibility to appeal.

Parliament will discuss the initiatives and take a decision. Regarding the Nuclear Energy Law, it may change the draft and then pass it. Finally, there will be a public vote on both initiatives in about 2003 and probably on the same date on the new Nuclear Energy Law in case a referendum against this law is sought.

In 1994, the Federal Council renewed the licence for the operation of the nuclear power plant of Beznau II. Several persons claimed in Strasbourg against Switzerland on grounds of violation of the European Convention on Human Rights (ECHR), as it is not possible to appeal against such decisions to a Swiss court. In his decision of 6 April 2000, the European Court of Human Rights found no violation of the Articles 6 para. 1 and 13 of the Convention.

In the spring of 1998, reports became public about radioactive contamination above recommended levels on rail wagons transporting spent nuclear fuel from Swiss NPPs to the French reprocessing plant of La Hague in 1997 and 1998. The questions arising from these contamination and especially their uncertain origin convinced the Swiss Federal Office of Energy to suspend until further notice all authorisations for rail and road transports of spent nuclear fuel on 8 May 1998. The transports were resumed in August 1999 based on a report by the Swiss Federal Nuclear Safety Inspectorate (HSK) of March 1999 which confirmed that the contamination hat no health consequences for the employees of the railway nor the population.

3.4. 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 Transports, Communications and Energy (EVED) is a regulatory body, which reports to the Federal Council. The Federal Office of Energy (BEW), also a regulatory body, reports to the Federal Department of Transports, Communications and Energy (EVED). The Swiss Nuclear Inspectorate is part of the Federal Office of Energy (BEW). The Commission for Safety of Atomic Installation Reports to the Federal Council via the Federal Office of Energy (BEW).

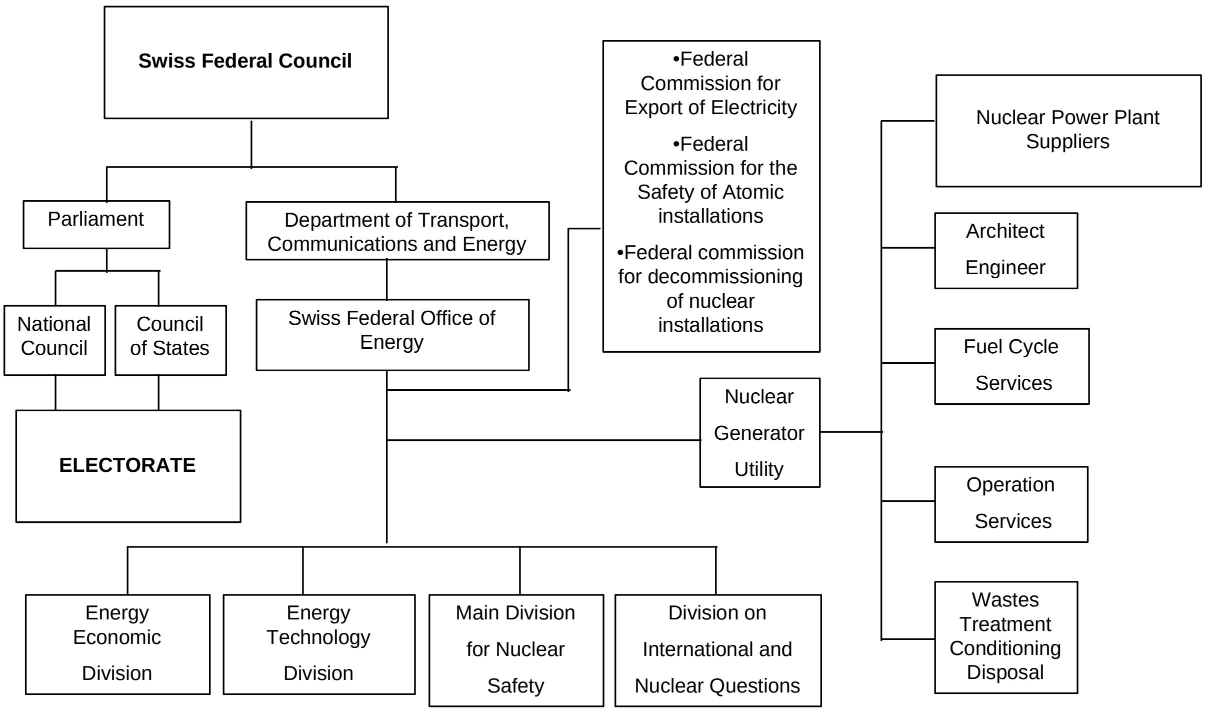

FIG. 1. Institutional Structure

4. NUCLEAR POWER INDUSTRY

4.1. Supply of Nuclear Power Plants

– 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))

- Rütschi Pumpen AG
  (Pumps for all circuits in nuclear engineering, canned motor pumps, pumps with shaft seals, complete piping systems with instruments and accessories; authorized by ASME-N-Stamp Class 1, 2, 3).

- Sulzer Thermtec Ltd, Nuclear services and valves
  (Development and manufacture of valves for safety and isolating functions of NPPs. Control valves, system-medium operated valves, solenoid and pilot operated valves, inductive position indicators and transmitters, high density fuel storage racks, systems for filtered containment venting, special devices and plant equipment, primary and secondary circuit piping systems and components, welded special constructions, structures and vessels, planning and engineering services for new design, retrofit and component re-qualification, plant life extension, preliminary investigations and studies, structural mechanics and fluid dynamics consulting, manufacture and procurement of equipment, planning and execution of comprehensive erection works, such as steam generator replacements, base-line and in-service inspection services, performance of leak test services).

4.2. Operation of NPPs

4.2.1. 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 350 MW(e) (net); NSSS by Westinghouse, turbine island by BBC)
- Kernkraftwerk Goesgen-Daeniken AG.

(PWR, 965 MW(e) (net), NSSS by KWU, turbine island by KWU)
- Kernkraftwerk Leibstadt AG.
  (BWR, 1030 MW(e) (net); NSSS by GESTSCO, turbine island by BBC)

4.2.2. Operation and maintenance service suppliers

- ABB, Asea Brown Boveri AG (see also 4. 1)
- 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) (see also 4. 1)
- 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 (see also 4. 1)

4.2.3. 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)

4.3. Fuel Cycle and Waste Management Service Supply

4.3.1. 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 controls in accordance with bilateral agreements and the guidelines of the Nuclear Suppliers Group (NSG) as well as negotiating bilateral agreements.

4.3.2. 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, the Netherlands). The fuel elements are manufactured in the U.S., the European Community (Belgium, Germany, United Kingdom, Spain, 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.

4.3.3. Waste Management and Storage

According to Swiss law, radioactive waste generated in Switzerland has to be disposed off in our country, although exceptions may be granted by the Government. The Government considers the feasibility of the safe final storage of radioactive waste in Switzerland to have been proven as far as low and intermediate level waste (L/ILW) is concerned. For high level waste (HLW), the safety of disposal in deep geological formations is considered to be proven in general.

<u>Centralised interim storage of radioactive wastes</u>

The utility-owned organisation ZWILAG is responsible for storing spent fuel, HLW and other wastes, for conditioning specific L/ILW waste streams and for incinerating wastes. Construction of the facility has been finalised and the operational license was issued in March 2000. Operation of ZWILAG will commence this year in a step-wise process which is based on a step-wise regulatory clearance process. The successful realisation of this interim storage facility relieves the time-pressure for establishing final disposal routes.

<u>Programme for disposal of L/ILW</u>

In 1994, the application for the federal general licence 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 licence application, the safety authority's review came to positive conclusions. However, because the project is blocked on the political level, the general licence 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 to continue 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. In early June it was agreed that this process will be guided and monitored by an expert group "Kantonale Fachgruppe Wellenberg", KFW, chaired by Prof. Walter Wildi. The main issues to be covered by this group include (i) the review of transparent exclusion criteria to be applied in the pilot tunnel for site investigation, (ii) the review of the waste inventory for the proposed repository, (iii) the review of the exploration concept taking into account the modified repository concept. For that purpose both the implementers (GNW/Nagra) and the regulatory body provided corresponding reports. Based on the work of KFW, it has been possible for the implementers to submit an application for a concession for the exploratory drift at the end of January 2001. A popular ballot in Nidwald on a concession for the exploratory drift is expected late in 2001 at the earliest.

Programme for disposal of HLW and long-lived ILW

Within the HLW/ILW repository programme, 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 programme is to demonstrate that a site for a repository exists in Switzerland. The corresponding documentation will be submitted to the authorities in 2002. The implementation of a repository would take place only towards the middle of this century and depends upon the evaluation of multinational options.

For the Opalinus Clay option, the drilling of a 1050 m bore hole at Benken (25 km north of Zurich) was finalised in spring 1999. The results of this bore hole together with a 3D-seismic survey over an area of about 50 km2 around Benken and the results from the Mont Terri Project provide an excellent and very promising database to assess the feasibility of a HLW repository.

4.4. Research and Development Activities

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 2000-2003**. It is the fifth 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 realisation 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 goals of the RD&D strategy of the present Concept 2000-2003 are set in the perspective of a sustainable development and the strategy is:

- to increase the RD&D activities in the "conservation" field, particularly by promoting the P+D (pilot and demonstration installations) projects; the funding will increase from 31 % today to 34 % of the total RD&D budget in 2003;
- to continue the effort in the field of "renewable energy sources" (including an important support of P+D projects) maintaining the funding at 34 %;
- and to reduce the "nuclear energy" research funding from 26 % to 23 %.

The co-ordination and monitoring of public sector energy RD&D programmes 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 programmes and ensuring the links with international research projects.

In 1998, public energy RD&D was funded with 182.6 MCHF (million Swiss francs) and in 1999 with 179.9 MCHF, of which 32.7 MCHF were available for R&D projects. The total amounts are equivalent to 122.07 and 119.7 MUSD (million US dollars at 1999 conversion rate). From these figures 35.4 MUSD (i.e. 29.1%) in 1998 and 30.6 MUSD (i.e. 25.6%) in 1999 were invested into "nuclear energy" research and 43.9 MUSD (i.e. 36.0%) in 1998 and 43.8 MUSD (i.e. 36.6%) in 1999 into research on "renewable energy sources". The figures for the year 2000 are estimated at 187 MCHF (124 MUSD); about 25% of this amount went into "nuclear energy" research and about 37% into research on "renewable energy sources" (Table 8).

TABLE 8. SWISS GOVERNMENT ENERGY RD&D EXPENSES IN MCHF (MILLION SWISS FRANCS) NOMINAL AND IN MUSD (MILLION US DOLLARS) AT 1998 PRICES

Total energy RD&D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
MCHF (nominal)	187.2	199.0	220.6	223.3	220.8	215.1	206.7	196.9	182.6	179.99	187
MUSD (1998)	144.5	144.9	156.3	154.2	149.9	144.5	138.2	131.9	122.0	119.7	124

Source: as published in the "Energy Policies of IEA Countries -1999 Review", Paris 2000, except for the figures for 1998, 1999 and 2000.

Paul Scherrer Institute (PSI)

The Paul Scherrer Institute (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 related research and scientific services, safety studies on the disposal of radioactive wastes; new methods for energy production and storage, energy systems analysis).

PSI started in 1998 with the construction of an advanced Swiss Synchrotron Light Source (SLS), which will go into operation in August 2001. The investment costs for this facility are 159 million Swiss francs. The Spallation Neutron Source SINQ is in operation since 4 years and produces neutrons with a proton beam on the SINQ target of more then 1.7 mA in 2000. 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.

In 2000, the extension of proton therapy facilities (PROSCAN project) started with the evaluation of a dedicated cyclotron (250 MeV) and the development of an advanced spot scanning gantry for the treatment of deep-seated tumours with protons. The goal of this project is the development of proton beam technology, which can be transferred to major hospitals for high quality cancer treatment.

For the year 2001, PSI has a budget of about 250 million Swiss francs (external funding and social and infrastructure costs included) and a staff of about 1200 employees, including 250 scientists and technicians paid by external funds. More than 200 doctoral students are working at PSI on their thesis.

Energy Research

About 30 % of PSI's annual government funding of 222 million Swiss francs is being used for energy and energy related environmental research. The non-nuclear energy research has increased by 25 % over the last 10 years. Over the same period a more than 30 % reduction in PSI (government)-funded research activities related to nuclear energy was achieved. This reduction in the nuclear sector could be compensated, to a large extent, by external funding (i. e. utilities, safety authorities). The resources thus released where used for new research projects, primarily for the construction of new facilities and instrumentation (i.e. SINQ and SLS).

Nuclear energy research at PSI will be reduced further and concentrate for the next planning period 2000-2003 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 is 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 Programmes.

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* programme is centred 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 is conducted in the framework of international co-operation (i.e. the PHEBUS programme in France).

The *waste management research* programme mainly focuses on performance and safety assessment of waste repositories (i. e. characterisation 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 programme on the safety of *advanced reactor systems* concentrates today mainly on topics of advanced LWRs. Over the last 3 years, an experimental programme for the investigation of passive decay heat removal and fission product retention in advanced LWRs was undertaken at PSI with a large experimental facility (PANDA), in close co-operation with the EPRI research programme and with the financial support of the Swiss utilities. The aim of the programme was to analyse passive safety features of advanced PWR and BWR concepts from industrial partners.

Substantial experimental and analytical effort was invested over the last years in issues of *advanced fuel cycles*, mainly the development of uranium-free (inert matrix) fuels for increased ‘burning’ of plutonium. This programme will be terminated in 2003.

In 1999, an initiative was started to design, build, operate and examine an exploratory liquid lead-bismuth spallation target for 1 MW of beam power MEGAPIE (MEGAwatt PIlot Experiment), taking advantage of the existing spallation neutron facility at PSI. This 4-years programme costs about 10 million Swiss francs and will be conducted in an international collaboration with partners from France (CEA/CNRS), Germany (FZK) and other interested countries. The project will be an important contribution for the development of accelerated driven system (ADS) concepts.

4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

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 found mainly regarding the formality of inspections, the extension of inspection programmes 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). Nevertheless, Switzerland stated that difficulties were encountered during the process undertaken in this direction and noted that the competence of both agencies could be respected better. Switzerland will follow closely this subject.

Regarding the International Atomic Energy Agency (IAEA), the necessary documents have been prepared to allow the signature of the Additional Protocol. Furthermore, the Swiss government has already agreed to the modifications to the statutes of the agency as decided by the General Conference in 1999.

Finally, Switzerland will continue to follow with great attention the evolution of the international nuclear projects, in particular the MEGAPIE project, being realised within the 5th European framework programme and has ambitions to join the "Generation IV NPP Initiative" of the DOE, with PSI being the scientific agent involved in this co-operation..

5. NUCLEAR LAWS AND REGULATIONS

5.1. Regulatory Framework

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 producing nuclear energy or for obtaining, processing, storing or rendering harmless nuclear fuels and radioactive wastes. The general license determines the site and the main features of the project. The application for a general license must be accompanied by:

- proof of need: The installation or the power to be generated must meet a real need in the country. When determining such a need, account should be taken of possible financial savings, oil substitution and the development of other forms of energy;
- proof of safe disposal: The safe long-term disposal as well as final storage of the radioactive wastes from the installation are to be provided for along with decommissioning and possible dismantling after final shutdown.

The applicant must fulfill further conditions relating to insurance cover and technical capability. The written application sent to the Federal Chancellery is published in the "Feuille Fédérale" (Swiss Official Gazette) and 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, within 90 days following publication of the application. The Federal Council transmits the application to the cantons and federal Departments concerned, for consultation. It also arranges for various expert reports to be prepared, mainly by the Safety Division (Hauptabteilung fur die Sicherheit der Kernanlagen : HSK) of the Federal Office of Energy (Bundesamt für Energiewirtschaft : BEW). The outcome of the consultations and reports in the "Feuille Fédérale" mark the onset of a new 90-day period during which anyone may submit objections to the Federal Chancellery. The Federal Council then invites the cantons, federal Departments and the experts whose conclusions have been challenged to state their case. 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.

Licenses for constructing, operating or modifying a nuclear installation are primarily technical since the main requirements relate to nuclear safety. The conditions to be met and the procedure are identical in all cases. The application for a license for constructing, operating or modifying a nuclear installation must be accompanied by a technical report (safety analysis report) which demonstrate the safe operation of the facility under normal, abnormal and accidental conditions. The application and the safety report are published in the "Feuille Fédérale". During a period specified by the BEW, third parties may oppose the application. The HSK prepares a safety assessment accompanied with conditions and recommendations. This assessment is published in the "Feuille Fédérale". Finally, the canton where the installation is to be located is consulted. The Federal Council is responsible for issuing such licenses, the Federal Assembly is not consulted. Construction and operating licenses may be split up: the construction license into no more than three sub-licenses, the operating license into a commissioning and an operating license proper.

In addition to the Federal Government authorization, the applicant must obtain various authorizations under cantonal law (law on construction and land use planning, protection of the environment and landscape, protection of workers, forestry, fire protection, water protection, use of river water for cooling purposes). For the import, export, transit and transportation of nuclear fuel a license is required. This license is delivered by the Swiss federal office of Energy (BEW). 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 SF 500 million for each installation, plus at least SF 50 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 SF 50 million, plus at least SF 5 million for interest payable and procedural costs.

A Nuclear Damage Fund was set up by the Federal Council, it is independent and managed by the Federal Office of Energy (BEW). The task of the Fund is to cover nuclear operators up to SF 1,000 million for each nuclear installation or transport operation (plus SF 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.

5.2. Main National Laws and Regulations

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

General legislation

- Federal Law on the peaceful use of atomic energy (RO 732. 0)
- Bill on definitions and authorizations in the atomic energy field (RO 732. 11)
- Bill on export and transit of goods and technology in the field of ABC weapons and missiles (RO 946. 225)

Organization and structure

- Bill on the federal commission about the safety of nuclear installations (RO 732. 21)
- Bill on the Paul Scherrer Institut (RO 414. 163. 1)
- Bill on the national alert center (RO 732. 34)
- Bill on the co-ordinated atomic and chemical protection (RO 501. 4)

Protection against Radiation

- Federal Law on radiation protection (RO 814. 50)
- Bill on the protection against radiation (RO 814. 51)

– Bill on the training of personnel in the radioprotection field (RO 814. 532. 1)
– Bill on measures to protect the vicinity of nuclear installations in case of emergencies (RO 732. 33)
– Bill on interventions in case of increase of radioactivity levels (RO 732. 32)

Regulatory regime for nuclear installations

– Federal Law on the peaceful use of atomic energy (RO 732. 0)
– Federal resolution related to the atomic energy Law (RO 732. 01)
– Bill on the funding for decommissioning of nuclear installations (RO 732. 013)
– Bill on the surveillance of nuclear utilities (RO 732. 22)

Radioactive waste management

– Bill on preventive measures taken in respect of management of a radioactive repository (RO 732. 11)
– Bill on collecting and dispatching of radioactive wastes (RO 814. 557)

Civil liability

– Bill on coverage of nuclear civil liability (RO 732. 441)
– Law on civil liability in nuclear affairs (RO 732. 44)

The costs of decommissioning the nuclear power plants are estimated at 1.5 billion francs. To cover this amount, a Decommissioning Fund was established in 1984. The owners of the nuclear power plants are paying contributions to this public fund on an annual basis. At the end of 1999, the fund totalled about 900 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 francs. This amount is backed by reserves of the owners of the NPPs which reached 7.24 billion francs at the end of 1998. According to the new Ordinance on the Radioactive 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.

5.3. 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

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 & Statisticst/The World Bank, www.worldbank.org/data.

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

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

Appendix 1

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.psi.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

OTHER NUCLEAR ORGANIZATIONS

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
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/