INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

SWITZERLAND

2003 Review

OECD

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

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- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

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- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

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Disclaimer

This report is based on the IEA review team visit to Switzerland that took place in November 2002. It was drafted prior to the results of the 18 May 2003 public vote on popular initiatives on nuclear power and the publication of the government's plans for electricity market reform.

On 18 May 2003, the general public rejected both the Moratorium Plus initiative with a 58.4% majority and the Power without Atoms initiative with a 66.3% majority. Consequently, the nuclear energy law can now be implemented, which implies further operation of existing nuclear plants as long as security allows and submission of new plants to public vote if a referendum is requested.

On 7 March 2003, the government announced plans to introduce a new law to reform the electricity market. In April 2003, it established a commission with representatives from all interest groups to plan the new law. This law should enter into force by mid-2007 at the latest.

In May 2003, the government proposed a plan to reduce the federal budget deficit, which would involve cutting the total budget of SwissEnergy. The government considers that this cut could be compensated by implementing new regulations or by imposing an energy tax, the revenue of which would be earmarked for SwissEnergy.

SUMMARY

The Energy 2000 Action Programme (Energy 2000) was the core of Swiss energy policy in the 1990s. It is succeeded by the SwissEnergy Programme (SwissEnergy) for the period 2001 to 2010. Energy 2000 had concrete objectives for electricity and fossil fuel consumption, increasing the use of non-hydro renewables and hydropower as well as upgrading the capacity of nuclear power plants. The totality of the Energy 2000 objectives were not achieved principally owing to inadequate funding, lack of energy efficiency regulation, excessive reliance on voluntary measures that were inadequately

taken by industry and the cantons' different degrees of implementation of federal energy efficiency recommendations. Performance and cost-benefit of the Energy 2000 policies and measures were carefully monitored and the experience gained was transferred to SwissEnergy, as demonstrated by the reallocation of certain resources. Additional reallocation may be required between renewables and energy efficiency programmes and measures. Given that the cantons have an important role in implementing SwissEnergy, particularly in the building sector, results of the cost-benefit analysis of different policies and measures as well as "best practices" should be widely shared and, where possible, harmonised between the cantons.

Security of supply is important for Switzerland, which is a landlocked country lacking fossil fuel resources. The government has a robust programme to ensure oil supply security, including its full compliance with the IEA 90-day obligation of net oil imports. Natural gas supply security is enhanced through the large number of interruptible contracts and compulsory stocks of heating oil, which are additional to the international stockholding obligations.

Within the IEA's 3 Es (Energy security, Environment and Economy), environmental issues are the priority of Swiss energy policy. Switzerland principally envisages to use actions implemented in the energy sector to achieve its Kyoto target of a reduction of greenhouse gas (GHG) emissions by 8% below 1990 levels by 2008 to 2012. SwissEnergy calls for a 10% reduction in carbon dioxide (CO_2) emissions below 1990 levels through reductions of consumption of combustibles by 15% and motor fuels by 8%. A variety of measures are proposed to meet these targets, including the development of voluntary commitments (VCs) and voluntary agreements (VAs) with industry and the imposition of a CO_2 "incentive" tax should other measures fail to bring about adequate reductions. Other measures include promotional activities and information dissemination programmes for industry, as well as regulations and standards for buildings, vehicles and electrical appliances.

Despite considerable efforts, the policies and measures still do not seem to be adequate to meet the Kyoto target or the more stringent national target for CO_2 reductions; according to IEA statistics, Swiss energy-related CO_2 emissions increased by 5.6% during 1990 to 2001. This issue may be better addressed if and when the CO_2 "incentive" tax is imposed but work needs to proceed promptly if this instrument is to be available in the near term. The government should further develop emissions trading and other flexible mechanisms given their potential economic benefits, even if these are only intended as supplementary and back-stop alternatives to domestic reductions. In this context, consideration might be given to whether a portion of the tax revenues could be devoted to purchasing GHG emissions permits from the international market.

Energy pricing and taxation need to be reviewed. Swiss heating oil prices are among the lowest in OECD member countries, partly because of the very low share of taxes by international comparison. This encourages neither energy saving nor the use of alternative energies with lower CO_2 emissions. Gasoline prices in Switzerland are lower than in neighbouring countries, leading to some "fuel tourism". On the other hand, natural gas prices for all consumers are among the highest in IEA member countries owing to rough topography, small market size, low connection density and the fragmented market structure. This discourages market penetration of natural gas. Electricity prices in Switzerland, particularly for small and medium-sized enterprises, are higher than European averages. This is partly explained by the taxes and charges set by the cantons and municipalities. Concerns exist regarding the efficiency of the operation of many publicly-owned small utilities and the profits they secure for their owners. The current price-setting mechanisms lack transparency and enable cross-subsidies from one consumer group to another. Some electricity is supplied free of charge or at low charge to local authorities, therefore jeopardising energy efficiency.

In 2001, nuclear power accounted for 25% of Switzerland's energy supply and 38% of power generation. In March 2003, the Federal Parliament endorsed a new Nuclear Energy Act that updates the current law from 1959. The law will do much to clarify the future role of nuclear energy in Switzerland. For economic, energy security and climate change mitigation reasons, the nuclear option should be kept open. Switzerland has interim storage of nuclear waste from nuclear energy production in Zwilag, with sufficient capacity for the expected lives of the current operating fleet; however disposal options still need to be defined. In 2002, voters in Nidwalden rejected the siting of an underground laboratory for the disposal of low- and intermediate-level nuclear waste. Despite this setback the government needs to continue to develop solutions.

A special feature of the Swiss political system is that citizens can approve legislation through referendums. Given the far-reaching impact of the referendums, it is vital that citizens are adequately informed on policy issues and the consequences of their votes. A public referendum on the Electricity Market Law (EML) was held in September 2002. The law proposal was rejected despite a broad political consensus. The government and market players are currently debating how the electricity market could develop; at the time of the IEA review team visit, no clear path had emerged. While respecting the results of the EML vote, the government should continue to incite competition in the market. An initial step could focus on allowing competition in the wholesale market by permitting the largest consumers and distribution companies to choose their suppliers. An independent regulator and an independent transmission system operator (TSO) should be established. The TSO could enable greater efficiency in the management of the transmission system and in cross-border trade and transit. Effective

unbundling is necessary to ensure transparent and non-discriminatory third party access (TPA).

The government also initiated legislation for gas market reform but the project was abandoned following the results of the public referendum on the EML. The gas industry is currently defining how to enable access within the present legislation, which allows negotiated TPA to high-pressure networks. This is commendable, but the government should step up its activities in monitoring the market and settling disputes in order to ensure transparent, fair and fast network access for both incumbents and new entrants. Routes to appeal should be defined and the decisions should come into force immediately in order to avoid incumbents delaying network access, for example by entering into lengthy court processes.

RECOMMENDATIONS

The government of Switzerland should:

General Energy Policy

- *Ensure a better balance in the overall energy policy by emphasising economic efficiency.*
- *Optimise the overall effect of the energy programmes and the use of resources by:*
  - *Developing programmes to assess the costs, benefits and "best practices" of energy policy implementation among and within the cantons;*
  - *Continuing the vigorous monitoring and cost-benefit assessment activities at federal level;*
  - *Reallocating resources to the most cost-effective policies and measures; and*
  - *Continuing to support the harmonisation of the cantons' energy and environmental programmes.*
- *Increase focus on pricing and taxation as energy policy tools in order to internalise the externalities and promote economic and energy efficiency.*
- *Increase public awareness of the consequences of energy-related popular initiatives and law proposals by analysing their potential impacts and communicate these to the general public.*

- *Develop and regularly update energy and CO_2 projections and scenarios for all sectors and fuels.*

Energy and the Environment

- *Take additional action to meet the GHG emissions reduction targets.*
- *Review energy-related climate change mitigation policies with a view to balancing efforts as the current focus on energy efficiency and renewables may not prove to be the most cost-effective solution.*
- *Develop implementation plans for the CO_2 "incentive" tax and emissions trading.*
- *Evaluate the effectiveness of VAs and VCs and envisage the possibility to extend them to all energy-intensive sectors, including oil refineries.*
- *Develop additional support programmes for the cantons to assist them in setting and implementing vehicle taxes that are proportional to CO_2 emissions, and federal programmes to support the innovative use of cleaner fuels in the transport sector.*

Energy Efficiency

- *Ensure clear allocation of responsibilities between the Confederation, the cantons and the various energy agencies. Aim to harmonise policies and measures by strengthening their collaboration.*
- *Continue and increase work on energy efficiency in buildings through:*
  - *Increasing energy efficiency in buildings in co-operation with the cantons;*
  - *Developing and disseminating building sector and space heating statistics; and*
  - *Encouraging individual metering of heating and hot water in existing buildings.*
- *Diversify energies for space heating.*
- *Intensify co-operation with consumer groups and environmental and business associations, including dissemination of information activities and planning and implementing labelling schemes and performance standards for appliances.*
- *Work to further engage financing institutions in the development of incentives for purchases and upgrades that improve energy-efficient infrastructure and equipment.*

Fossil Fuels

- *Use taxation of heating fuels as a tool to improve energy efficiency and address climate change.*
- *Link proposals for tax incentives to promote diesel fuel to further reductions in non-carbon emissions.*
- *Encourage industry to develop a natural gas infrastructure for gas use in the transport sector.*
- *Monitor pricing mechanisms at the natural gas distribution level to ensure transparency, cost-reflectiveness and non-discrimination.*
- *Encourage competition and induce efficiency in the gas market by:*
  - *Urging simple, fast and fair TPA to the networks as well as transparent and non-discriminatory rules for access and tariffs;*
  - *Providing resources to monitor the gas markets and settle disputes;*
  - *Ensuring that captive consumers also benefit from efficiency gains; and*
  - *Promoting the continuing depolitisation of the management of the gas utilities.*

Renewables

- *Continue to assess the cost-benefit of the renewables programmes, including subsidies, R&D and external costs, and ensure that the results are reflected in the allocation of financial resources. In particular, re-examine the cost-effectiveness of the solar energy programme and consider increasing resources for more cost-effective programmes, such as biomass and waste.*
- *Improve the framework for promoting renewables. Explore possibilities to introduce portfolio standards with tradable renewable energy certificates and review the feed-in tariff scheme.*

Nuclear Power

- *Maintain the nuclear option.*
- *Ensure that the general public is fully aware of the potential impacts of the nuclear initiatives and the draft nuclear law.*
- *Continue to take actions to develop safe radioactive waste repositories.*
- *Take actions to maintain sufficient levels of technological competence.*

Electricity and Heat

- *Ensure that adequate resources are devoted to price monitoring and protecting consumers from abusive electricity prices. Raise local authorities' awareness of economic, energy efficiency and environmental benefits of cost-reflective electricity pricing. Encourage them to phase out free electricity supplies to public consumers.*

- *After careful analysis of the vote on Electricity Market Law, continue efforts to introduce competition in electricity markets. Establish a national transmission system operator and a regulator, define the rules for TPA and allow market access for domestic and foreign suppliers, distribution companies and large consumers.*

- *Improve the possibilities for transmission network access by auctioning the capacities. Until a legal framework for market reform is in place, encourage industries to implement improvements.*

- *Study the economic potential for combined heat and power generation both in industry and space heating.*

Research and Development

- *Continue planning to facilitate the integration and alignment of near-term activities and long-term R&D objectives.*

ORGANISATION OF THE REVIEW

REVIEW TEAM

The International Energy Agency (IEA) 2003 in-depth review of the energy policies of Switzerland was undertaken by a team of energy policy specialists drawn from IEA member countries. The IEA review team visited Switzerland in November 2002 for discussions with the Energy Administration, energy industries and non-governmental organisations.

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Lea Gynther managed the review and drafted most of the report. Jonathan Pershing drafted the Energy and Environment chapter, and Robert-Rush Price drafted the Nuclear Power chapter and most of the Research and Development chapter. Monica Petit and Bertrand Sadin prepared the figures.

ORGANISATIONS VISITED

Agency of Renewable Energies and Efficient Application of Energy (AEE)

Board of the Conference of the Cantonal Energy Service

Canton of Geneva, Service of Energy (ScanE)

Canton of Zug, Energy Office

Canton of Zurich, Energy Service (AWEL)

Cemsuisse (the association for cement manufacturers)

Electrizitäts-Gesellschaft Laufenburg AG (EGL, power utility)

Energho (association for large consumers of energy and public buildings)

Energy Agency for Electric Appliances (EAE)

Energy Agency for the Economy (AEnEC)

Etrans Ltd (system co-ordinator of the Swiss transmission grid)

Federal Commission for Energy Research (CORE)

Federal Office for Water and Geology (FOWG)

IGEB (the association for energy-intensive industries)

Infras AG (consulting company)

Konsumenten Forum (kf, small consumers' association)

Minergie Programme Co-ordination Office

National Co-operative for the Disposal of Radioactive Waste (NAGRA)

Oil Industry Union (EV)

State Secretariat for Economic Affairs (Seco)

Swisselectric (association of the largest power utilities)

SwissEnergy Programme Office

Swisspower (electricity marketing and sales company)

Swiss Agency for Efficient Energy Use (SAFE)

Swiss Agency for the Environment, Forests and Landscape (SAEFL)

Swiss Association for Atomic Energy (SVA)

Swiss Association for Natural Gas Industry (VSG)

Swiss Business Federation (Economiesuisse)

Swiss Electricity Suppliers Association (VSE)

Swiss Energy Foundation (SES, environmental NGO)

Swiss Federal Institute of Technology, Zurich (ETHZ)

Swiss Federal Nuclear Safety Inspectorate (HSK/DSN)

Swiss Federal Office for Energy (SFOE)

Swiss Federal Office for National Economic Supply (FONES)

Swiss Federal Office for Spatial Development (ARE)

Swiss Federal Office of Transport (SFOT)

Swiss Federal Roads Authority (SFRA)

Swiss Federation of Trade Unions

The Price Surveillance Office

Zurich Municipal Electric Utility (EWZ)

The assistance and co-operation of all participants in the review are gratefully acknowledged.

REVIEW CRITERIA

The IEA *Shared Goals*, which were adopted by IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for in-depth reviews conducted by the Agency. The IEA *Shared Goals* are set out in Annex B.

GENERAL ENERGY POLICY

OVERVIEW

Switzerland[1] is a small, geographically isolated and landlocked country. The country's surface area is 41 000 km^2. Its location in the middle of the European energy markets makes it a potentially very important transit country for electricity, natural gas and freight. The population increased on average by 0.7% per annum between 1990 and 2001, reaching 7.3 million at the end of 2001. In 2001, its GDP per capita, measured using current purchasing power parities, was US$ 30 100[2], one of the highest in OECD member countries. Economic growth was slow in the 1990s but increased towards the end of the decade reaching 1.6% in 1999 and 3% in 2000. The Swiss economy did not escape the international slow-down and in 2001 its growth was about 1.3%, which was close to the OECD member country average. Switzerland is a federal country with 26 states (cantons); three of which are divided into half-cantons.

ENERGY MARKET

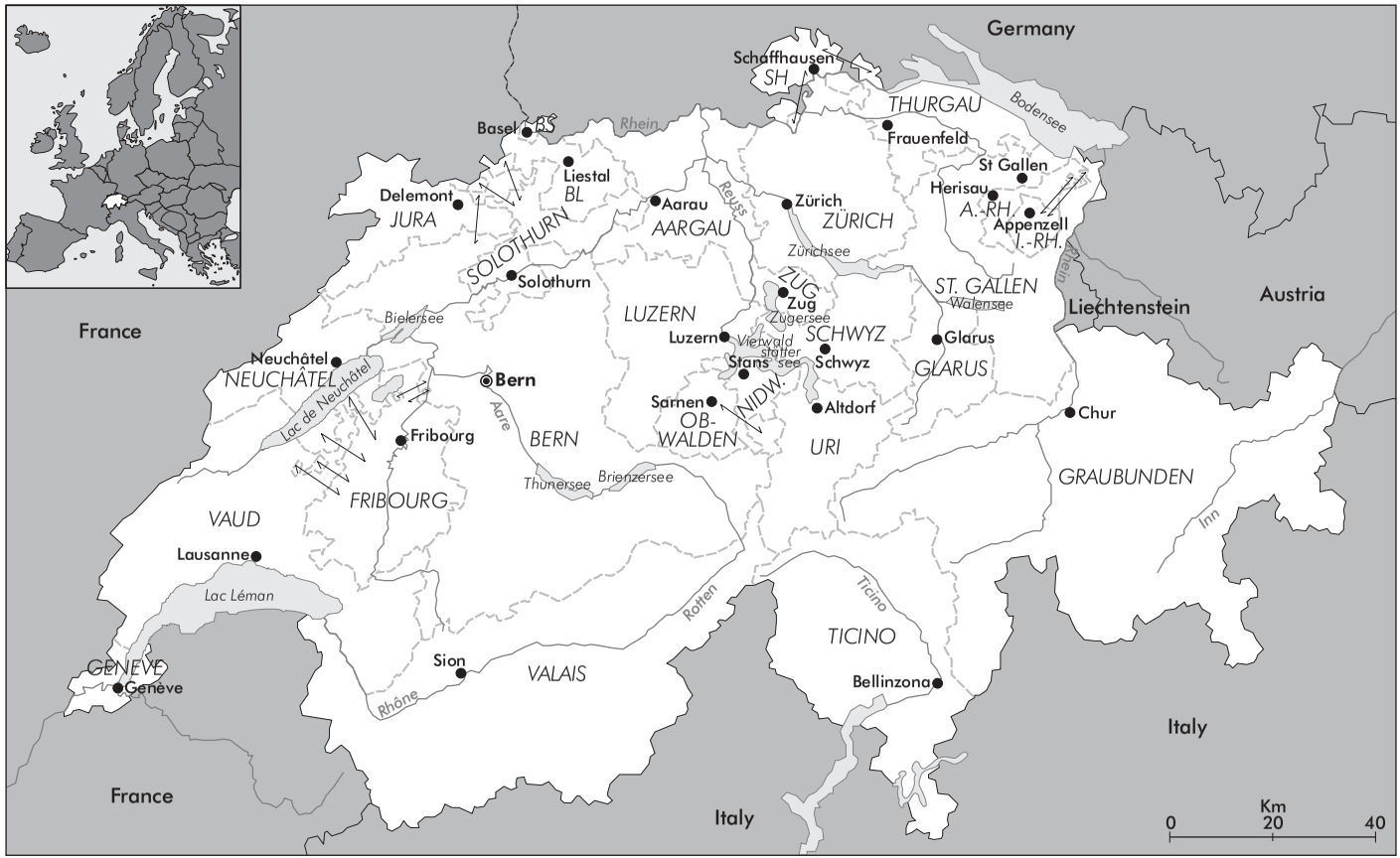
In 2001, total primary energy supply (TPES) in Switzerland was 28 Mtoe, up by 11.6% from the 1990 level, while GDP increased by 9.9%. Switzerland's oil dependence decreased from 53.6% in 1990 to 49.5% in 2001. In 2001, nuclear accounted for 25% followed by hydro (12.7%), natural gas (9%), combustible renewables and wastes (6%), coal (0.5%) and other renewables (0.5%). Electricity exports reduced TPES by 3.2%. Changes in the proportions of different fuels in TPES occurred between 1990 and 2001. The share of coal decreased from 1.4%, whereas the share of natural gas increased from 6.5%, combustible renewables and wastes from 4% and hydro from 10.2%, while the share of nuclear remained almost unchanged. Electricity exports increased from 0.7%.

Domestic energy production was 12.4 Mtoe accounting for 44% of TPES in 2001. The most important domestic energy sources are nuclear power and hydro, followed by combustible renewables and wastes and a very small

1. Often called Swiss Confederation.
2. On average in 2001, US$ 1 = CHF 1.687.

Figure 1

Map of Switzerland



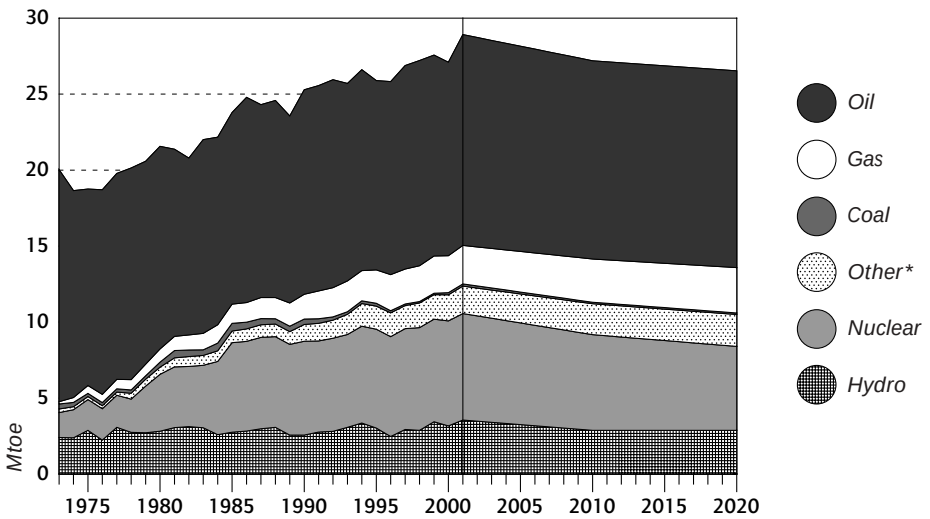
contribution of geothermal energy. Currently, Switzerland does not produce fossil fuels.

In 1997, oil and gas exploration was resumed under the lead of Schweizerische Erdöl in co-operation with the American Forest Oil Corporation. In 2000, test drilling took place in Weiach, north-west of Zurich. As neither gas nor oil was found, it is uncertain whether drillings will continue in this area. Nevertheless, a 40 metre thick layer of coal was discovered at a depth of 1 200 m.

Total final consumption of energy (TFC) was 21.6 Mtoe in 2001. Growth in TFC has been moderate for the last two decades, 12.2% in the 1980s and 9.7% in 1990 to 2001. The residential, services and "other sectors" are the largest energy-consuming sectors (45%), followed by transport (32%) and industry (23%) (see Figure 3). In 2001, oil accounted for 61.2% of TFC, electricity 21.6%, natural gas 10.7%, combustible renewables and wastes 3.6%, heat 1.6% and coal 0.7% as shown in Figure 4. Between 1990 and 2001, the share of oil in TFC decreased from 65.3% and the proportion of coal from 1.8%, while the share of gas increased from 7.7%.

Figure 2

Total Primary Energy Supply, 1973 to 2020

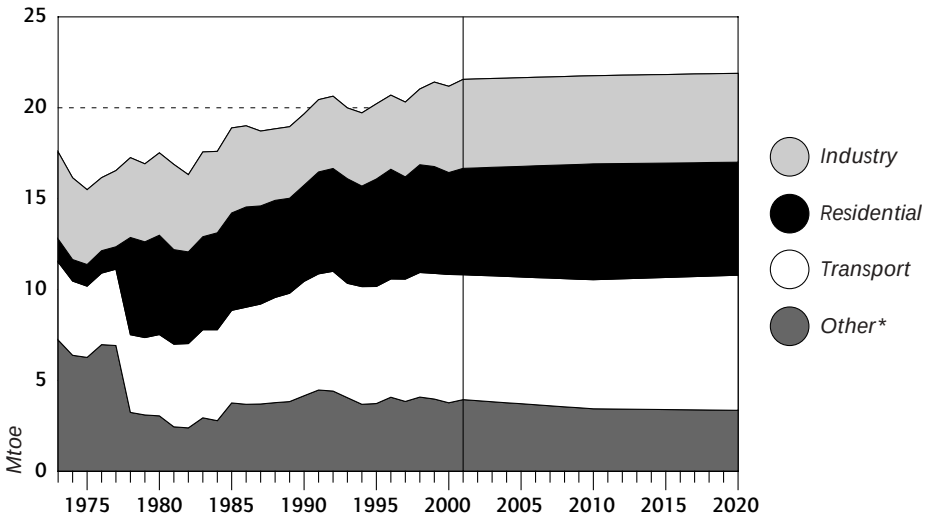


* includes geothermal, solar, wind, combustible renewables and wastes.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

Figure 3

Total Final Consumption by Sector, 1973 to 2020

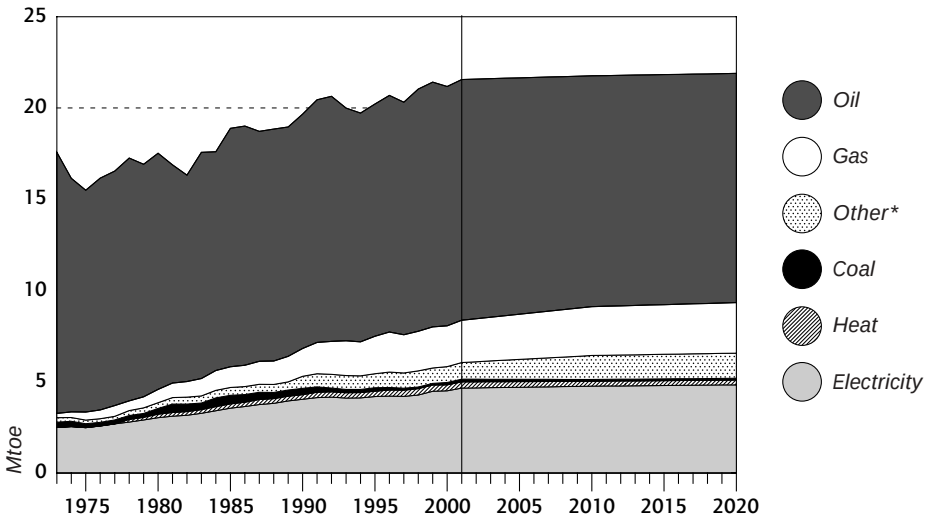


* includes commercial, public and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

Figure 4

Total Final Consumption by Source, 1973 to 2020



* includes geothermal, solar, wind, combustible renewables and wastes.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

ENERGY POLICY ADMINISTRATION

The cantons elaborate their own energy policy when legislation does not specifically give the competence to the Swiss government. Nuclear power and energy issues in transport are principally under federal competence whereas energy use in buildings is mainly under cantonal competence. Cantons are also responsible for the implementation of many measures decided at federal level. The majority of measures taken at cantonal level are implemented at municipal level.

The Federal Department of Environment, Transport, Energy and Communication (DETEC) has the principal responsibility for energy policy at federal level. It is also responsible for the Swiss CO_2 Law (see Chapter 4) and improvement of air quality. In practice, DETEC operates through the Swiss Federal Office of Energy (SFOE) and the Swiss Agency for the Environment, Forests and Landscape (SAEFL). The SFOE is in charge of SwissEnergy (see section on the SwissEnergy Programme). Responsibility for the implementation of the CO_2 Law is divided between the SFOE and the SAEFL; the SFOE is responsible for voluntary agreements and the SAEFL for CO_2 taxation. The SFOE has a staff of approximately 165, including Federal Nuclear Safety Inspectorate employees.

Energy policy planning and implementation must include both the "subsidiarity principle" and the "co-operation principle". The "subsidiarity principle" states that governmental action is devolved to the lowest possible level (within the Federal State) at which it can effectively be carried out. The "co-operation principle" requires that the government collaborates in partnership with the economic actors.

A specific feature of Swiss policy-making is the direct democracy; Swiss citizens have a constitutional right to make changes to the Federal Constitution and a right of referendum on federal laws. Changes to the Federal Constitution can be requested by means of a popular initiative signed by at least 100 000 voters. All constitutional changes must be submitted to a popular vote. If a minimum of 50 000 voters challenge a proposal for a new federal law, the proposal is put to a popular vote. To be accepted, a popular initiative must have a double majority, *i.e.* it must be supported by both the majority of citizens and the majority of cantons but a referendum only needs the majority of citizen votes.

ENERGY POLICY OBJECTIVES

Switzerland's energy policy is guided by Article 89 of the Federal Constitution, which calls for energy supply that is adequate, balanced over different sources, reliable, cost-effective and environmentally sound, and emphasises the importance of energy efficiency. Another objective of the government has been to introduce competition to the electricity and gas markets to make them operate more efficiently. However, development in

this area has been delayed owing to the results of the referendum held on the Electricity Market Law in September 2002.

The government's energy policy orientation for the period 2001 to 2010 is outlined in SwissEnergy, which was published in January 2001. It is a follow-up programme to Energy 2000, which defined the energy policy objectives for the period 1990 to 2000.

THE ENERGY 2000 ACTION PROGRAMME

Energy 2000 aimed to stabilise fossil fuel consumption and CO_2 emissions at 1990 levels by 2000. In 1999, following the passing of the CO_2 Law, a subsequent target was set to reduce them by 10% by 2010.

Energy 2000 was quite successful in achieving its objectives for electricity consumption, renewables, hydropower and nuclear capacity whereas the reduction in fossil fuel consumption was far from target (see Table 1). In addition to quantitative objectives the programme had several non-quantitative objectives. As a result of a public referendum in 1990 and of Energy 2000, which followed it, for the first time a consensus was achieved on energy policy priorities, particularly energy efficiency and renewables. The conciliation groups on hydropower and electricity transmission lines created practical solutions to problems in these areas. However, no consensus was achieved on the future use of nuclear power and disposal of nuclear waste. In 1990, a successful popular initiative introduced a ten-year moratorium (ban) on the construction of new nuclear plants. As the moratorium was to lapse in 2000, two popular initiatives were started in 1999, one calling for another ten-year ban and the other aiming to the phase-out of nuclear. Small, medium- and large-sized industries and municipalities created their own networks for co-operation with the energy field players, while the players in the renewable energy sector formed their own networks. Collaboration between the Confederation and the cantons improved. In addition to initiating implementing programmes for Energy 2000, the cantons issued their energy legislation and promoted the Minergie standards (see Chapter 5). Furthermore, harmonisation efforts in cantonal energy legislation were initiated.

One of the principal reasons that all the programme's objectives were not achieved was that its initial planned federal budget of CHF 170 million per annum was reduced to an average CHF 55 million financing per annum. Another factor was that all the cantons did not implement the intended individual heat metering and billing for apartment buildings. Furthermore, many of the key measures, such as energy efficiency targets for appliances and vehicles, were set on a voluntary basis and proceeded too slowly. The outcome of the programme was also affected by external circumstances, such as the decline of energy prices in the mid-1990s and speculation on the impact of electricity market reform.

Table 1

Achievement of the Objectives of the Energy 2000 Action Programme

Area	*Target 2000*[4]	*Change 1990-1999*[1]	*Degree of achievement (end of 1999)*[4]	*Change 1990-2000*[2]	*Degree of achievement (end of 2000)*[4]
Fossil fuel consumption	Stabilisation	+ 7.6%	..	+ 8.9%	not met
Electricity consumption	max. + 16%	+ 10%	..	+ 12.0%	met
Share of renewables (heat)	+ 3 percentage points	+ 37%	65% (+ 1.9 percentage points)[5]	+ 40.1%	70% (+ 2.1 percentage points)[5]
Share of non-hydro renewables (electricity)	+ 0.5 percentage points	+ 74.3%	125% (+ 0.6 percentage points)[5]	+ 84.3%	142% (+ 0.7% percentage points)[5]
Hydropower[3]	+ 5%	+ 4.5%	90%	+ 4.7%	94%
Capacity of existing nuclear plants	+ 10%	+ 7.9%	79%	+ 8.9%	89%

[1] At the end of 1999.
[2] Forecast.
[3] Including plants under construction in 1990.
[4] Compared to 1990 levels.
[5] The number in parentheses indicates the increase in contribution of renewable energy to total heat/electricity production.

Source: *Final Programme Report and 10th Annual Report*, DETEC, December 2000.

The use of resources and the results of the programme were carefully monitored. The total SFOE budget for Energy 2000 was CHF 558 million in 1990 to 2000; CHF 287 million, just over half the total budget, was allocated to renewables while almost all of the remainder went to energy efficiency. The government estimated that without the programme, fossil fuel consumption would have grown by an additional 5.3% and electricity consumption by an additional 3.6% during the programme years. Estimated CO_2 emissions reduction by this programme was 2.4 Mt to 3.3 Mt in 2000 as compared to the business-as-usual scenario. This led to an estimated saving in the energy bills of CHF 990 million in 2000. The employment impact of Energy 2000 was estimated by SFOE at about 38 000 person-years during the programme period and the European Centre for Economic Research (Prognos)[3] estimated that triggered investments totalled CHF 4.4 billion.

3. Prognos is an independent Swiss-based consulting company that carries out analyses to develop strategies for enterprises, organisations and the public sector.

Cost-benefit analysis, both for the programme period and the project lifetime, was carried out to study the effect of the different measures implemented. Table 2 shows the results of the cost-benefit analysis for 30 key activities.

Table 2

Cost-effectiveness of Measures in the Energy 2000 Action Programme

Sector	*Measure*	*CHF cents/kWh saved or generated*[1]
Public authorities	Energy City Programme	0.2
Motor fuels	Eco-Drive Quality Assurance	0.2
Public authorities	Caretaker courses	0.3
Hospitals	Energy management	0.3
SMEs	Eco-label E2000	0.3
Motor fuels	Promoting energy-efficient cars	0.5
Public authorities	Energy optimisation in complex plants	0.6
SMEs	Savings package	0.6
Motor fuels	Car-sharing	0.9
Motor fuels	Traffic management in municipalities	1.1
Residential buildings	Partnerships	1.2
Motor fuels	Bicycle and pedestrian campaigns	1.4
Public authorities	Energy accounting (buildings)	1.5
Industry	Energy optimisation in complex plants	1.5
Large consumers	Energy model with direct financial contributions from Energy 2000	1.6
Renewables	Energy in waste water treatment plants	2.2
Residential buildings	Symposiums, fairs	2.3
Residential buildings	Discussion forums, panels	2.4
Large consumers	Energy model without direct financial contributions from Energy 2000	2.7
Energy optimisation	Heating installations	2.9
Hospitals	Refurbishment measures	5.0
SMEs	Experience exchange	10.6
Renewables	Energy from fermentation	10.6
SMEs	Check-up of heating and cooling installations	14.2
Public authorities	Federal large consumers	16.5
Renewables	Wood heating systems	19.8
Renewables	Heat pumps	21.6
SMEs	Programmes for associations	25.0
Renewables	Thermal solar installations	29.4
Renewables	Photovoltaics	104.5

[1] Heat and electricity given in kWh. The cost-effectiveness for renewables is defined as total lifetime cost (including subsidies) per total generation and for energy efficiency as total lifetime cost (including subsidies) per energy saved. The results include funding from both the government and the partner organisations during the total lifetime of the measures.

Source: Swiss Federal Department of Environment, Transport, Energy and Communication (DETEC). Final Programme Report and 10th Annual Report, December 2000.

THE SWISSENERGY PROGRAMME

SwissEnergy was implemented at the beginning of 2001 for a 10-year period. It continues most of the policies and measures introduced during Energy 2000 and pursues the fossil fuel consumption and CO_2 emissions reduction targets established by the Swiss CO_2 Law (see Table 3). It established new targets for electricity generation and heat production from renewables. SwissEnergy calls for a 10% reduction in the final consumption of fossil fuels between 2000 and 2010, with a mandate to maintain the increase in electricity consumption at less than 5%. The target for fossil fuels is split into two sub-targets; a 15% reduction in combustible fuels and an 8% reduction in transport fuels. In addition, it calls for an increase of 3 TWh in heat production from renewables and an increase of 0.5 TWh in electricity generation from renewable sources.

Table 3

Objectives of the SwissEnergy Programme

Sector	*Objectives for 2010*[1]	
	"Business as usual"[3]	*New measures*[4]
Energy efficiency		
– Consumption of fossil fuels[2]	+ 2%	– 10%
– CO_2 emissions$_2$ (base year 1990)	stable	– 10%
from heating fuels	– 8%	– 15%
from motor fuels	+ 12%	– 8%
- Electricity consumption	+ 10%	up to + 5%[5]
Renewable energies		
– Hydropower	possibly stable	stable
– Other renewables		
electricity	+ 0.37 TWh[6]	+ 0.5 TWh
heat	+ 2.10 TWh[6]	+ 3.0 TWh

[1] Compared to 2000 (based on economic growth estimate of 2.2% per annum in 1998 to 2010).
[2] Excluding international flights, *i.e.* so-called "inland principle" of the CO_2 Law.
[3] Under the assumption that no measures are taken in addition to those introduced in Energy 2000.
[4] The government considers that achieving the CO_2 objectives and those of SwissEnergy requires strengthening of voluntary measures and the introduction of additional incentives and regulations.
[5] The government expects voluntary measures to result in savings of 5% by 2010 (*i.e.* double those of Energy 2000).
[6] Results of Energy 2000.

Source: *The Follow-Up Programme to Energy 2000*, DETEC, January 2001.

The cost-benefit analysis in Energy 2000 was unfavourable to most renewables. Consequently, direct federal subsidies to renewables have been reduced and additional financing will be given to energy efficiency measures. More

regulatory measures may be introduced if voluntary measures prove ineffective during the first few years of the programme. The administration of financing has changed. At present, the cantons receive lump-sum payments (so-called global contributions) for their own programmes and are free to allocate the money as they see appropriate. The money is subject to the cantons investing at least an equal amount from their own budgets. The payments will be readjusted depending on the effectiveness of cantonal programmes starting from 2004. Until then, the lump-sum payments are allocated in proportion to the cantons' population and their own financial contributions.

According to the Resolution of the Federal Council adopted in January 2001, SwissEnergy's budget will remain the same as that of Energy 2000, *i.e.* CHF 55 million per annum excluding R&D. The Federal Council decided on additional financing for the following purposes:

- CHF 45 million for the period 2000 to 2003 for the production of wood energy from the forest areas destroyed by the Lothar storm.
- CHF 5 million in 2001 for the Federal Office of Buildings and Logistics for implementing projects in federal buildings.
- CHF 4 million in 2002 principally for promoting renewables.

The programme's expenditure and achievements are subject to careful monitoring. In the first programme year the Confederation spent CHF 77.5 million (including CHF 8.9 million of global contributions and CHF 23 million of Lothar funds), the cantons spent CHF 39.1 million (excluding global contributions) and private partners CHF 16.6 million. SwissEnergy's total budget amounted to CHF 133.2 million in 2001. Global contributions increased to CHF 13 million in 2002 and the government's objective is to keep them at an average of CHF 14 million per year. Renewables received the largest share of the total budget (CHF 44.2 million, 40%[4]), followed by energy efficiency (CHF 39.9 million, 36%). Renewables' share decreased from about 50% under Energy 2000.

The key measures used to achieve the objectives are described in Chapters 4 on Energy and the Environment, 5 on Energy Demand and End-use Efficiency and 7 on Renewables.

ENERGY FORECASTS

Full-scale official forecasts[5] for energy production, supply and consumption based on updated economic, demographic and transport forecasts date back to 1996; the SFOE plans to publish new full-scale forecasts in 2004.

4. This excludes the exceptional Lothar funds.
5. Prepared by independent institutes under the supervision of the SFOE.

In 2001, the SFOE evaluated the effectiveness of Energy 2000 and SwissEnergy in addressing TFC (see Table 4). The projections in Table 4 do not include the CO_2 "incentive" tax but do take into account measures that were in place in 2001. Some economic variables were taken from the 1996 forecasts[6] and not updated. The projections indicate that, without additional measures, electricity and fossil fuel consumption targets will not be met in 2010.

Several policy scenarios with a CO_2 "incentive" tax and other policy measures[7] were prepared to estimate the economic and environmental impacts of phasing out nuclear power. This analysis was a basis for the government's message to the Parliament on the "Moratorium Plus" and "Electricity without Atoms" initiatives.

Table 4

Projections for Total Final Consumption[1], 1990 to 2030

(1 000 TJ per annum)

	1990	*2000*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*
Oil	518.0	518.3	519.1	519.0	518.5	515.3	509.8	502.8
Coal	15.1	3.2	4.3	4.1	4.1	4.1	4.2	4.2
Gas	69.8	101.2	107.6	112.1	114.1	115.8	117.1	119.4
Waste	6.9	15.0	15.1	16.3	17.2	16.8	16.8	16.3
Wood	24.3	30.1	30.0	30.0	29.8	29.6	29.3	28.6
Other renewables	1.7	5.1	6.8	8.7	9.9	11.3	12.4	13.3
Electricity	167.0	180.6	191.9	199.1	200.3	201.9	202.1	202.3
Heat	8.5	11.1	11.4	11.2	11.0	10.9	11.0	11.0
Total	**811.3**	**864.5**	**886.2**	**900.6**	**905.0**	**905.8**	**902.6**	**898.0**

[1] The data are not fully consistent with the IEA statistics in Annex A.

Source: SFOE.

ENERGY SECURITY

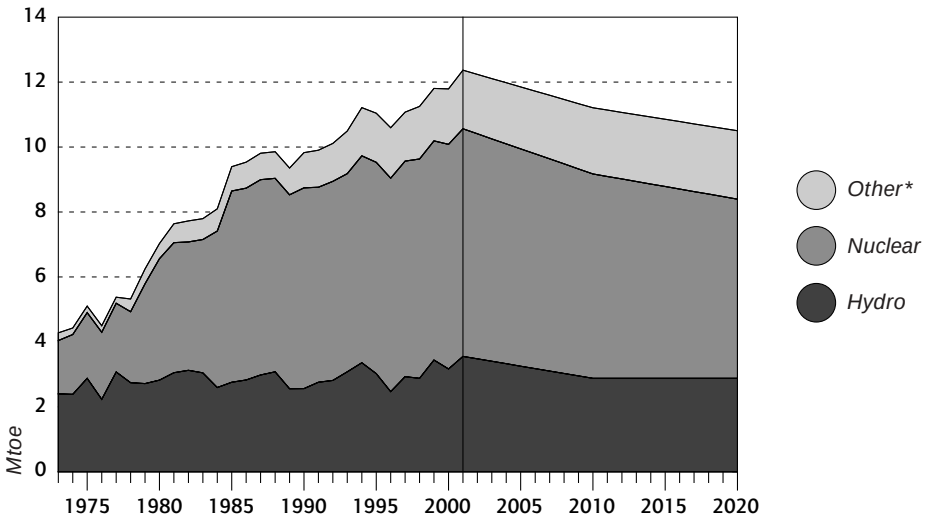
The 1982 Economic Supply Law entrusts the primary responsibility for securing supply, including energy supply, to industries. The government can only intervene in the case of serious shortages. Minor shortages should be handled by industry.

6. Some of the major assumptions were: 2.2% per annum increase in GDP from 2000 to 2010 and 1.3% per annum increase from 2010 to 2020; population increases from 7.1 million in 1999 to 7.4 million by 2020; oil prices will be US$ 16.5 per barrel in 2005, US$ 17.0 per barrel in 2010 and US$ 21.5 per barrel in 2020; and nuclear capacity will remain unchanged until 2020 and will be replaced after 50 to 60 years of use.
7. The work was carried out for the government by a team of six consulting companies and was co-ordinated by Prognos. Ecoplan carried out economic analyses.

Domestic energy production accounted for 44% of TPES in 2001. Nuclear accounted for 57%, hydropower for 29%, combustible renewables and wastes for 14% and other renewables for 1% of domestic production (see Figure 5). Switzerland has no fossil fuel production and is completely dependent on imports. Phasing out nuclear or a new moratorium, as proposed by popular initiatives, could dramatically increase Switzerland's import and fossil fuel dependency.

Figure 5

Energy Production by Source, 1973 to 2020



* includes geothermal, solar, wind, combustible renewables and wastes.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

Three aspects of energy security are essential to electricity, namely network infrastructure, supply security in ensuring adequate generating capacity and supply security of primary energy sources for generation. The 1902 Electricity Law obliges the government to publish a national plan for the development of the transmission networks. This so-called Subject Plan is an indicative plan. Its objectives are to better co-ordinate the network development activities, to clarify crucial aspects such as the demand and approximate geographical corridors of the projected lines, to accelerate the licensing procedure and to send signals to investors. The plan is updated every ten years but progress is monitored continuously. Currently, there is some congestion both in the national networks and in the interconnections, particularly between Switzerland and Italy, but also between France and Switzerland. Switzerland

is a net exporter of electricity except during the winter demand peak when it has to import. No significant changes are foreseen until 2010 on the amount of generating capacity or the use of different fuels for generation in the near and medium term. Longer-term development of new capacity and the need for additional imports depends on the future of nuclear power.

Switzerland imports and re-exports as well as transits large quantities of electricity. These energy flows can enhance security of supply and it is therefore very important for Switzerland to develop its energy markets in a similar way to its neighbours.

32% of gas demand for industrial customers and 100% for the power and heat generation sectors are on an interruptible basis. This corresponds to an average of 45% of total gas consumption in 1999. Deliveries to interruptible customers can be interrupted when temperatures drop below –10°C. Switzerland stores heating oil as a backup for interruptible gas supply contracts. Some 400 000 m^3 of light heating oil stocks, corresponding to 4.5 months of gas consumption, have been built to cover natural gas consumption. These oil stocks are managed separately from the compulsory oil stocks under Switzerland's international commitments. The compulsory oil stocks correspond to approximately 4.5 months of gasoline, diesel and heating oil consumption and the government aims at maintaining this level, which is higher than the IEA 90-day obligation of net oil imports.

ENERGY TAXATION

All energies for non-commercial use are subject to a 7.6 % value-added tax (VAT). As shown in Table 5, natural gas and oil are subject to excise taxes and payments to the emergency fund (so-called "Carbura fee"). Excise tax from steam coal was removed in 1999. There is also an additional tax on light fuel oil with a sulphur content exceeding 0.1%. Revision of taxes on diesel and gasoline is under discussion (see Chapter 6).

At the end of the 1990s, the public and the government made six energy tax proposals. All of them were rejected in a public vote in 2001. However, according to the CO_2 Law the government could implement, in 2004 at the earliest, a CO_2 "incentive" tax if Switzerland's national and international targets for reducing GHG emissions cannot be reached using measures already in place.

Cantons levy several taxes and charges on energy, particularly electricity (see Chapter 9), the most significant being a royalty on the use of water for hydropower generation.

Table 5

Energy Taxes in Switzerland, 2002[1]

(CHF per unit)

Sector/fuel	*Emergency fund fees CHF/unit*	*Excise taxes CHF/unit*	*VAT[2] %*
Households/electricity[3]	0	0	7.6
Households/natural gas	2.85/toe[4]	4.7/toe	7.6
Households/heating oil	6.05/1 000 litres	3.0/1 000 litres	7.6
Non-commercial use/unleaded gasoline	0.0094/litre	0.7312/litre	7.6
Non-commercial use/diesel	0.0061/litre	0.7587/litre	7.6
Industry/electricity[3]	0	0	0
Industry/natural gas	2.85/toe[4]	4.7/toe	0
Industry/light fuel oil	6.05/1 000 litres	3.0/1 000 litres	0
Industry/low sulphur heavy fuel oil	5.3/tonne	3.6/tonne	0
Industry/steam coal	0	0	0
Industry and commercial use/diesel	0.00605/litre	0.7587/litre	0

[1] For household use as of July 2002, for industrial and commercial use in the first half of 2002.
[2] VAT was 6.5% in 1995 to 1998, 7.5% in 1999 to 2000 and was increased to 7.6% on 1 January 2001.
[3] Water duties and concession fees were CHF 0.92 per kWh and payments to the State and local authorities CHF 0.35 per kWh.
[4] In 2001.

Source: SFOE.

CRITIQUE

There has been significant development in the Swiss energy policy since the 1999 IEA in-depth review. The CO_2 Law entered into force in 2000 and SwissEnergy was implemented in 2001. Some cantons have developed effective energy efficiency and climate change programmes. New gas pipelines have been commissioned and compulsory oil stocks have been established to enhance gas supply security. In 2002, the Electricity Market Law (EML) was rejected in a referendum. Major challenges for the next years will include energy market reform, achievement of the energy efficiency and climate goals and clarification of the role of nuclear power. There will also be a need to strike a balance between the different energy policy objectives.

Environmental issues are a central focus of Swiss energy policy. It is possible they have distracted attention from other important policy areas such as economic efficiency, principally in the electricity and natural gas sectors. SwissEnergy concentrates solely on climate change, end-use energy efficiency and renewables, and market reform is perceived only as an operational framework or, in some cases, a vehicle for achieving the objectives in these

three policy areas. Few initiatives, with the exception of the EML, were launched to improve economic efficiency in the energy markets.

It is highly commendable that progress towards the realisation of the Energy 2000 and SwissEnergy objectives has been conscientiously monitored for energy consumption, emissions, public expenditure, private investments, employment impacts and the cost-effectiveness of the measures. The transition from Energy 2000 to SwissEnergy has been smooth; most of the Energy 2000 activities are continued under SwissEnergy and financial resources have remained the same. Reasons for some of the Energy 2000 objectives not being achieved were analysed and the experience was used when designing SwissEnergy. In particular, it was recognised that voluntary measures may not be sufficient to achieve the objectives.

There have been changes in the use of resources following the introduction of SwissEnergy. Direct payments to projects by the government have practically been abolished. The cantons now receive lump-sum payments, which they use for the programmes of their choice. Some reallocation of resources between different policies and measures has taken place based on the results of cost-benefit analyses. However, this has not resulted in the most cost-effective allocation of limited resources. Renewables, which have weaker cost-benefit than most energy efficiency measures, still receive almost half of the total financing. There also appears to be a need for reallocation of promotional efforts among the different renewables (see Chapter 7).

According to the 1998 Energy Law, the government must evaluate the cantonal programmes and reallocate the resources to the cantons depending on the effectiveness of their efforts. This can improve the overall effectiveness of the energy policy measures. It can also lead to more harmonised energy efficiency, renewables and environmental programmes in the cantons given the need to compete over the limited resources. It is possible that the cantons will "copy" successful programmes from each other. The government can support this development by publishing information on "best practices". To this effect, the government has already worked together with the cantons to prepare draft decrees for energy efficiency (see Chapter 5).

Energy taxation and pricing could be used more effectively as tools to increase efficiency in the energy markets and to reduce energy consumption and emissions. At present, the energy taxes are purely fiscal. They are neither designed to internalise the externalities of energy transformation and use nor are they designed to reduce GHG and other emissions. The government recognised that new and stronger measures may be necessary to achieve the SwissEnergy objectives. Legislation allows the introduction of a CO_2 "incentive" tax if other measures do not prove adequately effective. Currently, the share of excise taxes in, for example, heating fuel prices is very low in Switzerland compared to many other European countries. If a revision of the

excise taxes is not possible, the CO_2 "incentive" tax could be used to encourage better energy efficiency and to internalise the environmental externalities. Price monitoring has been inadequate to ensure cost-reflective prices for all consumer groups. Other distortions include free deliveries of electricity to local administrations.

The importance of public awareness of the consequences of energy-related initiatives and understanding the trade-offs among various energy policy options is essential given the general public's important role in energy policy decisions in Switzerland. These issues are often very complex and/or technical, and consequently difficult to communicate to the general public. Despite the government's special efforts to provide information and to seek consensus on energy policies, the government proposals have not always been accepted as demonstrated by the rejection of the EML (see Chapter 9). The future of nuclear power was to be subject to a public vote in May 2003. It is therefore very important that the government provides the public with reliable and understandable information on all the consequences of the different alternatives.

The latest full-scale energy forecast dates back to 1996; partial revision was carried out in 2001 but does not include recent economic developments. More frequent forecasts of energy consumption, production methods and CO_2 emissions would assist subsequent monitoring, help in communicating the impact of energy policy decisions to the public and provide policy-makers and market players with timely and accurate information on market developments.

RECOMMENDATIONS

The government of Switzerland should:

- *Ensure a better balance in the overall energy policy by emphasising economic efficiency.*
- *Optimise the overall effect of the energy programmes and the use of resources by:*
  - *Developing programmes to assess the costs, benefits and "best practices" of energy policy implementation among and within the cantons;*
  - *Continuing the vigorous monitoring and cost-benefit assessment activities at federal level;*
  - *Reallocating resources to the most cost-effective policies and measures; and*
  - *Continuing to support the harmonisation of the cantons' energy and environmental programmes.*

- *Increase focus on pricing and taxation as energy policy tools in order to internalise the externalities and promote economic and energy efficiency.*
- *Increase public awareness of the consequences of energy-related popular initiatives and law proposals by analysing their potential impacts and communicate these to the general public.*
- *Develop and regularly update energy and CO_2 projections and scenarios for all sectors and fuels.*

Environmental issues, in particular efforts to reduce greenhouse gas (GHG) emissions, are a central focus of Swiss energy policy. Efforts are largely concentrated on meeting the Swiss commitment under the Kyoto Protocol, namely a reduction of 8% below 1990 levels by 2008 to 2012. The Swiss climate change policy has focused almost exclusively on the energy sector, despite the fact that emissions from other gases, such as methane, nitrous oxide, HFC, PFC and SF_6, account for approximately 16% of the national total.

The majority of energy-related environmental issues are adequately being addressed. These include local air and water pollution and the handling of nuclear waste.

CLIMATE CHANGE

GREENHOUSE GAS EMISSIONS

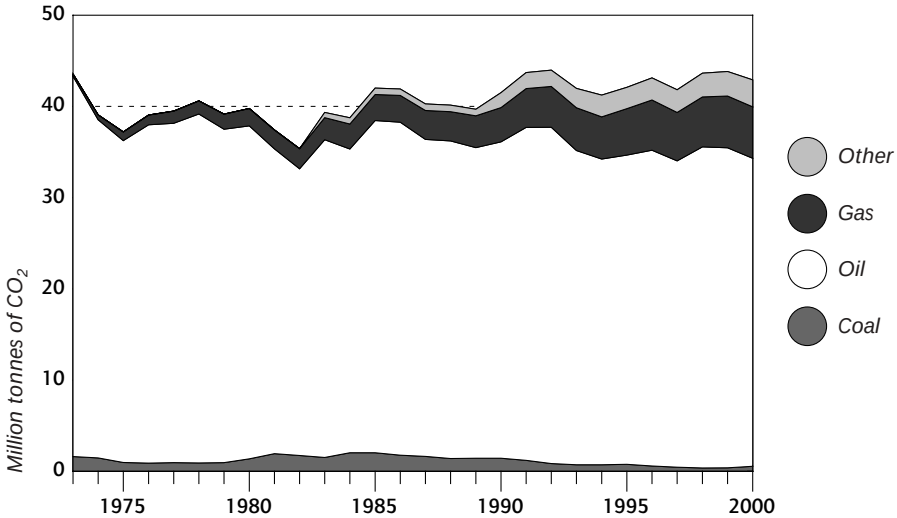
According to IEA statistics, between 1990 and 2001, Swiss energy-related CO_2 emissions increased by 5.6%[8]. In 2001, transport accounted for 34% of total CO_2 emissions followed by the residential sector (27%), industry (18%), the service sector (12%), energy industry (7%) and other sectors (2%). Oil use is by far the major source of emissions with a 78.3% share, followed by natural gas, 13.4%.

The evolution of GHG emissions and energy-related CO_2 emissions over the past decade has been somewhat atypical in the context of other European countries' emissions. Switzerland is one of the few countries in which the dominant source of electricity (over 95%) is generated by non-GHG emitting sources. Consequently, electricity generation contributed only marginally to the country's total GHG emissions. Despite significant increases in the use of gas, GHG emissions have essentially remained stable over the past decade. Switzerland's largest contributor to the country's GHG emissions is the transport sector with 14.91 Mt of CO_2 in 2000. GHG emissions from the transport sector increased by only 4.6% between 1990 and 2000 despite a decline in real petrol prices during this period.

8. This statistic is based on the IPCC Sectoral Approach. When calculated using the Reference Approach, emissions have increased by 5.9% over 1990 levels. It should also be noted that the IEA statistics are not fully compatible with UNFCCC statistics or national CO_2 statistics, which show a stabilisation of energy-related CO_2 emissions between 1990 and 2000.

Figure 6

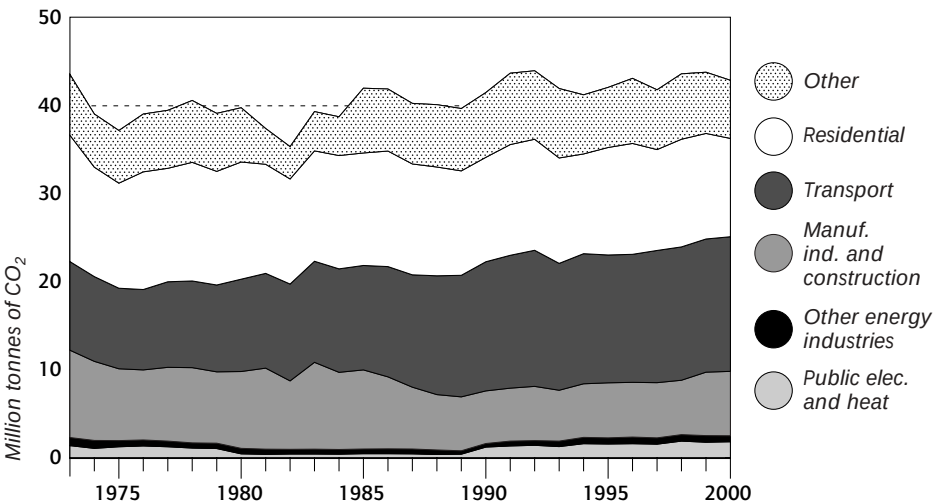
CO_2 Emissions by Fuel*, 1973 to 2000



* estimated using the IPCC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2002.

Figure 7

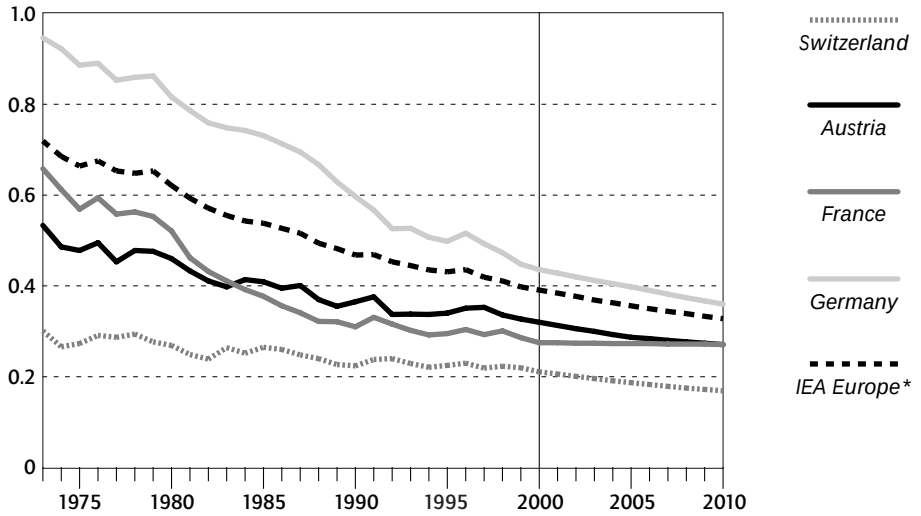
CO_2 Emissions by Sector*, 1973 to 2000



* estimated using the IPCC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2002.

Figure 8

Energy-related CO_2 Emissions per GDP in Switzerland and in Other Selected IEA Countries, 1973 to 2010



* excluding Norway from 2001 to 2010.

CO_2 Emissions/GDP using 1995 prices and purchasing power parities.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; *National Accounts of OECD Countries*, OECD Paris, 2002; and country submissions.

The residential sector represents approximately one-third of national consumption of oil and gas. Over the past decade it experienced a decline in consumption of 5.5%, principally in 2001, when emissions in the sector declined by 6.8%. As with the transport sector, this decline has occurred despite a substantial price decrease in real terms.

Trends in CO_2 and GHG emissions appear to be the result of the successful energy policy programme that has been in place over the past decade, rather than the result of either a reduced rate of economic or population growth. Despite a decline in GDP and government revenues in the early and mid-1990s, total GDP and GDP per capita increased by 8.9% over the decade. Population increased by 7% over the same period.

CLIMATE CHANGE POLICIES

An extensive programme has been developed to support the Swiss objectives of an 8% reduction in GHG emissions[9] under the Kyoto Protocol and a 10%

9. The Burden-Sharing Agreement covers CO_2, CH_4, N_2O, PFCs, HFCs and SF_6.

reduction in CO_2 under the domestic scheme. The programme is primarily of a voluntary nature (with strong emphasis on promotional activities and information dissemination programmes for industry and private citizens, as well as public/private-sector partnerships and incentives). It includes regulations and standards for buildings, vehicles and electrical appliances, promotion of renewable energy and, perhaps most significantly, provides for a stringent tax to be imposed if the voluntary approach is not sufficient.

Energy policy related to climate change has primarily been set through the Federal Law on the Reduction of CO_2 (implemented in May 2000), Energy 2000 (1990 to 2000) and SwissEnergy (2001 to 2010). In addition, transport policy at federal level and numerous cantonal policy activities have, and continue to exert, a considerable curbing effect on GHG emissions from the energy sector.

Federal Law on the Reduction of CO_2

The Federal Law on the Reduction of CO_2, adopted by Parliament in October 1999, mandates an overall reduction in CO_2 emissions of 10% below 1990 levels by 2010. It specifies that emissions from combustible fuels are to be cut by 15%, while petrol and diesel emissions are to be reduced by 8%. Policies to achieve the targets are initially of a voluntary nature. Guidelines for the voluntary programmes for industry were released in July 2001. The guidelines take into account policies and measures already adopted by industry and offer industry the possibility to enter voluntary agreements (VAs) or voluntary commitments (VCs) (see Chapter 5).

The adequacy of the voluntary measures will be assessed in 2004. Should they yield inadequate reductions, the Federal Law provides for a CO_2 "incentive" tax to be levied at beginning of 2004 earliest. However, the government does not consider that the introduction of the tax will be possible before 2005 because the VAs and VCs still need to be concluded and it takes time to evaluate their effectiveness. The maximum tax rate is set at CHF 210 per tonne of CO_2. The final tax levels will be set by taking account of the gap between the forecast path for emissions and that required to meet the agreed targets. While the maximum level has been agreed, the actual level of taxes needs to be approved by Parliament before entering into force. Tax exemption will be granted to industries that have entered into VCs. The tax will be revenue-neutral; its revenues will be redistributed to employers in accordance with wages paid and to the population on a per capita basis.

Energy 2000 and SwissEnergy Programmes

The Swiss CO_2 Law has been implemented through Energy 2000 and SwissEnergy. Energy saved by Energy 2000 was equivalent to almost 20% of annual consumption in 1999 (valued at CHF 4.7 billion) and CO_2 emissions

reductions were 10 to 14 Mt (see Table 6). The principal measures used were energy management, energy audits, encouragement of energy efficiency and use of renewables, information partnerships with the building industry, energy savings services for small and medium-sized enterprises (SMEs), and optimisation of building technologies. Most of these measures are continued under SwissEnergy, which also facilitates the implementation of VAs and VCs.

Table 6

Environmental Impact of the Energy 2000 Action Programme

Measures	*Energy savings (PJ)*	*Reduction in CO_2 emissions (Mt, min-max.)*	*Investment (billion CHF)*	*Federal budget (million CHF)*
Voluntary measures	73.3	4.3 – 6.0	2.4	495.2
Statutory measures	90.3	5.4 – 7.5	1.0	–
Investment programme	1.9	0.1 – 0.2	1.0	62.6
Total	**165.5**	**9.8 – 13.7**	**4.4**	**557.8**

Source: Final Report of the Energy 2000 Action Programme.

The government proposed a domestic emissions trading plan, although issues related to internal allocation of permits still remain to be negotiated. The targets in the proposal are annual, spanning the five years of the Kyoto time frame. Trading within sectors will be unrestricted, while trading between sectors will be regulated (still undefined). The proposal allows "credit" for energy efficiency and renewable energy projects undertaken outside Switzerland, *i.e.* within the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation (JI). Rules establishing how such credits might be obtained have yet to be adopted by the United Nations Framework Convention on Climate Change (UNFCCC). Details of the proposal remain sketchy, and there has been only limited government or public debate on how it might be developed.

Cantonal Programmes

The cantons exercise considerable authority in areas related to climate change mitigation, particularly with respect to buildings and energy efficiency, but also to renewable energy and in a more limited manner to the transport sector. The 1998 Energy Law shifts the burden of responsibility onto the cantons, particularly where building energy requirements and the preparation of the cantons' own promotion programmes (*e.g.* procedures for the payment of subsidies) are concerned. This approach is intended to enable the cantons to adjust their priorities to suit local conditions although the law also requires collaboration among the cantons. In August 2000, the Conference of Cantonal

Energy Directors agreed on a package of standard regulations in the energy field to promote harmonisation in energy legislation. Most cantons have revised their energy laws in recent years, while virtually all have developed, or are in the process of preparing, their own promotion programmes.

PROJECTING THE EFFECTS OF POLICIES

Specific assessments of the effectiveness of individual policies have not been undertaken; however, the SFOE has carried out several forecasting studies to project the combined effects of its policies to reduce GHG emissions. The studies imply that the voluntary measures currently implemented and planned are unlikely to achieve the Swiss commitment under the Kyoto Protocol. With measures already implemented, gross emissions are anticipated to decline by 3.7% below 1990 levels by 2010, driven significantly by an increase in transport-related emissions of more than 7%. Projected economic growth of nearly 30% between 1990 and 2010 offset much of the efficiency gains projected to arise from policy actions.

Swiss forecasts suggest that imposition of the CO_2 "incentive" tax allowed under the Swiss CO_2 Law will maintain emissions at or below the Kyoto targets. They also suggest that achieving the targets will necessitate taxes of CHF 40 per tonne of CO_2 on petrol and diesel in 2005, rising to CHF 100 by 2010, and taxes of CHF 50 on other fuels in 2005, rising to CHF 160 per tonne by 2010. A new round of scenario construction and modelling, incorporating more recent energy and statistical data, is to begin in 2003. The results may provide a better assessment of the existing programmes and subsequently guide the development of a future tax discussion. A comparison of the results of the existing policy and the level of emissions expected from the CO_2 "incentive" tax is provided in Table 7.

Table 7

Projected Development of CO_2 Emissions under the Existing Policies and the CO_2 "Incentive" Tax, 1990 to 2010

	1990 *(Mt CO_2)*	*2000* *(Mt CO_2)*	*2010 Energy Law* *(Mt CO_2)*	*2010 CO_2 "incentive" tax* *(Mt CO_2)*
Energy transformation	1.5	1.5	1.5	1.5
Residential	13.3	12.4	12.1	10.9
Commercial and institutional	5.4	5.4	5.1	4.7
Industry	7.2	6.5	6.6	6.1
Transport	14.4	15.1	15.5	14.6
Total	**41.8**	**41.0**	**40.8**	**37.8**

Source: Third National Communication of Switzerland, 2001.

In Switzerland, heating systems and industrial combustion produce 91% of sulphur dioxide (SO_2), while motor vehicles produce 8%. Motor vehicles produce 56% of nitrogen oxides (NO_x), another 30% is produced by combustion equipment and 85% of carbon monoxide (CO) is produced from a combination of motor vehicles, heating and industrial combustion.

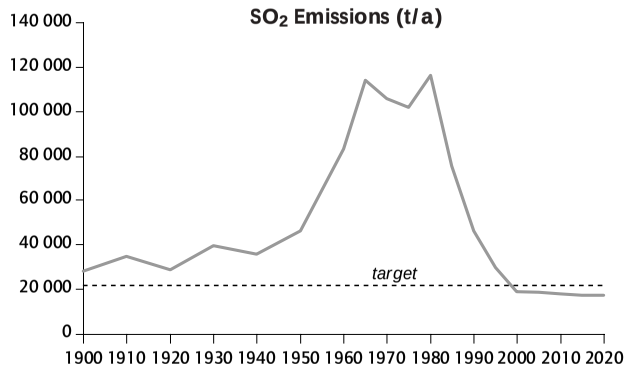
Ambient air quality standards are set in accordance with the values recommended by the World Health Organization (WHO) and the UN Economic Commission for Europe. Legislation to reduce emissions is incorporated in the Environmental Protection Law, which includes a "precautionary principle" that emissions must be kept as low as is technically and operationally possible. Since the introduction of the air pollution control legislation, federal, cantonal and local authorities have adopted a broad range of measures to reduce the release of pollutants and their impacts. Consequently, winter smog has virtually ceased to be an issue and substantial investments have been made in modern waste-incineration and industrial installations. Fuel oil contains far less sulphur than it did in the past and combustion equipment burns more cleanly as a result of strict standards. The tougher exhaust emissions control regulations for motor vehicles have also brought substantial improvements.

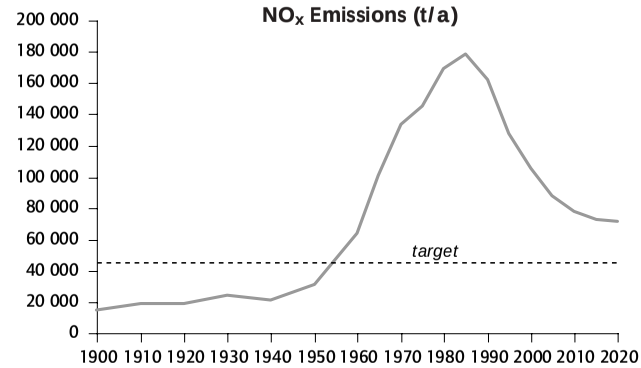
More than fifteen years after the introduction of the Ordinance on Air Pollution Control (adopted in 1985), it is clear that Switzerland's clean air policy objectives have not yet been fully achieved, although they have met with considerable success (see Figure 9). While SO_2, CO and lead pollution have declined substantially over the past ten years, there has only been a slight fall in pollution due to NO_x, suspended particulates and dust fallout. In urban areas concentrations of nitrogen dioxide, small particles (PM_{10}) and, in some cases, ozone, exceed ambient air quality standards. Excessive levels of pollution due to ground-level ozone, caused by the precursors NO_X and volatile organic compounds (VOCs), are mainly being recorded in rural areas and south of the Alps.

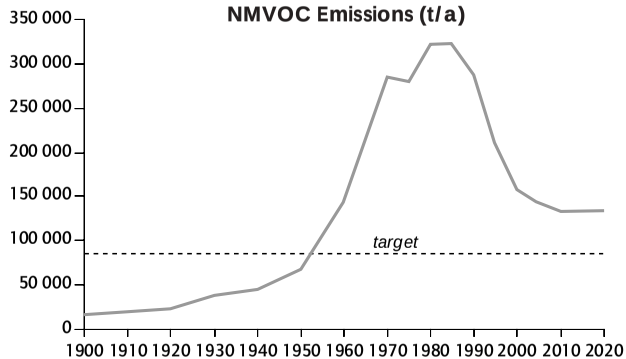
Policies to address air pollution focus on two policy "streams", namely source-oriented and effect-oriented. In Stage 1 of the source-oriented stream, policies incorporate preventive emissions controls, calling for the use of best available technologies where economically feasible. In Stage 2, regulations will be imposed, tightening emissions limits. Decisions on the timing and stringency of these limits are derived from the effect-oriented elements of the strategy, which regularly assesses ambient air quality and quality standards, and adjusts these as new information becomes available from the scientific community. In addition to the Environmental Protection Law, the government has passed legislation governing the quality of heating and motor fuels (governing sulphur and lead content), imposed taxes on the sulphur content

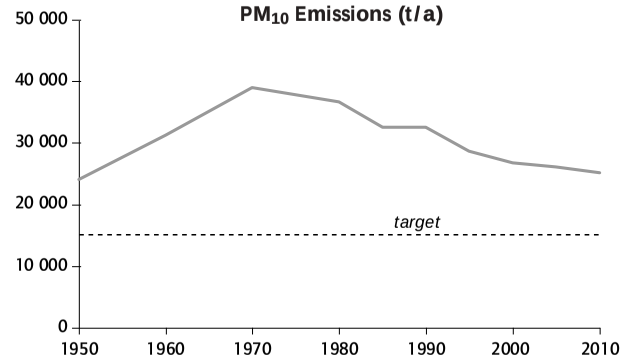
Figure 9

SO_2, NO_x, NMVOC and PM_{10} Emissions, 1900 to 2020









t/a: tonnes per annum.

Source: SAEFL.

of extra light fuel oil and on VOCs, and introduced emissions-based landing fees at national airports.

Extensive use of hydropower, and the re-routing of a significant portion of Swiss surface water has, and will continue to have, environmental consequences. The 1991 Water Protection Law, which takes effect in 2007, promotes improved environmental management of watercourses. This law does not take into account the possible effects of climate change, which may have an impact on the availability of water resources and demand additional consideration for local environment.

CRITIQUE

Switzerland places high priority on the efficient management of its resources in an environment-conscious manner. Given that the Swiss economy is export- and tourism-oriented and is closely linked to EU policies, environmental policies affecting the energy sector must be developed, taking into account the international market conditions and the relative competitiveness of Swiss industry.

The Kyoto Protocol target on global GHG emissions presents significant challenges for Switzerland given that 96% of its electricity is generated from hydropower or nuclear plants, which do not lead to GHG emissions. Despite considerable climate change mitigation efforts, the Swiss programme does not appear to be adequate to meet either the Kyoto target or the more stringent national target for CO_2 reduction. This may be better addressed if and when a CO_2 "incentive" tax is imposed. Work needs to proceed promptly if this instrument is to be available in the near future. Clearly, given the sensitivity surrounding the imposition of such a tax, a programme that engages the public in full consultation will need to be incorporated into the implementation of the initiative.

In the interim, the current programme of voluntary measures may be extended more widely throughout the Swiss economy. For example, refineries are not yet participating in the VCs, although they might find significant cost-effective reduction opportunities if given the incentive to do so.

Switzerland's future efforts to develop additional programmes should include a re-evaluation of whether the existing effort is cost-effective, both for its current and future GHG emissions goals. For example, while significant gains are currently projected from energy efficiency and substantially smaller gains are projected from renewable energy, renewable energy programmes continue to be funded at very, perhaps disproportionately, high levels. Using a combination of economic and political indices, the policies might be re-examined to re-balance the portfolio. Very heavy reliance is placed on a voluntary approach; given the stringency of the targets, it may be necessary to adopt a more aggressively binding set of targets and regulations.

The government should also further develop programmes for emissions trading and other flexible mechanisms within its policy portfolio in order to reduce costs. The development of a domestic emissions trading regime will become more important as the European Union proceeds with the implementation of its own Emissions Trading Directive. Swiss industries, particularly those that compete with industry in Europe, may find themselves at a competitive disadvantage if a comparable Swiss regime is not established. In this context, consideration might be given to whether a portion of the tax revenues (expected when the Swiss CO_2 Law is fully implemented) is devoted to purchasing GHG emissions permits from the international market.

Switzerland needs to develop programmes to implement the domestic instruments that allow the purchase of emissions offsets from project-based activities abroad, through both the Kyoto Protocol's CDM and JI processes. The effort was initiated through the establishment of the Swiss Activities Implemented Jointly (AIJ) programme office, and the release, in late 2001, of a concept paper on the implementation of the Protocol's flexible mechanisms. This preliminary effort will need considerable expansion and refinement if the Swiss are to use this policy tool effectively to reduce their total emissions reduction costs. In addition, Switzerland should continue to collaborate with other countries towards the development of workable rules for the development of efficient international market-based mechanisms envisioned under the Kyoto Protocol (*i.e.* emissions trading, CDM and JI).

The complex mix of the competences of the cantons and the Confederation will continue to require a policy that works to strengthen both. Thus, the Confederation should continue to develop tools to assist the cantons in promoting and disseminating their own programmes, while working to bring the most innovative of the cantonal policies forward to the wider national community. Some of the most innovative policy options being developed may be in the transportation sector, currently one of the most troublesome areas for the Swiss policy effort. Using the experiences from the cantons or communes on new innovative solutions may help to develop robust and practical options that will be needed to address the climate change problems over the longer term.

All forms of new power generation have met with opposition given their potentially negative impact on the environment. Should nuclear power be phased out or Switzerland significantly increase generation from renewables, it will be important that the government clarifies how it intends to proceed with its policies to address environmental damages (including CO_2 and pollutant emissions) caused by new generating capacity. Until this is done, it will be difficult for industry to incorporate these environmental criteria into planning processes, and the government will probably face continued opposition to its energy policies from both industry and the general public.

RECOMMENDATIONS

The government of Switzerland should:

- *Take additional action to meet the GHG emissions reduction targets.*
- *Review energy-related climate change mitigation policies with a view to balancing efforts as the current focus on energy efficiency and renewables may not prove to be the most cost-effective solution.*
- *Develop implementation plans for CO_2 "incentive" tax and emissions trading.*
- *Evaluate the effectiveness of VAs and VCs and envisage the possibility of extending them to all energy-intensive sectors, including oil refineries.*
- *Develop additional support programmes for the cantons to assist them in setting and implementing vehicle taxes that are proportional to CO_2 emissions, and federal programmes to support the innovative use of cleaner fuels in the transport sector.*

ENERGY DEMAND AND END-USE EFFICIENCY

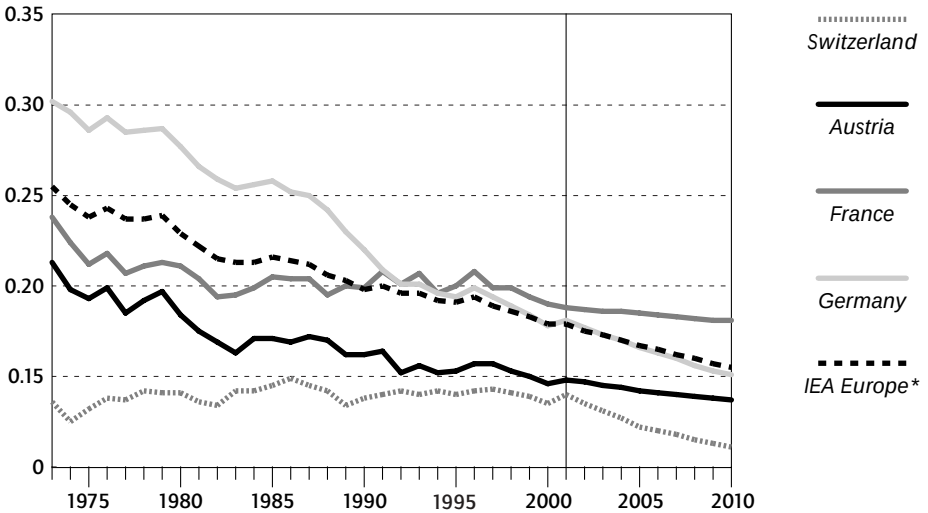
END-USE TRENDS

In 2001, total primary energy supply (TPES) in Switzerland was 28 Mtoe, up by 11.6% from the 1990 level. Switzerland's energy intensity (TPES per unit of GDP) is among the lowest of all IEA member countries (see Figure 10). Since 1990, it has been relatively stagnant, with a decrease in energy intensity during the second part of the 1990s being eradicated by an increase in 2001.

Total final consumption (TFC) was 21.6 Mtoe in 2001, up by 9.7% from 1990. The transport sector had the biggest share (32%), followed by the residential sector (27%), the industry sector[10] (23%) and other sectors (18%), principally the services sector.

Figure 10

Energy Intensity in Switzerland and in Other Selected IEA Countries, 1973 to 2010



* excluding Norway from 2002 to 2010.
Toe per thousand US$ at 1995 prices and purchasing power parities.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; *National Accounts of OECD Countries*, OECD Paris, 2002; and country submissions.

10. Including non-energy use 0.42 Mtoe.

Energy consumption in the residential, services and other sectors increased by 3.7% between 1990 and 2001. Seasonality of demand resulted in important annual variations in consumption. Recent statistics on the use of different types of heating do not exist; however, the SFOE estimates that heating oil accounts for approximately half of the heat demand in the residential and service sectors. Natural gas and electricity demand increased slowly but steadily.

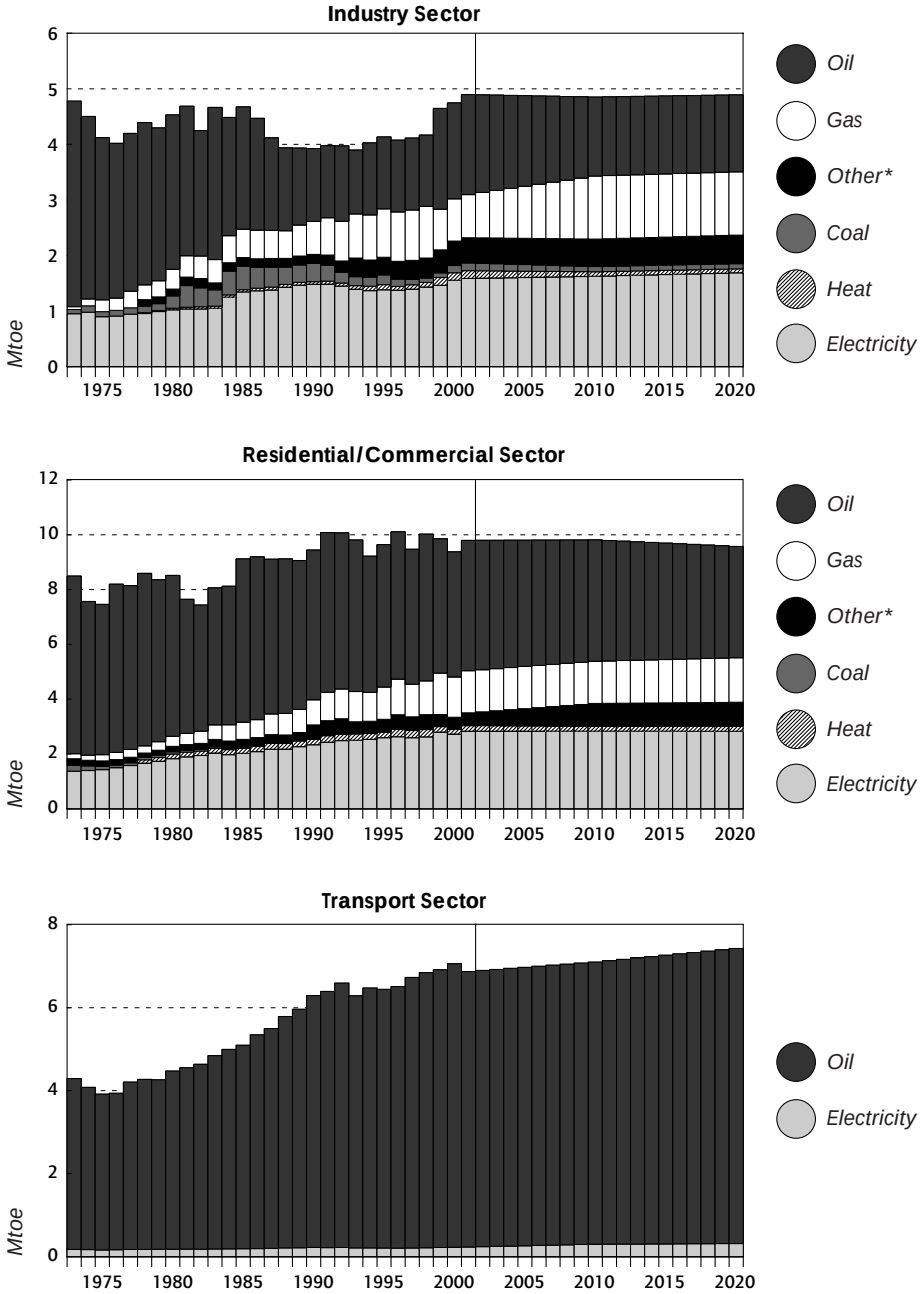
Consumption in the transport sector grew by 9.2% between 1990 and 2001. Despite energy efficiency improvements in the transport sector[11], TFC is increasing with mobility, principally because of population growth, number of vehicles and increased mileage. However, in 2001 there was some decline for the first time after the mid-1990s. At present, 102 billion passenger-km are travelled every year. Public transport, mainly trains, accounts for 18% of the total passenger transport on land; the EU average[12] was about 21% of the total in 1999. Freight transport volume is about 28 billion tonne-km per annum, of which approximately 9 billion tonne-km are carried by rail. Despite the large share of rail transport in the total mileage, fuel used by individual cars in road transport still dominates the development of energy consumption in the transport sector. The number of diesel cars is growing slowly but steadily; in 1999 they represented about 7% of new car sales.

Industrial energy consumption did not grow in the early 1990s owing to an economic slow-down. A large share of the 25% growth observed from 1990 to 2001 in this sector occurred during the last three years, outpacing economic growth over the same period. The government estimates that energy consumption in this sector will not grow in this decade. No single industrial sector dominates industrial energy consumption; the largest energy-consuming industries are "non-specified industries" (which represent 19% of all industrial consumption), chemical and petrochemical industries (with a 16% share) and paper, pulp and printing (with a 15% share) and non-metallic minerals (with an 11% share). The remainder is distributed between many different industries.

11. In 1990, a car weighing 1 000 kg consumed 7.5 litres per 100 km, whereas in 1999, consumption had dropped to 6.33 litres, *i.e.* 16% less.
12. The EU figure includes air transport in addition to buses, coaches, tramway, metro and railways. Therefore, it is not fully comparable. Air transport in Switzerland is negligible and the figure given represents quite well public transport in the country.

Figure 11

Total Final Consumption by Sector and by Source, 1973 to 2020



* includes geothermal, solar, wind, combustible renewables and wastes.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

INSTITUTIONAL FRAMEWORK

During the last decade, the Confederation's and cantons' responsibilities for energy policy, including energy efficiency, have undergone major changes. Prior to the constitutional amendment approved in a referendum in 1990, the corresponding 1990 Law on Energy Use and the corresponding 1991 Decree on Efficient Energy Use, the cantons had more competences in energy policy than the Confederation. The constitutional amendment established the competences at federal level; however, the 1998 Energy Law gave more responsibilities back to the cantons. The competence in energy efficiency policies is currently split between the Confederation and the cantons. Legislation and policies related to buildings are mainly under cantonal competence[13] whereas energy labelling and most transport issues (*e.g.* motor vehicle standards) are under federal competence. The policies and measures adopted by the Confederation in industry are mainly voluntary and have been developed in co-operation with industry.

Energy efficiency policies differ widely in the various cantons (see below Sectoral Policies). The Confederation has no legal means to enforce harmonisation. However, it can promote it with its global contributions to the cantons, which will be allocated in accordance with the effectiveness of the cantonal programmes. Collaboration between the cantons takes place within the framework of the Conferences of Cantonal Energy Directors and Services, which were established in the mid-1970s and have permanent secretariats. All the cantons participate in the conferences at energy director and energy office levels. The conferences meet regularly to discuss and make recommendations on energy efficiency in buildings and the public sector.

The 1998 Energy Law and the Swiss CO_2 Law envisage the possibility of giving various tasks to private organisations to implement SwissEnergy. In this context, four non-governmental energy agencies have been established, namely the Energy Agency for the Economy, Agency of Renewable Energies and Efficient Application of Energy, Energy Agency for Electric Appliances and Swiss Agency for Efficient Energy Use (see box).

SECTORAL POLICIES

RESIDENTIAL AND SERVICES SECTORS

SwissEnergy aims to reduce the consumption of fossil fuels for heating by 15% between 2000 and 2010 and to limit growth in total electricity consumption at 5%. Many measures have been introduced to achieve these targets, and

13. The cantons have always had full competence in the area of building standards and this did not change in either of the reallocation of responsibilities.

Non-governmental Energy Agencies

The Energy Agency for the Economy (AEnEc) was established in 1999 by Economiesuisse and several trade associations in order to help enterprises improve their energy efficiency by using voluntary measures, thus allowing them to avoid the CO_2 "incentive" tax. Its principal activity is the preparation and conclusion of VAs. AEnEc's objective is to have at least 40% of energy consumption in the industrial and services sector covered by the VAs by end 2003. It implements a monitoring system for its members who are involved in SwissEnergy. Its budget is CHF 13 million for the period 2001 to 2003.

The Agency of Renewable Energies and Efficient Application of Energy (AEE) was established in 1998 by the major Swiss renewable energy and building industry associations. Its principal tasks are to promote the rational use of energy and renewables. It has received a mandate and financing (up to 50% of related expenses) from SwissEnergy to organise and support marketing efforts for renewables and to provide training in the area.

The Energy Agency for Electric Appliances (EAE) was established in 2000. It is a joint venture by Electrosuisse, a consumer organisation (Konsumenten Forum, kf) and three associations in the electric appliances sector (Swiss Professional Association for Electric Appliances for Households and Trade, FEA, Schweizer Licht Gesellschaft, SLG, and Schweizerischer Wirtschaftsverband der Informations-, Kommunikations- und Organisationstechnik, SWICO). EAE's objective is to increase energy efficiency of electric appliances and their use. It encourages industry to produce more energy-efficient appliances and importers to import them, and raises consumer awareness. In 2002, the EAE entered into a co-operation agreement with the SFOE to implement SwissEnergy in this sector.

The Swiss Agency for Efficient Energy Use (SAFE) was established by environmental non-governmental organisations in 1998 to promote ecological and consumer interests, in particular the efficient use of energy. One of its objectives is to work towards achieving the SwissEnergy target to limit the increase of electricity consumption to 5% between 2000 and 2010. Another is to stabilise electricity consumption by appliances at the 2000 level by 2010. SAFE promotes and develops energy labelling for domestic appliances and lamps, and attempts to limit the access of inefficient products to the markets by providing information services to consumers.

those set by Energy 2000. The core activities include building standards, individual metering of heat and hot water, standards and labelling for electric appliances and harmonisation efforts between the cantonal policies. These are discussed in more detail below.

In the building sector, efforts are being made to promote new standards (*e.g.* SIA 380/1 and 380/4) and to incorporate these into cantonal legislation. In addition to the main construction industry standard, there are

two other recognised quality standards, namely the Minergie standard that has the support of the cantons as well as the Confederation, and the passive house standard of the Passive House Institute of Germany. These standards seek to promote low energy consumption through clearly defined and monitored technical specifications. New and renovated buildings meeting the Minergie standard consume significantly less energy[14] than conventional homes (*e.g.* SIA standard) and require on average 6% additional investment in new buildings. Since the introduction of Minergie in 1997, some 1 500 buildings (8.6% of total floor area in public buildings) have received this label and many others (17.2% of total floor area in public buildings) meet the standards without applying for the label. A few cantons subsidise construction that complies with the Minergie standard and some banks offer special mortgage conditions if a property complies with the Minergie standard. The Confederation has decided that all buildings constructed or subsidised by the Confederation must aim to comply with the Minergie standard.

The passive house standard is even more demanding than the Minergie standard[15]. A passive house is a building in which a comfortable interior climate can be maintained without active heating and cooling systems. The house almost heats and cools itself, hence "passive". This objective is achieved by good insulation, passive use of solar energy, energy-efficient windows and frames, pre-heating of incoming air underground, heat recovery systems, renewable or energy-efficient systems to provide energy for hot water and low-energy appliances.

The cantons are also involved in the management of activities at local level, for example the Energy City Programme. More than 70 cities, with a total population of 1.5 million, have received the Energy City Label by formulating their energy policy programmes with objectives, deadlines, budgets and quantifiable measures. Energho is an association of major energy consumers in the public sector, including hospitals, cantonal buildings and large federal consumers. Fifteen cantons adhere to Energho, which assists them in their efforts to improve energy efficiency in public buildings. Just as many cantons practice energy accounting to record energy consumption in their own buildings.

At present, under 0.5 million of a total of 1.2 million residences have individual metering of heating and hot water. Under the previous Energy Law this individual metering in new and existing buildings was obligatory for the whole country, whereas the 1998 Energy Law stipulates an obligation for new buildings only. The cantons are required to draw up corresponding provisions. In this process, many have decided not to keep the obligation for consumption-based heating cost allocation for existing buildings.

14. Under the Minergie standard, the specific energy consumption of new houses is limited at 170 MJ/m^2 and new blocks of flats at 137 MJ/m^2. Average energy consumption in houses built before 1990 is 310 MJ/m^2 and in blocks of flats 300 MJ/m^2.
15. In a "passive house", the specific energy consumption should not exceed 54 MJ/m^2 (15 kWh/m^2).

Several labelling schemes have been introduced for different appliances as an initiative of the Confederation. In 2002, implementation of the EU energy-labelling scheme for household appliances with efficiency indicators A-G was made mandatory. It applies to refrigerators, freezers, washing machines, tumble-dryers, dishwashers and light bulbs. Switzerland uses the Group for Energy Efficient Appliances (GEEA)[16] Energy Label for electronic appliances and water equipment, but is now considering whether to continue using this or to apply the Energy Star Label to the IT-electronics. Industry prefers to use Energy Star because the criteria are easier to fulfil but the government is concerned that Energy Star overlaps with other labels already in use.

Table 8

Cantonal Implementation of the Model Decree[1]

Module	*Cantons[3]*	*% of Swiss population*
Basic insulation	ZH, GL, FR, BL[2], AR, SG, GR, TG[2], TI, NE, JU[2]	45
Supplementary standards for new buildings	ZH, BS[2], BL[2], AR[2], TI, NE	30
Individual metering and billing of heating and hot water in existing buildings	BE[2], NW, GL, BS, BL, TG	24
Justification for need for cooling and/or humidification	ZH, LU, UR, SZ, GL, FR, SO, BS[2], BL[2], AR, SG, TG, TI, NE, GE	60
Electric heating without stand-by	UR, ZG, FR, BL[2], TI, NE	15
Electrical energy (SIA 380/4)	GL[2], FR[2], TI, NE	10
Open air heating and swimming pools	ZH[2], LU, SZ[2], GL, ZG, SO, BL[2], TG, TI, NE	45
Heavy users	ZH, UR, SG, NE	26
Work approval (as carried out by private suppliers)	ZH, GL, FR, AR, SG, GR[2], TI	35
Energy Plan	ZH, UR[2], FR[2], TG, NE	26

[1] Status on 1 February 2003.

[2] Varies from the Model Decree.

[3] AG = Aargau, AI = Inner-Rhoden, AR = Ausser-Rhoden, BE = Bern, BL = Basel-Landschaft, BS = Basel-Stadt, FR = Fribourg, GE = Geneva, GL = Glarus, GR = Graubünden, JU = Jura, LU = Luzern, NE = Neuchâtel, NW = Nidwalden, OW = Obwalden, SG = St. Gallen, SH = Schaffhausen, SO = Solothurn, SZ = Schwyz, TG = Thurgau, TI = Ticino, UR = Uri, VD = Vaud, VS = Valais, ZG = Zug, ZH = Zurich.

Source: SFOE.

16. GEEA is a forum of representatives from European national energy agencies and government departments working with industry on voluntary information activities in the field of energy-efficient home electronics, office equipment and IT-equipment.

The cantons have made an effort to harmonise their legislation through the Conferences of Cantonal Energy Directors and Services, which have issued a model decree with ten modules on the efficient use of energy. The cantons have not fully incorporated the different modules into their legislation (see Table 8). The modules related to individual metering of heating and hot water in existing buildings and permit requirements for direct electric heating have been adopted more commonly than those using energy-efficient appliances, energy labels and motor vehicle taxes based on fuel consumption.

TRANSPORT SECTOR

Given that transport plays a major role in energy use and CO_2 emissions, SwissEnergy aims to reduce the 2000 level of consumption of transport fuels by 8% by 2010.

Recent trends demonstrate that private vehicle use is increasing, while public transport use is decreasing. SwissEnergy aims to maintain a constant ratio of public to private use, which implies that policies to improve the accessibility and attractiveness of rail and urban public transport systems are high priority. However, the Swiss policy of promoting rail use for freight transit and internalising externalities has created some international tensions with neighbouring countries that object to the higher prices this entails as well as the problems faced by long-distance haulers.

The heavy vehicle fee, in force since January 2001, is a tax related to distance travelled and vehicle weight and is intended to internalise freight transport costs, including externalities related to health and environment. The maximum charge was set at CHF 0.02 per tonne-km in 2001 and will increase to CHF 0.03 in 2005. In parallel, the maximum weight limit for heavy vehicles allowed to enter Switzerland increased from 28 tonnes to 34 tonnes and will be increased to 40 tonnes in 2005. The tax is anticipated to raise CHF 1.5 billion per annum which will be used for investments in rail infrastructure; one-third of the revenues will go directly to the cantons. The 2001 tax revenue was approximately CHF 750 million. The first visible effects of the new tax are a stabilisation of distances travelled by trucks but it is difficult to disentangle the effects of the tax from those of the general improvements in the road freight system. Distance travelled by heavy vehicles increased by 7% in 2000 and decreased by 5% in 2001. The tax has brought about some renewal of the truck fleet. Sales of heavy goods vehicles increased by 45% the year before the introduction of the tax, primarily because the new trucks belong to the lowest, and therefore cheapest, emission class and the owners wanted to optimise the size of their trucks.

The cantons have authority over vehicle pricing policy and local traffic regulations. Currently, many cantons have imposed vehicle taxes that are

proportional to horsepower, weight or engine size, although only a few have adopted policies that relate taxes to CO_2 emissions. The cantons also have legal authority over vehicle registration and driver training, which are being used to promote increased environmental performance. A number of other innovative transport-related programmes are being developed in the cantons, such as the VEL2 Programme in Canton Ticino, which is supported by SwissEnergy and promotes alternative, low or zero emitting vehicles (hybrid and internal combustion engine vehicles) through subsidised pricing. The Better Mobility Programme of the Canton of Basel subsidises the purchase of electric bicycles for company use as an alternative to car use; 600 bicycles were purchased under the programme in 2001. The cantons have also shown an interest in alternative fuels; for example, the Canton of Zurich has six service stations providing biogas from waste for hybrid vehicles. The gas industry is investing in natural gas distribution systems to enable natural gas use in the transport sector.

At the beginning of 2003, an energy label on distance-related energy consumption and CO_2 emissions became mandatory for new passenger cars. The label applies to cars with unloaded weight under 3 500 kg and a maximum of nine seats, which are either hybrid or operate with fossil fuels. A vehicle's rating is determined by vehicle weight, fuel consumption and fuel type. The SFOE expects the label to reduce fuel consumption in the transport sector by 5%.

SwissEnergy also uses a number of other measures in the transport sector. For example, the impact of instruction on energy-efficient driving, the EcoDrive courses, is estimated to save 10% to 15% in fuel consumption among those who have taken the course. There were approximately 30 000 members of car-sharing schemes in 2000.

INDUSTRY AND OTHER LARGE CONSUMERS

At present, measures in the industrial sector are mainly voluntary, such as the Swiss Energy Model, benchmarking for smaller enterprises and the newly introduced voluntary agreements (VAs) and voluntary commitments (VCs). Large consumers in the private and public sectors participated in Energy 2000 and SwissEnergy as partners through their associations.

The Swiss Energy Model aims to improve energy management by large energy consumers in the industrial and services sector. The participating companies are typically those with an annual energy bill in excess of CHF 50 000 per annum, for example cement, pulp and paper, and plastic injection moulding. The participants are divided into groups of eight to 15 companies that jointly endeavour to find ways to increase energy efficiency under the guidance of the AEnEc. Prior to concluding a target agreement, existing energy consumption is

measured and the economic potential for energy saving is estimated. The targets for CO_2 emissions, CO_2 intensity and energy efficiency in 2010 are based on a simple forecast of the CO_2 trends up to 2010. The programmes are supervised by consultants who provide the companies with feedback on project status, effectiveness of the measures applied and potential for further improvement. One of the objectives is to build up a "know-how pool" through close co-operation between the companies in the group.

The small and medium-sized industries did not join the Swiss Energy Model. The AEnEc, supported by SwissEnergy, developed a benchmarking scheme for them to follow their specific energy consumption and specific CO_2 emissions. The participating companies are divided by branch into groups of maximum 30 companies. Each company establishes its own energy efficiency objectives with the help of AEnEc, which measures and compares their progress.

The Swiss Energy Model is used as a basis for the introduction of VAs and VCs. The VAs are for less energy-intensive companies and the VCs are for larger industries, groups of consumers and energy-intensive companies. In the agreements, the progress is measured in terms of energy efficiency. In the commitments, the criteria will be CO_2 intensity but there will also be a cap on total CO_2 emissions levels; trading of CO_2 allowances will be accepted. Industries are signing VCs to avoid the CO_2 "incentive" tax in 2004, which is possible if targets are achieved. If the targets under the commitment are not met, the company must pay the CO_2 tax. However, if the company exceeds the quota as a consequence of unexpected growth in its business volume, it can renegotiate its CO_2 cap. The other signing party in the VAs and VCs is the AEnEc. The VAs and VCs are subject to approval by the SFOE and the SAEFL. In November 2002, 13 VCs representing 150 companies had been made with AEnEc; the authorities had approved five of these, although the final signatures were still pending. At the same time, over 20 VCs were being elaborated. Progress in the voluntary measures, both VAs and VCs, will be subject to auditing and analysis by third parties and to control by SwissEnergy. AEnEc's objective is to have 40% of the economy's CO_2 emissions covered by voluntary measures by the end of 2003.

MONITORING AND ASSESSMENT

The Confederation and the cantons place particular importance on the need to carefully and regularly monitor and evaluate all the energy efficiency programmes and measures under their responsibility. The measures taken have been periodically evaluated to increase their effect and to encourage the learning process for all participants. Energy 2000 and SwissEnergy evaluation reports are published on an annual basis. They provide a detailed examination of the progress made in implementing the programmes, assess

the degree of realisation of the different objectives and analyse the expected energy efficiency, environmental, investment and employment impacts.

Impact evaluation of specific measures (*e.g.* energy-efficient vehicles) is carried out principally using the bottom-up method but also top-down methodology is used. In the bottom-up approach, information is collected on the key parameters, such as the number of efficient vehicles sold and the average distance driven per year. Specific energy consumption (*e.g.* 100 MJ per passenger-km) is calculated and compared to the national average. The impact on the economy is estimated in terms of a reduction of energy consumption (*e.g.* TJ per annum). One example of the top-down approach is collecting market information on the total number of efficient heat pumps sold, estimating their share of the total heat pump market and calculating the energy savings compared to the use of less efficient heat pumps. As a result of such analysis, direct subsidies for heat pumps were recognised to be inefficient and were abolished, the first energy label developed under Energy 2000 (the GEEA Energy Label for certain applications) may be abolished and measures introduced under Energy 2000 have been revised and improved under SwissEnergy.

CRITIQUE

Despite the many policies and measures already in place, it will be very challenging for Switzerland to meet its SwissEnergy objectives for fossil fuels and electricity consumption. Fossil fuel consumption increased in the first project year by 1.1%, compared to the reduction target of 10% for this decade, and electricity consumption increased by 3.2%, which is equivalent to more than half the cap for this decade. Energy intensity in Switzerland is among the lowest of all IEA member countries, principally because Swiss industry is not very energy-intensive. Despite the efforts in Energy 2000 and SwissEnergy, energy intensity is slightly higher than it was in 1990, whereas the IEA average has been constantly decreasing. The SFOE carried out very careful monitoring and assessment of the progress under Energy 2000 and SwissEnergy and the effectiveness of existing policies, which is highly commendable. This has enabled the Confederation to evaluate the need for policy revision. Consequently, the Confederation has recognised that stronger additional measures, such as the CO_2 "incentive" tax, will be necessary if existing measures do not prove effective to achieve the SwissEnergy targets (see Chapter 3).

During the 1990s, some of the responsibility for energy policy-making, including some energy efficiency policies, was transferred twice between the cantons and the Confederation. Given the long perspective needed in policy-making, the institutional framework should be as stable as possible. Non-governmental organisations carry out many potentially effective programmes; however, their role in the implementation of the SwissEnergy objectives needs

to be clarified in order to avoid the government supporting overlapping efforts. There are several collaboration platforms between the Confederation and the cantons in different areas of energy efficiency. It should be ensured that no important areas of energy efficiency policy fall between these discussion forums and frameworks and that there is no duplication.

The cantons have full responsibility for energy efficiency policies in the building sector. Sporadic programmes by the cantons do not lead to efficient use of resources and an optimum outcome. The Confederation has made an effort to help the cantons harmonise their building legislation. It supported the Conferences of Cantonal Energy Directors and Services to develop a model decree that covers many areas of energy efficiency. The Confederation should continue its efforts to support such guidelines for best practices. Another tool that the Confederation will shortly have at its disposal is the allocation of financing under SwissEnergy, which is based on the effectiveness of cantonal programmes. This is likely to encourage each canton to look for the most cost-effective measures and compare their efforts to those of other cantons.

The model decree, which includes individual metering of heating and hot water, has been adopted by less than half of the cantons and only few apply it to existing buildings, whereas all new buildings are subject to the regulations. The cantons are hesitant to pursue individual metering in existing buildings because of the resistance by home-owners who fear high metering costs. The government has identified this measure to be one of the most effective in achieving energy savings. On the basis of a cost-effectiveness analysis, the government could consider encouraging the cantons to financially support this activity as part of their SwissEnergy budget.

The new voluntary Minergie building standard has proven to be cost-effective by significantly reducing energy consumption in buildings. Implementation of the standard is proceeding slowly because all the cantons do not have the resources or the ability to implement it fully and effectively. The Confederation should help the cantons implement the standard more rapidly and improve their utilisation by the building industry. Programmes to provide financial incentives should be strengthened.

The structure and development of building and space heating is being monitored by annual building registers and a microcensus that takes place every ten years. The data are used in energy models to describe changes on a yearly basis. Further improvements may help in planning and monitoring energy efficiency policies.

Heating oil dominates the space heating market. Promoting the use of alternative heating fuels, including renewables, natural gas and other technologies like heat pumps and district heating would be beneficial. These energies and technologies could help to reduce the sector's CO_2 emissions.

Local benefits, such as reduced particulate emissions and associated health risks could be gained from using more natural gas and electricity.

The recent initiative for labelling new cars will help consumers to compare energy consumption between different cars and may increase the importance of energy consumption as one of the decisive factors when choosing a new car. However, not all the transport initiatives and policies are necessarily consistent with energy efficiency and environmental objectives. For example, the AVANTI popular initiative to enlarge the highway system is likely to increase road use. Additionally, the relatively lower gasoline prices (see Chapter 6) in Switzerland promote fuel tourism, increase Swiss emissions and encourage Swiss drivers to use roads more.

Switzerland is in the process of introducing VAs and VCs in the industrial sector. Industry is fully convinced that the government cannot avoid introducing the CO_2 "incentive" tax. Consequently, they appear to be making a significant effort to make the VCs work in order to avoid being subject to the tax. The objective of SwissEnergy is to reduce the absolute volume of CO_2 emissions, but the targets in the VAs are set for CO_2 intensity. It is therefore possible that while industries achieve their CO_2 intensity target, overall CO_2 emissions might increase if industrial production grows. It is commendable that there is an intention to make binding contracts between the agreement party and individual industries to avoid a "free-rider problem", *i.e.* some companies within a particular industrial branch not doing their share while others carry a larger part of the burden. It is not clear, however, if all industrial enterprises will be willing to sign these contracts and what measures the agreement party can have towards the individual industries in case of non-compliance with their contract.

The government has a mandate to introduce the CO_2 "incentive" tax at the earliest at the beginning of 2004. This leaves little time to demonstrate the effectiveness of voluntary measures, and for industry and the authorities to finalise the VAs and VCs and to design and implement monitoring and evaluation practices. Further work appears to be necessary to establish evaluation criteria for the effectiveness of the voluntary measures as there are not, for example, sectoral targets for energy consumption or emissions. Therefore, it is possible that industry may also be subject to some taxation before they can demonstrate that VAs and VCs are effective. The government may need to delay the implementation of the CO_2 "incentive" tax.

The labelling schemes can improve consumer awareness of the energy efficiency of appliances when buying them. However, it is also important to provide information on appropriate use and maintenance. The consumer associations have welcomed the introduction of labelling schemes but are concerned about their large number because they can be very confusing for consumers and can overlap. At present, appliance efficiency standards take

the form of labels regarding efficiency rather than mandating minimum performance standards, with the exception or refrigerators and freezers. The plan to introduce such standards is commendable but should be carried out in close co-operation with industry.

Some banks already give mortgages with preferential interest rates to buildings that conform to the Minergie standard. They anticipate that efficiency gains will reduce operating costs, thus making it easier for building owners to pay back loans. The initial investment cost is often a barrier to household consumers making investments in energy efficiency equipment, which could eventually fully reimburse its costs. This new approach, which is taken by some banks following government encouragement, is clearly more market-oriented than government subsidies or tax rebates and should be promoted. Possibilities to apply it to other energy efficiency infrastructure and equipment should be explored.

RECOMMENDATIONS

The government of Switzerland should:

- *Ensure clear allocation of responsibilities between the Confederation, the cantons and the various energy agencies. Aim to harmonise policies and measures by strengthening their collaboration.*
- *Continue and increase work on energy efficiency in buildings through:*
  - *Increasing energy efficiency in buildings in co-operation with the cantons;*
  - *Developing and disseminating building sector and space heating statistics; and*
  - *Encouraging individual metering of heating and hot water in existing buildings.*
- *Diversify energies for space heating.*
- *Intensify co-operation with consumer groups and environmental and business associations, including dissemination of information activities and planning and implementing labelling schemes and performance standards for appliances.*
- *Work to further engage financing institutions in the development of incentives for purchases and upgrades that improve energy-efficient infrastructure and equipment.*

OIL

INDUSTRY STRUCTURE

The Swiss oil market continues to consolidate as shown by the decreasing number of members in the Central Swiss Office for Imported Fuels and Combustible Liquids (Carbura). Carbura membership is compulsory for all Swiss oil product importers. The number of members in this association decreased from 88 importers in 1990 to 53 importers in mid-2000. The number of companies in retailing has also declined from almost 700 in the 1970s to 460 today.

Switzerland's two refineries cover about 35% of domestic oil product demand. The Collombey refinery has a capacity of 2.3 Mt per annum. It is owned by Tamoil. The Cressier refinery has a capacity of 3.3 Mt per annum. In May 2000, Petroplus International acquired the refinery from Shell.

Imported crude oil for domestic refineries is mainly of light and low-sulphur quality. This reflects both high middle distillate and gasoline consumption with almost no domestic demand for heavy fuel oil and environmental legislation.

A conversion unit is being built at the Collombey refinery, which will allow Tamoil to conform to new product specifications and reconvert heavy fuel oil into light products. The costs are estimated at CHF 300 million and the new unit will be commissioned in 2003. This investment will enable Swiss refineries to meet the new EU standards that will come into force in 2005.

At the beginning of 2000, the government introduced new environmental standards on transport fuels. Benzene content in gasoline is now limited to under 1%, while sulphur content is limited to 150 ppm in gasoline and 350 ppm in diesel, and sales of leaded gasoline have been forbidden.

Oil products distribution is quite concentrated. The four principal oil companies, namely Shell, BP, Esso and Tamoil, account for over 70% of the retail oil market but the supermarket pumps have gained a fair market share. The number of filling stations is declining. At the beginning of 2002, there were 3 559 filling stations compared to 3 666 at the beginning of 1999 and 6 300 in 1970. The number of stations with convenience shops increased while the number of unattended stations sharply diminished.

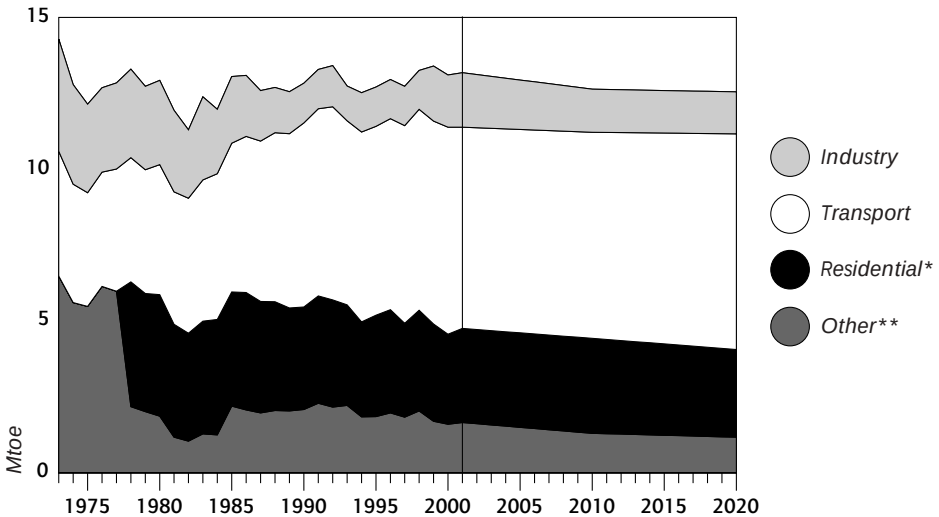
SUPPLY, DEMAND AND TRADE

Oil supply remained relatively stable during the last decade amounting to 13.9 Mtoe in 2001. The share of oil in TPES decreased from 77.4% to 53.6% between 1973 and 1990 and reached 49.5% in 2001.

The demand for transport fuels (gasoline, diesel and kerosene) is increasing and accounted for 50% of total oil consumption in 2001, whereas heating oil demand is decreasing owing to strong competition by other fuels. However, the share of heating oil in the total heat market remains at 50%. Unlike many other European countries, Switzerland's proportion of gasoline and diesel use in transport has remained unchanged over the past ten years. Although diesel cars account for only 4% of the current fleet, their share in the sales of new cars has recently increased to 16%.

Figure 12

Final Consumption of Oil by Sector, 1973 to 2020



* prior to 1978 the Residential Sector was included in Other Sectors.
** includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

All oil is imported. In 2001, crude oil imports totalled 4.7 Mt. The sources were Libya (50%), Nigeria (31%), Algeria (10%) and Iran (9%). Imports from Libya have been increasing, while those from Nigeria have been decreasing. Oil product imports amounted to 8.8 Mt in 2001 and the share of different products was diesel (52%), gasoline (31%), kerosene (13%) and other products (5%). Oil products are imported mainly from the Netherlands (35%, using mostly barges along the Rhine), France (22%, pipelines and Rhine barges), Germany (19%, Rhine barges), Belgium (14%, mainly by rail) and Italy (10%, tank trucks). Oil product exports, mainly to other OECD member countries, totalled 0.6 Mt in 2001 and were composed primarily of residual fuel oil and small amounts of bitumen and liquefied petroleum gas.

INFRASTRUCTURE

The Swiss oil supply system is based on the following elements:

- Two crude oil pipelines and one oil products pipeline (crude oil from Fos-sur-Mer, France, and Genoa, Italy, and oil products from Lavéra, France) representing some 53% of total oil supply.

- The Rhine river, railway and, marginally, trucks from the refineries in southern Germany, Belgium and the Netherlands account for about 40% of total supply.

- Finally, trucks and, to a lesser extent, railways for the supply of oil products from Italian refineries are equivalent to about 7% of Swiss oil supply.

PRICES

Gasoline prices are lower in Switzerland than in neighbouring countries and lower than the OECD European average (see Figure 13). Diesel prices are higher in Switzerland than in the neighbouring countries. They are also higher than the OECD average (see Figure 14), reflecting the higher level of taxes (64.4% of retail price) levied by the Swiss government on this fuel.

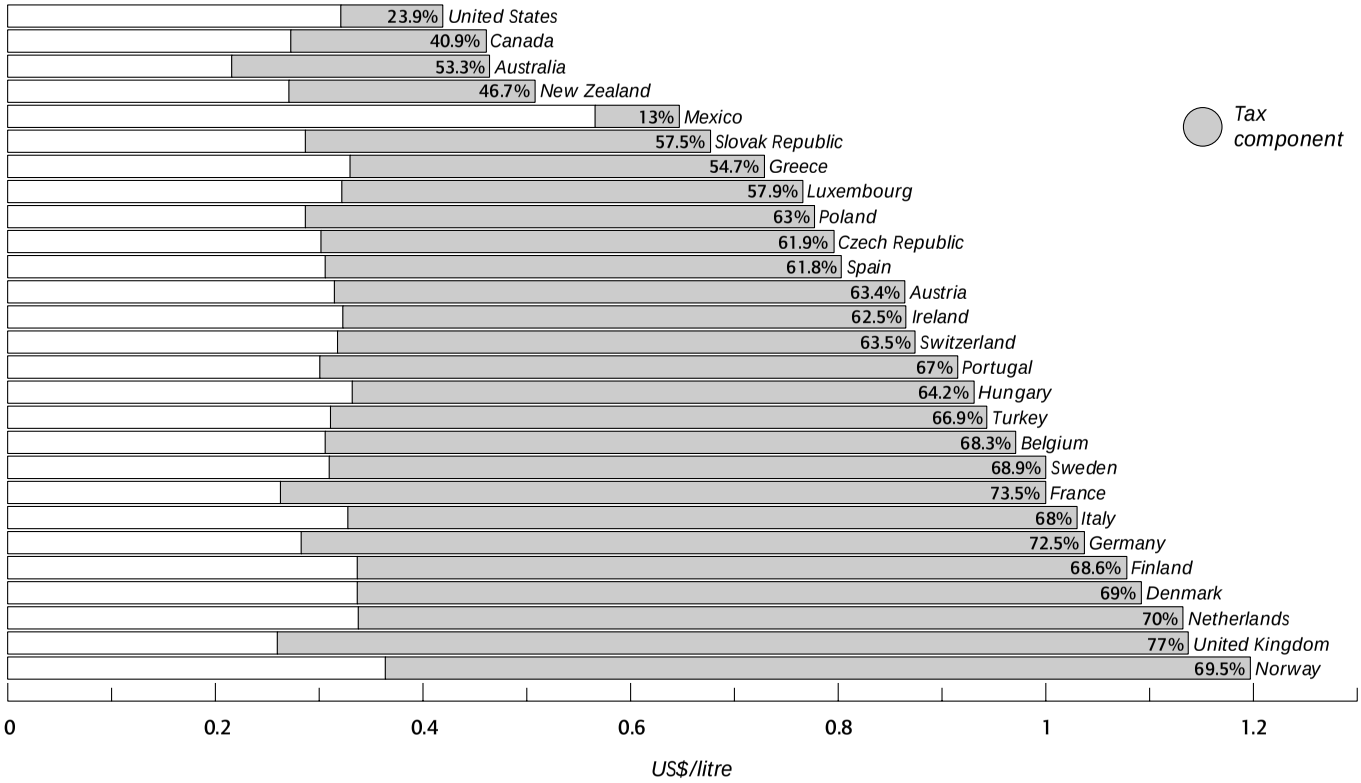
Following the development of world market prices, the peak of gasoline and diesel prices during the last ten years was reached in 2000 and prices have declined since then. Heating oil prices for households have increased by 48% between 1998 and third quarter 2002.

Lower gasoline prices in Switzerland have led to some "fuel tourism". According to an SFOE estimate, some 15% of all gasoline sold in Switzerland is purchased by foreign drivers. Diesel trucks and diesel cars have a strong incentive to refuel outside the country. To address these issues, and to promote diesel vehicles, which are more efficient than gasoline vehicles, the government and the oil industry are currently discussing the possibilities and effects of lowering taxes on diesel and compensating the fiscal loss by increasing taxes on gasoline. Similar proposals were made in the past, but have not been implemented because of concerns over higher emissions of some pollutants from diesel vehicles as compared to gasoline vehicles.

In 2001, the heating oil (light fuel oil) prices for households were the third-lowest (after the Slovak Republic and the United Kingdom) within OECD member countries and 27% under the OECD average. One of the reasons being very low taxes on heating oil. Two-thirds of the total taxes on heating oil shown in Figure 15 are Carbura fees for financing emergency stocks.

Figure 13

OECD Unleaded Gasoline Prices and Taxes, Third Quarter 2002

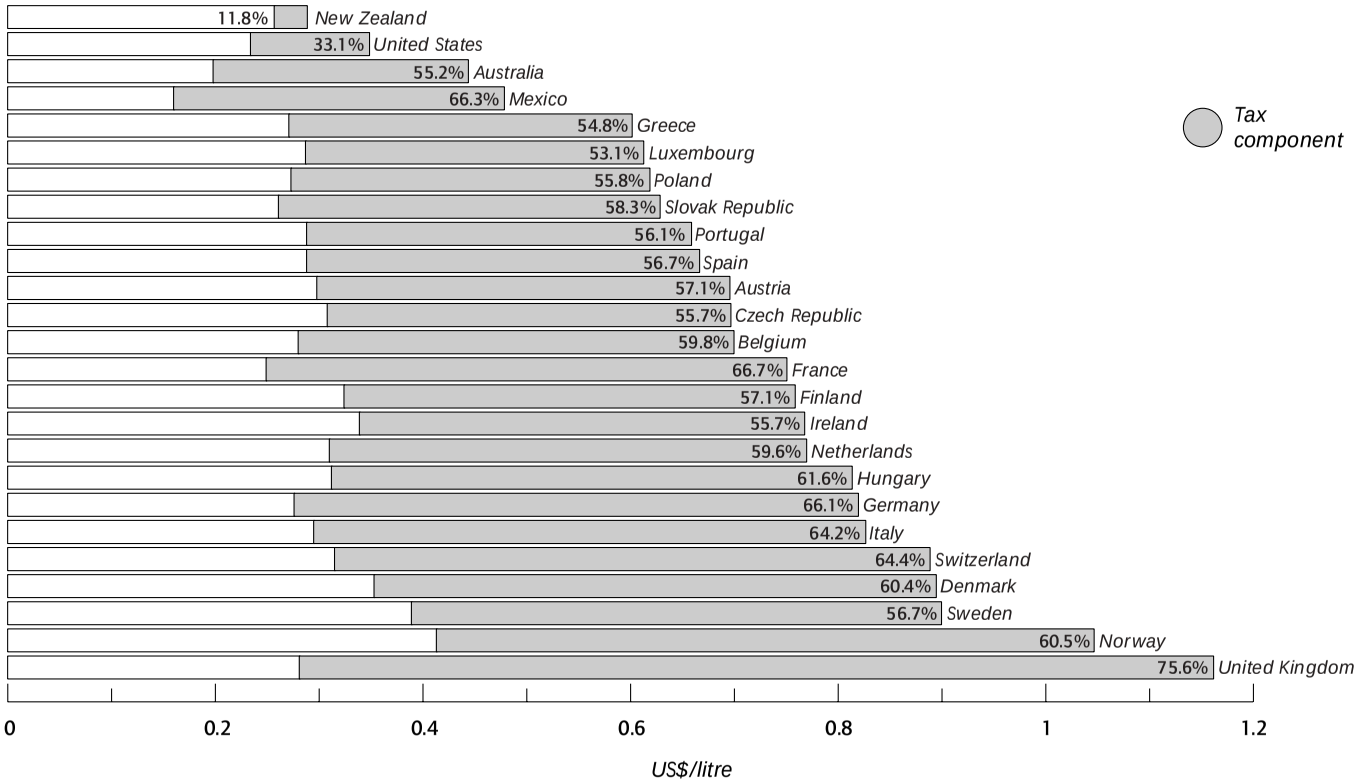


Note: data not available for Japan and Korea.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

Figure 14

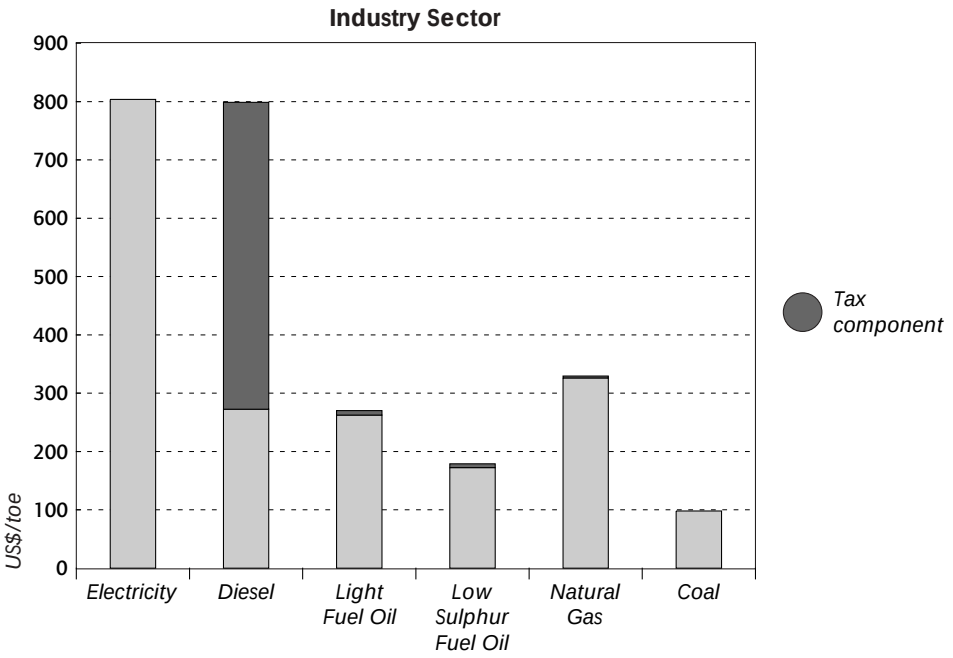
OECD Automotive Diesel Prices and Taxes, Third Quarter 2002

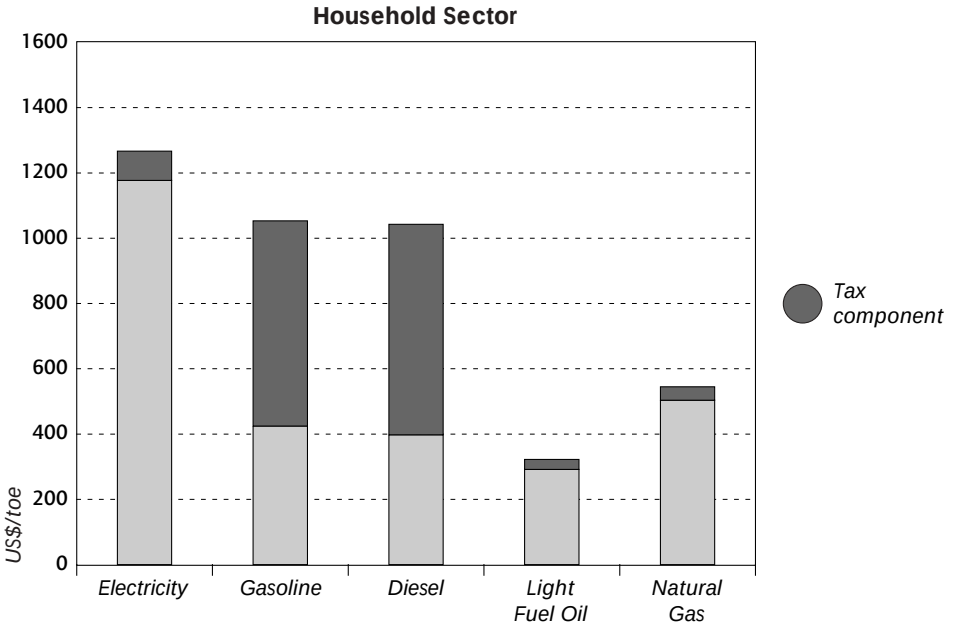


Note: data not available for Canada, Japan, Korea and Turkey.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

Figure 15

Fuel Prices, 2001





Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

EMERGENCY RESPONSE MEASURES

Given that Switzerland is a landlocked country situated at the end of international logistic lines, it has always followed a robust stockholding policy covering more than the 90 days of net imports emergency reserves commitment required by the Agreement on an International Energy Program (IEP). On 1 January 2002, Switzerland held stocks representing more than 130 days of net imports. It also maintains a detailed demand restraint programme kept in readiness for immediate implementation.

Switzerland's compulsory oil stocks policy is based on the 1982 Federal Law on National Economic Supply, as well as on the 1983 Ordinance on the Main Principles of Stockpiling and the 1983 Ordinance on Establishing Compulsory Stocks on Fuel Oils and Transport Fuels.

Companies importing oil in quantities greater than 3 000 m^3 per annum into Switzerland are obliged to apply for an import licence, which is conditional upon signing a contract with the Federal Office for National Economic Supply (FONES), by which the importer commits itself to hold a quantity of stocks in relation to its domestic market share. Although compulsory stocks remain in the ownership of the oil importers, they are under the control of the Swiss authorities, who can dispose of them should the need arise.

COAL

Coal has little importance in Switzerland and no increase in coal demand is expected in the future. In 2001, total coal supply was 0.15 Mtoe contributing 0.5% to TPES. 80% of coal is used in the cement industry, which has been replacing coal by other fuels. All coal is imported, mainly from South Africa. The obligation to maintain coal emergency stocks was terminated in 1998.

NATURAL GAS

INDUSTRY STRUCTURE

The gas industry is a multi-tiered, decentralised structure with a large number of mainly publicly, but also privately-owned gas utilities.

Swissgas is Switzerland's largest natural gas importer, with a market share of 77.5% in 2001. Swissgas is also responsible for handling questions pertaining to the natural gas industry, such as supply and infrastructure, and representing and defending the interests of the Swiss gas industry abroad. Swissgas is owned by the Union Bank of Switzerland, Crédit Suisse, the Swiss Natural Gas Industry Association and the four regional natural gas companies, namely Gasverbund Mittelland, Erdgas Ostschweiz, Gaznat and Ergas Zentralschweiz.

The remaining 22.5% is imported through the four regional gas companies. Almost all of the natural gas imported by Swissgas is sold to these four regional gas companies.

Gas transmission pipelines are owned by ten companies, including Swissgas and the four regional gas companies. The other five transmission companies are either owned by local distribution companies or are privately owned. There are various cross-shareholdings between the transmission companies. The companies buy gas both from Swissgas and directly from abroad and resell it to distribution companies. They also sell some gas directly to final consumers (about 10% of total consumption).

Approximately 100 companies are active in natural gas distribution. Most of these companies are also involved in other activities such as water, electricity and heat supply. The seven largest gas companies[17] supply 50% of the gas demand, while about 50 other companies supply 10%. The cantons and municipalities own most of the gas distribution companies. Some distribution companies are not separated from local administration. However, municipalities have started to make this separation to pave the way for market reform.

Table 9

The Main Gas Transmission Companies

Company	*Transmission volume GWh in 2001*	*Ownership*
Swissgas	25 359	EGO, GVM and Gaznat 19.45% each; ASIG 16.45%; UBS 14%; Crédit Suisse 7%; EGZ 4.2%
Transitgas[1]		Swissgas 51%; SNAM 46%; Ruhrgas 3%
Gasverbund Mittelland (GVM)	11 770	Cantons and communes 100%
Erdgas Ostschweitz (EGO)	10 068	Cantons and communes 100%
Gaznat	8 230	Cantons and communes 40%; aluminium, cement and chemical industry 40%; gas industry 20%
Unigas	6 400[2]	Gaznat 60%, GVM 40%
Erdgas Zentralschweiz (EGZ)	1 782	Cantons and communes 100%
Gansa	859	Cantons and communes 97.1%, Forces Motrices Neuchâteloises[3] 2.9%
AIL (Chiasso-Lugano)	572	Cantons and communes 100%
EBRAG (Trübbach-Chur)	..[4]	Cantons and communes 100%

[1] Transitgas transports gas to Italy and imports gas for Swissgas.
[2] 3 800 GWh to Gaznat and 2 600 GWh to GMV.
[3] Public company mainly involved in electricity.
[4] Not available.

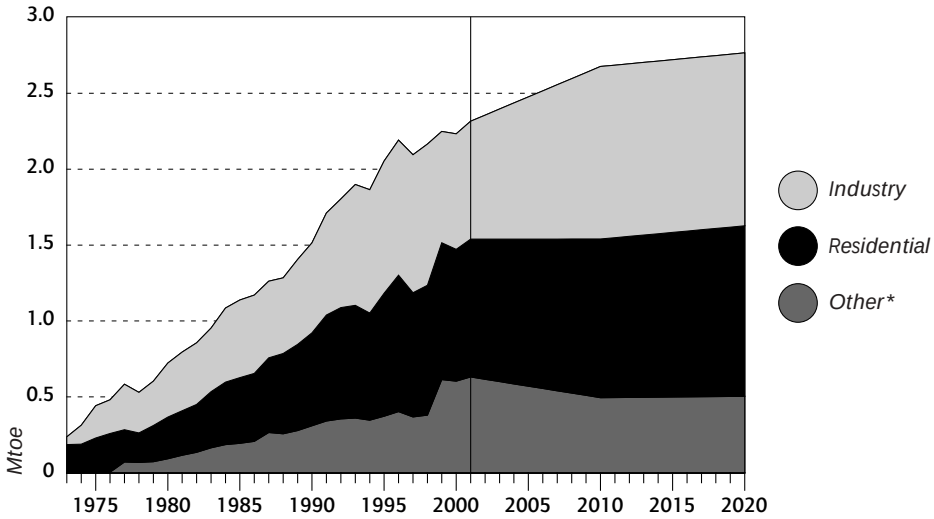
Source: Annual reports of the gas companies and the Swiss Association for Natural Gas Industry.

17. Basel (14.3% of total sales), Zurich (10.8%), Geneva (6.6%), Soleure (6.6%), Lausanne (5.1%), Bern (3.5%) and Bienne (2.6%).

Switzerland is a small gas market; with about 3 bcm, its share of the European gas market represents approximately 1%. Natural gas is, however, becoming increasingly important in the Swiss energy mix. Gas demand increased by 55% between 1990 and 2001 reaching 2.53 Mtoe and representing 9% of TPES. In 2001, final consumption of gas was 2.32 Mtoe (corresponding to 10.7% of TFC), of which 66% was used in the residential and services sectors and 34% in the industrial sector (see Figure 16). Gas's current share in the heating market represents about 22% compared to 16% in 1990. Natural gas use for electricity generation and heat production accounted for 8% of total gas demand in 2001.

Figure 16

Final Consumption of Natural Gas by Sector, 1973 to 2020



* includes commercial, public service and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

Government and the gas industry expect a slight increase in gas demand if more consumers join the existing gas networks and if gas consumption increases in the transport sector, although this may only represent a small share of energy consumption by the transport sector. The future of nuclear power, however, could have a significant impact on gas demand in the longer term if the popular initiatives for the extension of the nuclear moratorium or the phase-out of nuclear power are accepted (see Chapter 8).

The number of Swiss gas consumers is fairly small by international comparison. According to the Swiss Association for Natural Gas Industry (VSG), 19 companies represented 20% of total gas demand in 1996. Only

nine of these companies had an annual consumption superior to 250 GWh (or about 25 mcm per year, *i.e.* the present threshold for eligibility under the EU Gas Directive) representing about 14% of total gas demand, while ten companies consumed more than 150 GWh.

All natural gas is imported via pipelines. Switzerland has no gas reserves of its own. It has fairly diverse supply sources. In 2001, the import sources were Germany (50%), the Netherlands (21%), France (15%), Russia (12%) and Italy (2%).

Recent commissioning of new pipelines (see Infrastructure) will increase Switzerland's role as a transit country. During the next few years the annual transit volumes to Italy will amount to 6 bcm from Norway and 4 bcm from the Netherlands.

The European Association of Gas Transmission Operators classifies the 60 European cross-border nodal points into three categories according to available transmission capacity. Links from Germany (Wallbach) and France (Oltingue) to Switzerland have been rated in the most congested category.

Security of gas supply is enhanced through long-term contracts, interruptible consumers with dual firing possibilities and compulsory heating oil stocks, which are additional to those required by Switzerland's international commitments (see Chapter 3).

INFRASTRUCTURE

Switzerland's pipeline network measures about 15 600 km and covers some 770 municipalities, enabling 65% of the population to access gas. Switzerland has no gas storage facilities of its own. However, Gaznat has signed a commercial storage contract with GDF (France) to compensate the seasonal variation in demand. It rents storage capacity in the French underground gas storage facility located at Etrez, north-west of Geneva.

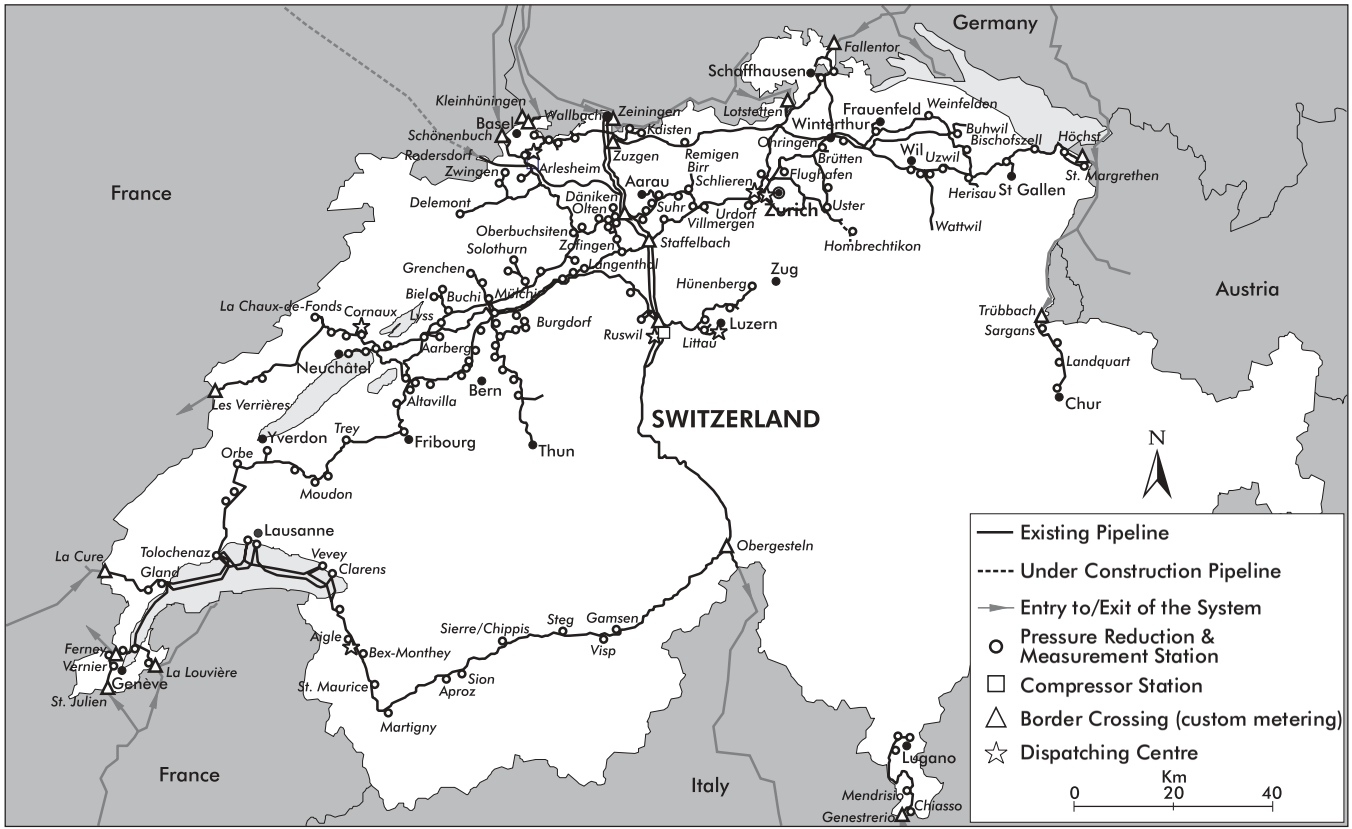
Annual investments in the extension of the pipeline network amount to CHF 500 million. The high-pressure pipeline system has been extended to meet increasing demand for domestic use and transit to Italy. In 2002, the transport capacity of the Transitgas pipeline system through Switzerland doubled and the French and Swiss networks were connected by a new pipeline, which enables imports of Norwegian gas to Switzerland.

There are no plans to extend the distribution networks. The distribution companies are concentrating on increasing the connection density, *i.e.* to persuade more clients to join the existing networks. Soft loans are available for building the gas grid in the framework of the federal law on financing investments in mountainous areas.

The Swiss gas industry is investing in developing the natural gas infrastructure to support gas use in the transport sector. In 2002, 30 natural gas filling

Figure 17

Natural Gas Infrastructure



Source: *Natural Gas Information 2002*, IEA/OECD Paris, 2002.

stations were in operation in Switzerland and VSG estimates the number to increase to 100 by 2006.

MARKET REFORM

In 1963, the Swiss Gas Pipeline Law (Article 13) allowed third-party access (TPA) to the high-pressure gas network and designated SFOE as the dispute settlement authority. The law obliges the transmission companies to carry gas for third parties "under favourable economic and technical conditions", with the third party paying the appropriate fee. However, no attempt was made to use this possibility until October 2001 when Swissgas allowed some foreign suppliers to access the Transitgas network with one-year contracts.

Since 1996, the government had studied the possibilities to reform the Swiss gas market using the EU Gas Directive as a guideline for the process, while taking into account the specific Swiss situation. The government began preparations for a draft law that would reform the gas market. However, the draft gas law was abandoned as a consequence of the results of the Electricity Market Law (EML) referendum.

The government is currently using existing legislation, mainly the Pipeline Law, complemented by the gas industry's "co-ordination agreement for transport", which they have started to prepare. The objective is to define how TPA to the regional high-pressure network could be organised, irrespective of the outcome of the preparations of a new gas law. It is foreseen that an agreement comprising the following three modules, binding to the parties involved, shall be concluded in 2003:

- Setting-up and operation of a transmission system operator for TPA.
- The rules for the determination of TPA tariffs.
- The general conditions for TPA to the regional high-pressure grid.

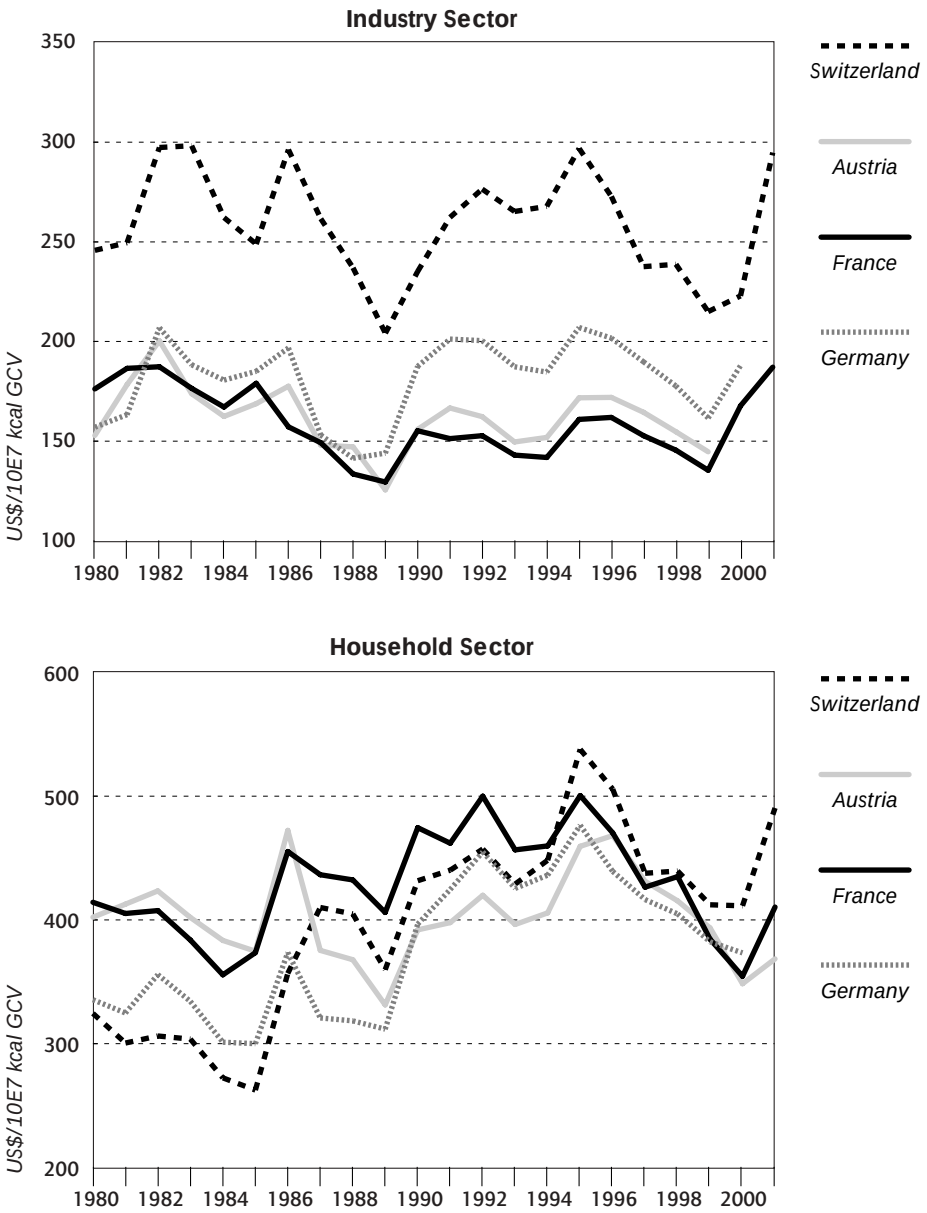
PRICES

Each gas distributor sets its own tariff structure and prices; in most cases, the prices for domestic consumers are subject to approval by local authorities. However, there are instances where the local authority rather than the gas distributor sets the prices. Gas pricing is predominantly based on the fuel it substitutes, such as heavy or light fuel oil in industry and light fuel oil or electricity in the household sector. As prices for these fuels vary in different parts of the country, gas prices also differ in each region.

Natural gas prices for all users remained relatively stable during the 1990s (see Figure 18) but increased rapidly from 2000 to 2001, with a time-lag of about half a year compared to oil prices. Gas prices for all consumers are among the highest within IEA member countries (see Figure 19). However, if

Figure 18

Gas Prices in Switzerland and in Other Selected IEA Countries, 1980 to 2001

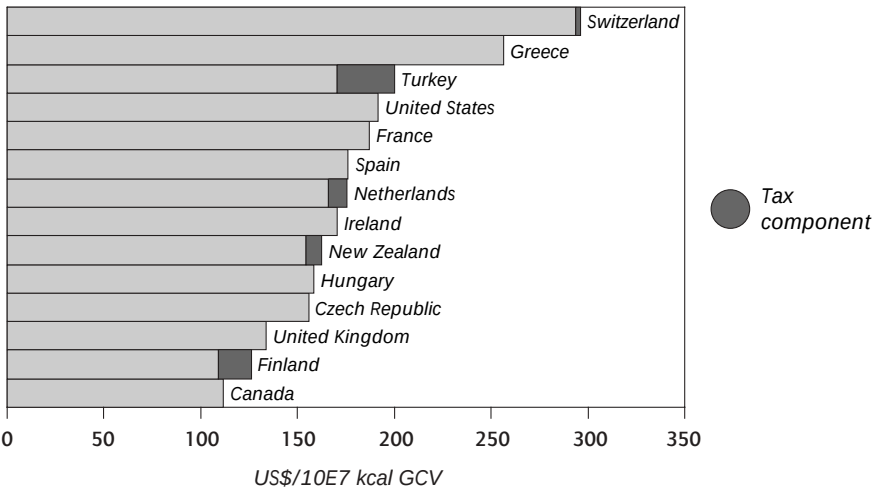


Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

Figure 19

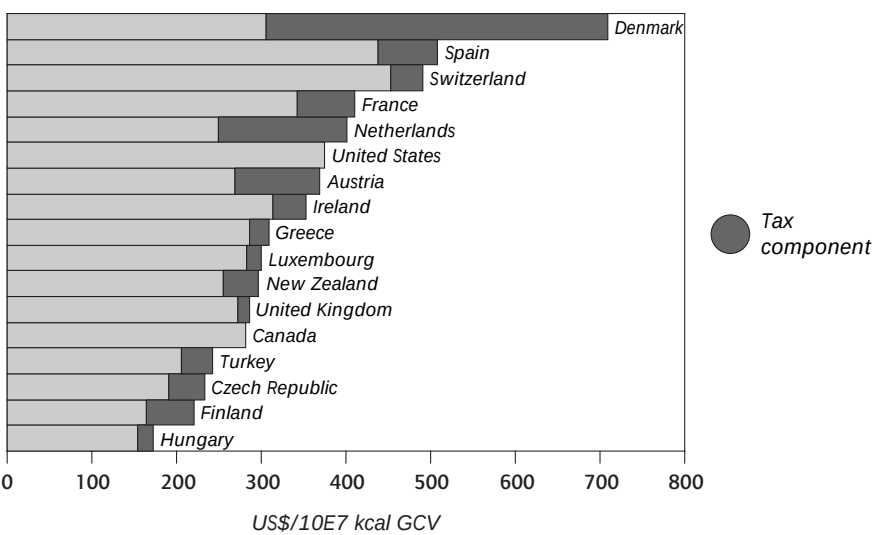
Gas Prices in IEA Countries, 2001

Industry Sector



Note: Tax information not available for Canada and the United States. Data not available for Australia, Austria, Belgium, Denmark, Germany, Italy, Japan, Korea, Luxembourg, Norway, Portugal and Sweden.

Household Sector



Note: Tax information not available for Canada and the United States. Data not available for Australia, Belgium, Germany, Italy, Japan, Korea, Norway, Portugal and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

purchasing power parities (PPPs) are taken into account when comparing the prices for households, these are lower than the average. Price levels in Switzerland increased owing to the small size of the market, an absence of large consumers, low density of connections, the large number of small distribution companies and the topography that leads to higher construction costs.

CRITIQUE

SwissEnergy's target to reduce TFC of fossil fuels by 10% between 2000 and 2010 appears to be very ambitious given that TFC of fossil fuels increased by 5.3% during the past decade, despite the stabilisation objective established in Energy 2000 and the accompanying policies and measures. Despite most of the activities in Energy 2000 being continued in SwissEnergy, fossil fuel consumption appears to be growing. According to IEA statistics, in 2001 it increased by 1.1%. Such a short-term development is insufficient to fully evaluate the effectiveness of the measures given that consumption levels were affected by many short-term factors such as the cold winter of 2001, fuel tourism and a decline in travel as a result of economic slow-down and the events of 11 September 2001. Nevertheless, stronger measures will be necessary to reverse the growing trend of fossil fuel consumption as the underlying variables, such as increasing population, industrial production and vehicle fleet, will increase by 2010.

OIL

The Swiss oil market seems to work effectively though the retail markets remain somewhat concentrated. All oil is imported but from diverse sources and there is domestic oil refining capacity which contributes positively to the security of supply. The refineries have made significant investments to meet the tightening Swiss and European environmental requirements.

Heating oil accounts for approximately 50% of the Swiss heating market and 17% of national energy demand. Encouraging efficient use of heating oil, or competition by natural gas and carbon-free electricity, can have a significant impact on CO_2 emissions. The current heating oil prices do not encourage energy savings or the use of other energies with lower CO_2 emissions. Heating oil prices are very low in Switzerland compared to those in other countries, partly because of the very low share of taxes by international comparison. Heating oil prices are also very low compared to the prices of competing energies, such as natural gas and electricity. Taxation could be used as a tool to encourage energy efficiency in the heating sector and, consequently, to reduce CO_2 emissions without putting an excessive burden on the Swiss consumers. There are two alternatives to implementation, namely revising the existing excise taxes or using the new CO_2 "incentive" tax as a tool.

In Switzerland, taxes on diesel fuel are the same as those on gasoline. There have been several proposals over the past years to lower diesel taxes and possibly increase gasoline taxes, given that diesel engines are more efficient than gasoline engines and consequently have lower CO_2 emissions. The government is currently discussing the latest similar initiative. Another objective has been to reduce fuel tourism, which is a consequence of Switzerland's different taxation policies compared to its neighbouring countries. Diesel engines emit more harmful pollutants, such as particles and non-methane volatile organic compounds (NMVOCs) with health risks even at fairly low concentrations. In the past, the government decided not to reduce diesel taxes to avoid health risks. Careful balancing of these conflicting objectives is needed until emissions control technologies to address, in particular, the particle problem associated with diesel engines become more widely available and European norms are developed and applied.

NATURAL GAS

Swiss gas demand has continued to increase, albeit slowly, over the past few years, thus contributing to the diversification of the energy mix. Switzerland has also become quite an important gas transit country after the commissioning of new pipelines; this can have a positive impact on security of supply as well as on the development of the domestic gas market. Gas has some potential in becoming even more important in the future but much will depend on market reform, pricing and taxation of natural gas as well as competing energies and the development of gas use in transport. Decisions on the future of nuclear power can also have a significant impact.

The Swiss gas industry has a keen interest in developing infrastructure for the use of gas in the transport sector and it is making significant investments. Wider use of natural gas vehicles could contribute to the reduction of oil dependency and would have significant environmental and health benefits compared to other transport fuels. However, energy efficiency and CO_2 emissions of natural gas buses tend to be marginally worse than those of modern diesel buses. At present, taxation of natural gas for transport use does not take into account its relative benefits compared to other transport fuels.

Natural gas prices for all consumers are among the highest within IEA countries. High prices are decreasing the competitiveness of natural gas and slowing down its market penetration. In effect, the share of gas in the Swiss market is still clearly smaller than in most other European countries. The high prices can be partly explained by high investment costs due to topography and the small size of the markets, but other key factors appear to be the pricing and taxation policies and the market structure. The pricing mechanism lacks transparency because pricing is not always based on cost and it is subject to political discretion as the utilities do not always have

operational independence from the local authorities. Few resources in the Price Surveillance Office have been allocated to monitor and analyse price information for large consumers. Lack of transparency raises concerns over possibilities for cross-subsidies from one consumer group to another.

With the intention to improve efficiency in the gas sector, the government began to prepare a new gas market law, which would gradually liberalise the gas market. Its preparation, however, has been postponed as a consequence of the results of the EML referendum. The government also had doubts about the prospects of gas-to-gas competition given the small size of the gas market and the small number of larger gas consumers.

Nevertheless, it is necessary to reform the gas market. Switzerland is located in the middle of Europe, surrounded by EU countries, which have started to open their gas markets. It may be inappropriate for Switzerland, which is fully dependent on gas imports from or via these countries, to develop its gas market in a completely different direction and at a different pace from its neighbours. Small Swiss consumers appear to be more concerned about the public service viewpoint of network-based energies than their prices, while larger consumers are more cost-conscious and would like to see more efficiency and lower prices on the gas market. Market reform could also benefit the smaller consumers if the government ensures that efficiency gains are transferred to the prices they pay.

The gas industry is developing a co-ordinated agreement for transmission to define how to enable access within the current legislation, which allows TPA to high-pressure networks. This approach may enable easier and more transparent access at least for some larger consumers and distribution companies. The risk is that not all the players (including new entrants) will be able to access the market on fair terms and it is not clear if this agreement will ensure adequate transparency. Germany's experience demonstrates that market access, which is fully based on voluntary agreements between the market players, can take a long time to develop. Given the small size of the Swiss market, existing legislation that already allows negotiated TPA, uncertainties about future gas market legislation and the fact that it is almost impossible to extend competition to small consumers, this path may be the fastest and entail the lowest regulatory cost. Much will depend on the details of the agreement, which will be concluded in 2003.

The government should follow closely the contents of the agreement and its impact on the market. It should ensure that market access is simple, fast and fair. Preferably, there should be a fixed time frame during which the network operators should give access. TPA tariffs should be cost-reflective, transparent and non-discriminatory both for newcomers and incumbents. Benchmarking could be used as a tool to assess the tariff levels. A crucial step is to establish dispute settlement and appeal processes as stipulated by existing legislation.

The SFOE should step up the activities in monitoring the market and be prepared to settle disputes. Given the initiative already taken by industry to develop co-ordinated agreements, the need to secure resources for these activities is becoming acute. SFOE's decisions should be made binding to the parties on a provisional basis to avoid situations where incumbents try to delay access by relying on lengthy and costly court procedures.

It is commendable that in recent years the management of many gas utilities has been separated from local administration. This development should be further encouraged as it increases transparency and efficiency. Another notable structural issue is the dominant position of Swissgas and its subsidiary Transitgas in the gas market and their shareholding structure. It may not be easy to achieve effective competition if one player achieves a very dominant role in the market. Cross-shareholdings between gas market players may reduce their interest in competing with each other.

RECOMMENDATIONS

The government of Switzerland should:

- *Use taxation of heating fuels as a tool to improve energy efficiency and address climate change.*
- *Link proposals for tax incentives to promote diesel fuel to further reductions in non-carbon emissions.*
- *Encourage industry to develop a natural gas infrastructure for gas use in the transport sector.*
- *Monitor pricing mechanisms at the natural gas distribution level to ensure transparency, cost-reflectiveness and non-discrimination.*
- *Encourage competition and induce efficiency in the gas market by:*
  - *Urging simple, fast and fair TPA to the networks as well as transparent and non-discriminatory rules for access and tariffs;*
  - *Providing resources to monitor the gas markets and settle disputes;*
  - *Ensuring that captive consumers also benefit from efficiency gains; and*
  - *Promoting the continuing depolitisation of the management of the gas utilities.*

SUPPLY

In 2001, energy from renewable sources[18] amounted to 5.4 Mtoe, of which 3.55 Mtoe was hydropower, 1.67 Mtoe was combustible renewables and wastes and 0.13 Mtoe was other renewables. This represents an increase from 1990, when energy from renewable sources totalled 3.66 Mtoe, of which 2.56 Mtoe was hydropower and 1.03 Mtoe was combustible renewables and wastes. The contribution of renewables to TPES was 19% in 2001.

In 2001, electricity generation from renewables (including large-scale hydropower and waste) was 42.8 TWh, representing 61% of total gross generation. Hydropower contributed 41.3 TWh (excluding pumped storage), municipal solid waste 1.5 TWh (of which approximately half was renewable) and other renewables 0.02 TWh. At the end of 2001 the installed capacity of hydropower was 13.24 GW (excluding 1.63 GW of pumped storage), municipal solid waste was 0.28 GW and solar power was 0.02 GW.

SFOE estimated that in 2001, 703 ktoe of heat was produced from renewables with contributions from wood (334 ktoe), renewable waste (193 ktoe), biogas (28 ktoe) and solar (25 ktoe). The SFOE estimate includes 123 ktoe of ambient heat, which refers to the use of heat pumps that consume electricity. Renewable waste is usually used in district heating applications.

The only large hydropower plant built during the last four years was the 1 200 MW plant in Bieudron, that was commissioned in May 1998. Some 200 MW additional capacity has been acquired by capacity increases in existing power plants and by the construction of 12 small units with less than 3 MW capacity. There are few remaining sites suitable for the development of new large hydropower installations. The government is concentrating on increasing the installed capacity of existing hydropower plants through renovation and maintenance and developing small-scale hydropower plants.

Although wood energy is Switzerland's second most important indigenous renewable energy source after hydropower, its potential is not being fully exploited. The government believes that it is both economically feasible

18. Includes large-scale hydropower and waste.

and environmentally acceptable to double the use of wood-based biomass from 2.5 mcm to around 5 mcm without over-exploiting Switzerland's forest resources. Most wood use currently takes place in the residential sector.

At present, less importance is given to other renewables, including solar, wind, geothermal and ambient heat. However, the solar collector surface has been increasing and reached 1.3 million m^3 in 2000. Switzerland has one of the highest per capita figures for installed photovoltaics, next only to those in Japan.

SFOE has estimated that the technical wind power potential at environmentally acceptable sites in Switzerland is 1 500 MW, with 1.6 TWh generation per annum. Although wind farms have been created during the past few years and several projects for new wind power plants are under way, wind power development faces increasing public opposition. Good wind power locations in Switzerland are situated at altitudes starting at 800 m above sea level in hilly or mountainous country with difficult general climatic conditions (ice, cold), turbulent wind, difficult access and landscape protection problems. Many of these problems have been solved technically but they do reduce the economic competitiveness of wind power.

Switzerland is testing new co-generation methods to harness geothermal energy to supply heat to residential areas. The country is also interested in using more heat pumps for space heating.

POLICY

OBJECTIVES

Energy 2000 established two objectives for renewables, namely to increase hydroelectric generation by 5% between 1990 and 2000, and to increase the contribution of non-hydro renewables in electricity generation to 0.5% and in heat production to 3%. Heat production from renewables increased by only 2.1%, while the objective for hydroelectric generation was almost met. The objective for non-hydro generation was clearly exceeded; its proportion in power generation increased to 0.7%, principally as a consequence of augmentation in municipal waste incineration.

SwissEnergy established two objectives for renewables for 2010, namely to generate 0.5 TWh of additional electricity and 3 TWh of additional heat compared to 2000 levels. These are equal to a 60% increase in electricity generation and a 40% increase in heat production from renewables. There are no fixed targets for individual renewable energy sources but the government has made some estimates on the possible future use of each renewable energy source (see Table 10).

Table 10

Potential Increases in Renewable Energy Use by 2010 Compared to 2000

Renewable energy	*Potential increases in use by 2010 compared to 2000*
Solar thermal	By 15% per annum (similar to the last 10 years)
Photovoltaics	By at least 1.5 MW per annum
Wood	To the level of 4 million m^3 per annum (compared to 2.5 million m^3 per annum today)
Other biomass	To the level of 0.5 TWh per annum (total for heat and electricity)
Ambient heat (heat pumps)	To the level of 0.5 TWh per annum
Geothermal	To the levels of 5 MW_e and 10 MW_{th}
Wind power	To the level of 50-100 GWh per annum
Waste (renewable fraction)	By 30% in electricity generation

Source: SFOE.

FEED-IN TARIFFS

Electricity companies are obliged to purchase electricity from renewable energy sources at a fixed feed-in tariff according to the following principles:

- The feed-in tariff is on average CHF 0.15 per kWh for renewables. The tariff is adjusted to be higher during daily peak periods and lower in summer but the annual average must be met.
- The feed-in tariff is applied to all renewable energies except hydropower with a capacity of more than 1 MW and (renewable) waste.
- Cantonal authorities can reduce the tariff where production costs by small hydropower plants (< 1 MW) are much lower than the fixed feed-in tariff.
- The cantons can also establish higher feed-in tariffs. For example, in Geneva the feed-in tariff for photovoltaics is CHF 0.60 to CHF 0.90 per kWh.
- The cantons can establish individually or in co-operation with other cantons a compensatory fund in favour of electricity companies, which are obliged to buy electricity from renewables generators when the purchase share is "over-proportional" to their turnover (determined on a case-by-case basis by the cantons' authorities). These funds would be financed by all electricity suppliers inside the canton, but no such funds have yet been established.
- The obligation for utilities to purchase electricity from companies producing electricity from renewables only applies to electricity that exceeds the generator's consumption (the generators cannot sell their electricity at a higher price and at the same time purchase electricity at a lower price).

The above-mentioned feed-in tariff should have expired in July 2003, but in November 2002 it was extended by the SFOE for a further five years. The Parliament is discussing measures for new financial support to renewables as part of the new Nuclear Energy Act proposal. One of the proposals is to allocate CHF 3 to renewables from every MWh generated by nuclear, namely a CHF 70 million transfer of revenues from nuclear power to renewables.

FEDERAL PROGRAMMES

During Energy 2000, renewables received CHF 287 million financial support from SFOE, which represented approximately half of the total budget for Energy 2000. In the last three years of Energy 2000, expenditure on renewables totalled CHF 35.2 to CHF 37.5 million per annum whereas between 1990 and 1997 the average budget for renewables was CHF 22.5 million per annum. Most of the total budget was used for promotional activities (46.5%), but a substantial amount was also used for R&D (37.5%) and pilot and demonstration projects (16%). Projects supported totalled 15 000 with an installed thermal capacity of 722 MW and electric capacity of 21 MW. Solar energy received almost half of the funds (49.6%), followed by heat pumps (16.3%), wood (15.8%) and other renewable energy sources (18.3%). Promotional activities included SFOE subsidies to solar collectors and automatic wood heating systems (> 100 kW), but also more indirect measures, such as information dissemination, training and consulting.

The cost-benefit analysis of promoting renewables during Energy 2000 favoured energy efficiency over renewables and consequently the government announced a shift in support for energy efficiency programmes. However, in 2001 renewables still received CHF 67.2 million (50.5%) of the total SwissEnergy budget of CHF 133.2 million. This includes CHF 23 million of Lothar funds[19], which provides significant support for wood energy use. CHF 46.9 million (72%) of the renewables budget in 2001 came from SFOE, CHF 13.8 million (21%) from the cantons and CHF 6.5 million (10%) from third parties. While Energy 2000 concentrated mainly on solar energy, wood and heat pumps, SwissEnergy's scope has been widened to cover all other renewables.

Until 1998, federal financing for promotional activities was paid directly to the programmes and projects. The 1998 Energy Law gave more responsibilities to the cantons. It also allowed the Confederation to give

19. Wood energy has been granted a special budget of CHF 45 million for 2000 to 2003 for the production of energy from the areas of forest destroyed by the Lothar storm in December 1999. Without Lothar funds the total budget was CHF 110.2 million, with renewables receiving CHF 44.2 million (40%).

financing for renewables and energy efficiency to the cantons that had established their own promotional programmes. The 1998 Energy Law allows direct funding by the Confederation but makes it an exception. Under SwissEnergy, the Confederation gives about CHF 12 million[20] per annum to the cantons as lump-sum payments for promoting energy efficiency and renewables (excluding R&D and pilot projects) provided that the cantons invest at least the equivalent amount of money for these activities. There is no requirement concerning how the money should be allocated to renewables and energy efficiency, but from the beginning of 2004 payments will depend on the effectiveness of the cantonal programmes. Until then, the lump sums are allocated in proportion to population and the size of the cantonal budgets. Direct funding by the government to renewables has been reduced to CHF 2 million per annum and is mainly used for pilot and demonstration projects and projects of "national importance". In 2001, the government received an additional CHF 4 million one-time budget increase to be used principally to promote renewables. Most of this money goes to district heating systems supplied by waste heat. The Parliament has allocated some additional direct support for solar energy.

The Energy 2000 renewable energy sub-programme established the so-called "actor network" comprising associations in hydropower, biomass, heat pumps, solar, wind, geothermal and co-generation and district heating fields. In 1998, the Agency of Renewable Energies and Efficient Application of Energy (AEE) was established by the "actor network" for political lobbying and marketing activities for renewables. The AEE currently has 27 member associations and three observers.

CANTONAL PROGRAMMES

Each canton has its own policies for renewables (see Table 11). For example, the Canton of Zurich emphasises measures in the building sector. In 1995, it established a target to meet up to 20% of the heating and hot water demand in new buildings with renewable energy sources or waste heat[21]. The Canton of Geneva gives priority to the local production of hydropower but also promotes other renewables. The small Canton of Zug subsidises wood energy projects and the City of Zug, solar energy. Eighteen cantons promote the use of solar for heating purposes and ten cantons promote electricity.

20. This is the average budgeted amount. The actual payments were CHF 8.9 million in 2001 and CHF 13 million in 2002.
21. The owners and planners can decide if they want to meet the target by using waste heat or renewables or by reducing the use of non-renewable energies through energy conservation (*e.g.* using better insulation).

Table 11

Cantonal Renewable Energy Programmes, 2000

Field	*Canton*[1]
Wood energy	ZH, UR, ZG, FR, SO, BL, SH, AR, GR, AG, TG, TI, VD, VS, NE, GE, JU
Solar thermal	UR, NW, FR, SO, BS, BL, SH, AR, GR, TG, VS, NE, GE, JU
Photovoltaics	FR, SO, BS, BL, SH, AR, AG, VD, VS, GE
Heat pumps	UR, BS, BL, SH, VD, NE
Small hydropower schemes	UR
Heat recovery	BS, BL
Geothermal energy	BS
Waste heat	AG

1 AG = Aargau, AI = Inner-Rhoden, AR = Ausser-Rhoden, BE = Bern, BL = Basel-Landschaft, BS = Basel-Stadt, FR = Fribourg, GE = Geneva, GL = Glarus, GR = Graubünden, JU = Jura, LU = Luzern, NE = Neuchâtel, NW = Nidwalden, OW = Obwalden, SG = St. Gallen, SH = Schaffhausen, SO = Solothurn, SZ = Schwyz, TG = Thurgau, TI = Ticino, UR = Uri, VD = Vaud, VS = Valais, ZG = Zug, ZH = Zurich.

Source: SFOE: *Energy 2000 Final Programme Report*.

"GREEN ELECTRICITY"

Switzerland continues to debate the mechanisms for the promotion of "green electricity". One issue is the labelling of electricity according to its origin. Several labelling schemes exist but Naturemade is one of the most comprehensive. It was launched in summer 2000 as a result of long negotiations and planning by some power producers, environmental NGOs and consumer associations. The first plants and products were certified in November 2000 by Verein für umweltgerechte Elektrizität (VUE)[22]. The certificate system has two levels and includes special measures to promote non-hydro renewables:

- The first level, Naturemade Basic, is a declaration of the source (plants using renewables) and origin (own plants or purchased energy) of renewable electricity. Large hydropower plants (> 10 MW) have to establish an environmental management system within five years from receiving the Naturemade Basic certificate.
- The second level, Naturemade Star, was defined for environmentally preferable electricity. Power plants can be granted the Naturemade Star label if they fulfil Naturemade Basic criteria as well as additional criteria for

22. VUE, the association for environmentally benign electricity, was established in October 1999 on the initiative of EWZ and WWF. All the major interest groups are represented in VUE.

lifecycle characteristics. For example, the generator must establish an eco-assessment ("eco-indicator '99"); the minimum efficiency for wood-fired plants is set at 60% and environmental protection requirements are set for hydropower, photovoltaics and wind power generation. Hydropower plants can also achieve this level if they comply with certain criteria. Principally, they must have a lower environmental impact than traditional hydropower plants. For example, they have to leave sufficient water in streams and rivers (*i.e.* respect residual flow limits) or allow fish to pass through weirs.

- Hydropower units with more than 0.1 MW capacity must establish a fund to improve the ecological situation in the power plant site. The funds are financed from a levy on certified electricity; Naturemade Star producers pay CHF 0.009 per kWh whereas Naturemade Basic producers pay only CHF 0.001 per kWh.

- Specific provisions were developed to protect other renewables from competition by large hydropower plants and to create an incentive to develop non-hydro renewables. The marketers of all Naturemade certified electricity must guarantee that at least 5% of their certified electricity sales has the Naturemade Star certificate.

Currently, only 1% of Swiss hydropower generation is Naturemade certified because not all electricity generated from renewables meets environmental standards.

Utilities are using the Naturemade label in their marketing efforts for "green electricity". Another marketing initiative is the Solar Stock Exchange established by EWZ in Zurich. The Solar Stock Exchange acts as broker between producers and consumers. Electricity generated by privately-owned grid-connected PV systems is purchased by utilities at prices that cover costs and then resold by the utility at the same price to its customers. The contract duration between the electricity producer and the utility is 20 years but customers can unsubscribe every year. The kWh price in the exchange has now dropped to CHF 0.85 (end of 2001) in the City of Zurich.

Currently, approximately 3% to 5% of consumers are buying "green electricity" equivalent to 5% of their total electricity demand. At present, 60% of the population can have access to "green electricity". The SwissEnergy objective is for all consumers to have the possibility to choose "green electricity" and to be aware of this possibility. The AEE organises "green electricity" information sessions in the municipalities and has created an internet-based information service where interested consumers can find potential "green electricity" suppliers.

CRITIQUE

Switzerland has a significant amount of large-scale hydropower, but uses little other renewables. Despite significant investments in renewables, excluding

hydro or combustible renewables, their use increased only by about 64 ktoe between 1990 and 2001. The objectives of Energy 2000 were only partly achieved. The objectives of SwissEnergy for this decade are small in absolute terms but are challenging because unused hydropower potential is moderate, wind power is facing increasing local opposition and Switzerland, given its climate, is not an ideal location for PV. The most important unused potential seems to lie in biomass, solar thermal energy and waste heat.

Energy 2000 cost-benefit analysis results indicate very low cost-benefit in supporting renewables compared to, say, energy efficiency activities. Some reallocation has taken place but renewables still receive about 40% of the SwissEnergy budget (excluding the special Lothar funds). There were also large variations in the cost of different renewables. Total lifetime cost of PV per kWh of useful final energy was three to four times higher than for wood heating systems, heat pumps or solar thermal installations, about ten times higher than for fermentation and about 48 times higher than for waste water treatment plants.

A significant amount of the SwissEnergy budget is paid as a lump sum to the cantons who decide how to use the money. To ensure that the budget is used efficiently, it is very important to develop harmonised criteria to evaluate the effectiveness of the cantonal programmes in terms of achieving the SwissEnergy targets and to reallocate the payments accordingly. As the government budget for SwissEnergy is limited, it has been a sensible policy to oblige the cantons to contribute at least the equivalent amount of money as the federal financing they receive.

The existing feed-in tariff support system is relatively easy to implement and has shown positive results for small hydropower plants. However, one deficiency is that all electricity generated from renewables receives the same feed-in rate that has been worked out on the basis of the long-term marginal cost of indigenous power plants. This has become too generous for small hydropower plants in good locations, which gives no incentive for further cost reduction. It has also led to disputes about the reduction of the tariffs as envisaged by the law for cases of large discrepancies between costs and feed-in tariffs. Simultaneously, small hydropower plants do not have the potential to meet the renewable energy targets. The level of the feed-in tariff is fixed but the government's decision to reduce it was once justified by reductions in generation cost through technology development (learning curves in technology and electricity generation). Technology developments, such as the potential of different technologies to deliver the increased renewable energy targeted and the position and slope of each particular renewable technology learning curve should be taken into consideration when applying feed-in tariffs. The most successful systems have been those with different rates for different technologies; where support levels can match long-term technology potential and most effective movement down the experience curve. Another current deficiency is that the feed-in tariff system does not burden the utilities

in an equal way. Higher burden is placed on utilities in regions with more renewables generation and potential. This will create difficulties in the context of electricity market reform.

The government has two possibilities to improve the framework for promoting renewables, namely revision of the feed-in tariff system or adoption of portfolio standards together with tradable renewable energy certificates (TRECs). A balanced, well-designed law with appropriate pre-set[23] feed-in tariffs and time guarantees can have the advantage of providing some predictability to investors but does not guarantee the achievement of certain targets, and often comes at a high cost.

If portfolio standards and TRECs are designed correctly with targets matching availability and appropriate financial penalties for non-compliance, they may offer a lower-cost solution to meeting a "more certain" renewable energy target. Portfolio standards have the advantage of being more market-oriented, driving chosen renewables by market pressures for optimal economic location and technology selection. Some of the work needed for implementing such a system has already been done. The government has estimated the potential for renewables, and the Naturemade label could be used as the basis for establishing the TRECs. A review of the energies that might be accepted for the system could be necessary to include as many renewable energy sources as possible. Switzerland's potential market for renewables, other than large-scale hydropower plants, is relatively small. Care should therefore be taken that schemes introduced do not lead to excessive administrative burden.

Switzerland has been an innovative leader in marketing "green electricity" through local or national labels, such as Naturemade and the Solar Stock Exchange. Portfolio targets, coupled with innovative marketing, could offer the economically optimal option.

The SwissEnergy objective to extend access to "green electricity" to all consumers is a very market-oriented approach and the recently introduced labels help to ensure that "green electricity" comes from renewable sources. However, it is not evident that all the monopolistic utilities will have much incentive to start marketing "green electricity". To ensure that all Naturemade-labelled hydropower can be sold under the label, enough electricity will have to be produced from other renewable sources to meet the 5% requisite. This requirement is likely to increase electricity generation from "new" renewable sources provided there is adequate interest in the market for the more expensive "green electricity". So far, consumers have shown little interest.

23. A pre-set scheme must consider the technology's international and regional growth rates, the Swiss resource potential for each technology, spatial planning constraints and policies, supply infrastructure situation and how these influence the learning curves for technologies marketed in Switzerland. For example, for the PV modules, learning is happening at global level but for the balance of the system, learning is dependent on individual countries and the industrial capacity within those countries to further reduce overall cost by going down the learning curve.

The EML, which was rejected in September 2002 (see Chapter 9), included measures to promote renewables, such as exemption from network access charges, financing the cost difference between the market price and the feed-in tariff by a national grid company, immediate market access for "green electricity" and loans for modernisation and improvement of the performance of hydropower plants. It appears that opposition to the law was not targeted on the provisions for renewables. Nevertheless, it was a setback as regards increasing the possibilities to market and buy "green electricity".

RECOMMENDATIONS

The government of Switzerland should:

- *Continue to assess the cost-benefit of the renewables programmes, including subsidies, R&D and external costs, and ensure that the results are reflected in the allocation of financial resources. In particular, re-examine the cost-effectiveness of the solar energy programme and consider increasing resources for more cost-effective programmes, such as biomass and waste.*
- *Improve the framework for promoting renewables. Explore possibilities to introduce portfolio standards with tradable renewable energy certificates and review the feed-in tariff scheme.*

INTRODUCTION

There are five nuclear units in Switzerland with a net capacity of 3 200 MW (see Table 12). In 2001, approximately 38% of the electricity produced in Switzerland was generated by nuclear power plants. The Beznau I, Beznau II, Mühleberg and Gösgen units also supplied about 330 GWh of process and district heat.

Table 12

Nuclear Power Plants in Operation in Switzerland, 2001

Name	*Type*	*Net capacity (MW_e)*	*Commissioning date*	*Electricity generation in 2001 (TWh)*
Beznau I	PWR	365	1969	3.09
Beznau II	PWR	365	1971	2.57
Mühleberg	BWR	355	1972	2.77
Gösgen	PWR	970	1979	7.80
Leibstad	BWR	1 145	1984	9.09
Total		**3 200**		**25.32**

Source: Swiss Federal Nuclear Safety Inspectorate, Annual Report 2001.

Both Beznau units were supplied by Westinghouse and are operated by Nordostschweizerische Kraftwerke. Mühleberg was supplied by General Electric and is operated by Bernische Kraftwerke BKW-FMB Energie (under Axpo Holding). Gösgen was supplied by Kraftwerk Union (now Siemens) and is operated by Kernkraftwerk Gösgen-Daeniken. Leibstadt was supplied by General Electric and is operated by Kernkraftwerk Leibstadt.

Since the last in-depth review, thermal nuclear capacity has increased by 180 MW (about 60 MW net electrical power) through capacity upgrades at Leibstadt. Nuclear electricity generation increased by 1.35 TWh (5.6%) from 1997 to 2001.

Reactor operation is very efficient in Switzerland with its plants routinely achieving some of the highest availability factors in the world. In 2001, according to the International Atomic Energy Agency (IAEA), the Swiss availability factor averaged about 89% compared to a world average of around 83%. Measured by cumulative energy availability factor, Switzerland has one of the highest in the world, with 85%, which indicates a consistently high level of operation and maintenance.

The ages of the Swiss nuclear units range between 18 and 33 years. Three of the units, Beznau I, Gösgen and Leibstadt have unlimited operating licences, with operation depending on the continued demonstration of safety. In 1992, Mühleberg was issued a ten-year operation licence after refurbishment and a 10% capacity upgrade, and in 1998 its licence was extended to 2012. The current operating licence for Beznau II will expire at the end of 2004. The responsible utility has applied for a new operating licence and has submitted the required Safety Report. The evaluation and approval processes, which include a public consultation process, are expected to be completed during 2004.

The economics of operating nuclear power plants appear to be competitive. Data from one study[24] indicate that Switzerland's nuclear power plants have the lowest per kWh costs compared to non-nuclear power plants (hydroelectric, CHP and oil-fired plants). Nuclear power plant costs ranged from CHF 0.032 to CHF 0.0417 per kWh whereas non-nuclear power plant costs ranged from CHF 0.0617 to CHF 0.0636 per kWh.

Nuclear power plants owners are responsible for funding their decommissioning. The total estimated cost of decommissioning the five units currently in operation is CHF 1 800 million. The Confederation manages the Decommissioning Fund 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; at the end of 2001 the fund had accumulated CHF 908 million.

A 10-year moratorium on new plant construction ended in 2000. A permit to construct a new nuclear power plant must be obtained from the Federal Council, which must demonstrate a national need for the increased energy supply. The Parliament must then ratify the decision. Further, site-specific licensing would then be conducted with the relevant canton. Given the current excess electricity generating capacity, the uncertain future of nuclear energy (two referendums were to be voted in May 2003, see below) and waste disposal, it is unlikely that a new power plant will be built in the near future.

LEGAL AND REGULATORY FRAMEWORK

LEGAL FRAMEWORK

Nuclear energy use in Switzerland is regulated by an amendment to the Constitution (Article 24 *quinquies*), approved by the Parliament and all the cantons by a referendum in 1957, stipulating that nuclear legislation should fall within the sole jurisdiction of the Confederation. The cantons have a residual jurisdiction with regard to licensing of nuclear installations. Following a 1990

24. Böhringer, C., M. Wickart and A. Müller (December 2001), "Economic Impacts of a Premature Nuclear Phase-out in Switzerland", Centre for European Economic Research.

referendum, Article 19 (approved in 1990) stipulated that licences for new nuclear power plants could not be obtained during a period of ten years.

The 1959 Federal Law on Atomic Energy, complemented by the Federal Decree on the 1978 Atomic Energy Law, provides the basic regulations currently in force regarding licensing for the construction and operation of nuclear installations. The 1991 Radiation Protection Law provides the broad principles of protection against radiation and gives the Federal Council power to promulgate detailed implementation regulations such as the 1994 Radiation Protection Ordinance, based largely on the most recent recommendations of the International Commission on Radiological Protection.

Switzerland has signed but not ratified the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy and the 1963 Brussels Supplementary Convention. The government indicates that it has not ratified these conventions on the grounds that the 1983 Swiss Act on Nuclear Third Party Liability contains certain provisions that differ from those in the Paris Convention. Swiss law provides for unlimited liability in the event of a nuclear accident and as of 1 January 2001, the amount of private liability insurance for nuclear facilities was CHF 1 000 million with an additional CHF 100 million to cover the cost of proceedings.

Switzerland has signed and ratified the 1994 Convention on Nuclear Safety, the 1986 Convention on Early Notification of a Nuclear Accident, the 1986 Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the 1968 Treaty on Non-proliferation of Nuclear Weapons, the 1996 Comprehensive Test Ban Treaty and the 1979 Convention on the Physical Protection of Nuclear Materials.

REGULATORY AUTHORITIES

The Federal Council has overall regulatory and administrative powers in the field of nuclear energy and radiation protection. Its decisions are submitted for approval to the Federal Assembly (Parliament). DETEC (including the SFOE) and the Federal Department of the Interior (including the Federal Office of Public Health and the Federal Office of Education and Science) are responsible for implementing the provisions adopted by the Federal Council.

The Federal Council is the licensing authority for Switzerland; it issues general and specific licences. The general licence has been applicable to any new nuclear installation since 1978 and includes the site licence. Specific licences are required for construction, commissioning, operation, modification and decommissioning of nuclear installations.

The Swiss regulatory body is composed of the SFOE, which is responsible for security issues and in some cases also the fuel cycle, the Swiss Federal Nuclear

Safety Inspectorate (HSK/DSN), which is the supervisory authority, and the Federal Commission for the Safety of Nuclear Installations (KSA/CSA), which is an advisory committee. Both HSK/DSN and KSA/CSA are part of DETEC.

The HSK/DSN is the competent authority for supervising Swiss nuclear installations at all stages of their life. Its responsibilities include the following:

- Establishing safety criteria and requirements.
- Preparing safety evaluation reports to support the decision of the licensing authority.
- Supervising the fulfilment of regulations through inspections, reporting and requesting of documentation.
- Granting, suspending or withdrawing permits.
- Ordering the application of all measures to protect persons and property and other important rights, to safeguard Switzerland's national security and ensure compliance with its international commitments, within the framework of a valid licence.

The KSA/CSA is an advisory committee that reviews and comments on licence applications and the corresponding safety evaluation reports and forwards its conclusions and recommendations to the Federal Council. Its responsibilities include the following:

- Commenting on new and changed laws and the development of regulations with respect to nuclear safety and recommending additional or modified regulations.
- Recommending measures to increase the safety of nuclear installations or to improve the licensing procedure and operation surveillance.
- Proposing research work in the field of nuclear safety.

The Federal Commission for Protection against Radiation and the Federal Commission for the Monitoring of Radioactivity, which come under the Federal Department of the Interior, are respectively responsible for monitoring and advising on questions related to radiation protection.

FUTURE OF NUCLEAR POWER

Switzerland has a history of public opposition and concern about nuclear power. Between 1979 and 1990, six referendums and five popular initiatives against nuclear energy were proposed. The result of this public debate culminated in a double decision taken by the Swiss population in 1990 to

accept the continued operation of the existing nuclear power plants and to impose a 10-year moratorium on granting licences for new nuclear installations (waste management facilities excepted).

Two popular initiatives were initiated in 1999, namely "Electricity without Atoms" (SOA) and "Moratorium Plus" (MOP). SOA calls for the Beznau plants and the Mühleberg plant to be permanently shut down within two years of the referendum, an instant ban on reprocessing spent fuel, and places a 30-year operating limit on the Gösgen and Leibstadt plants. It also requires that nuclear electricity generating capacity be replaced primarily with renewable energy and CHP and, only if needed, by fossil fuels. MOP would create a moratorium on new nuclear plants for ten years (renewable for subsequent 10-year periods subject to public referendums) and limit the operational life of existing reactors to 40 years. The public were to vote on these initiatives in May 2003. Figure 20 shows the development of nuclear generating capacity in the scenario of the two popular initiatives and in the scenario that the Beznau I, Beznau II and Mühleberg power plants operate for 50 years, and the Gösgen and Leibstad power plants operate for 60 years (so-called Reference Scenario).

The government has analysed the impacts of the three scenarios on the generation mix and electricity trade up to 2030. All three scenarios assume electricity demand will increase by 15% between 1998 and 2010 and then level off – not confirming the 5% cap established by SwissEnergy for the 2000 to 2010 period.

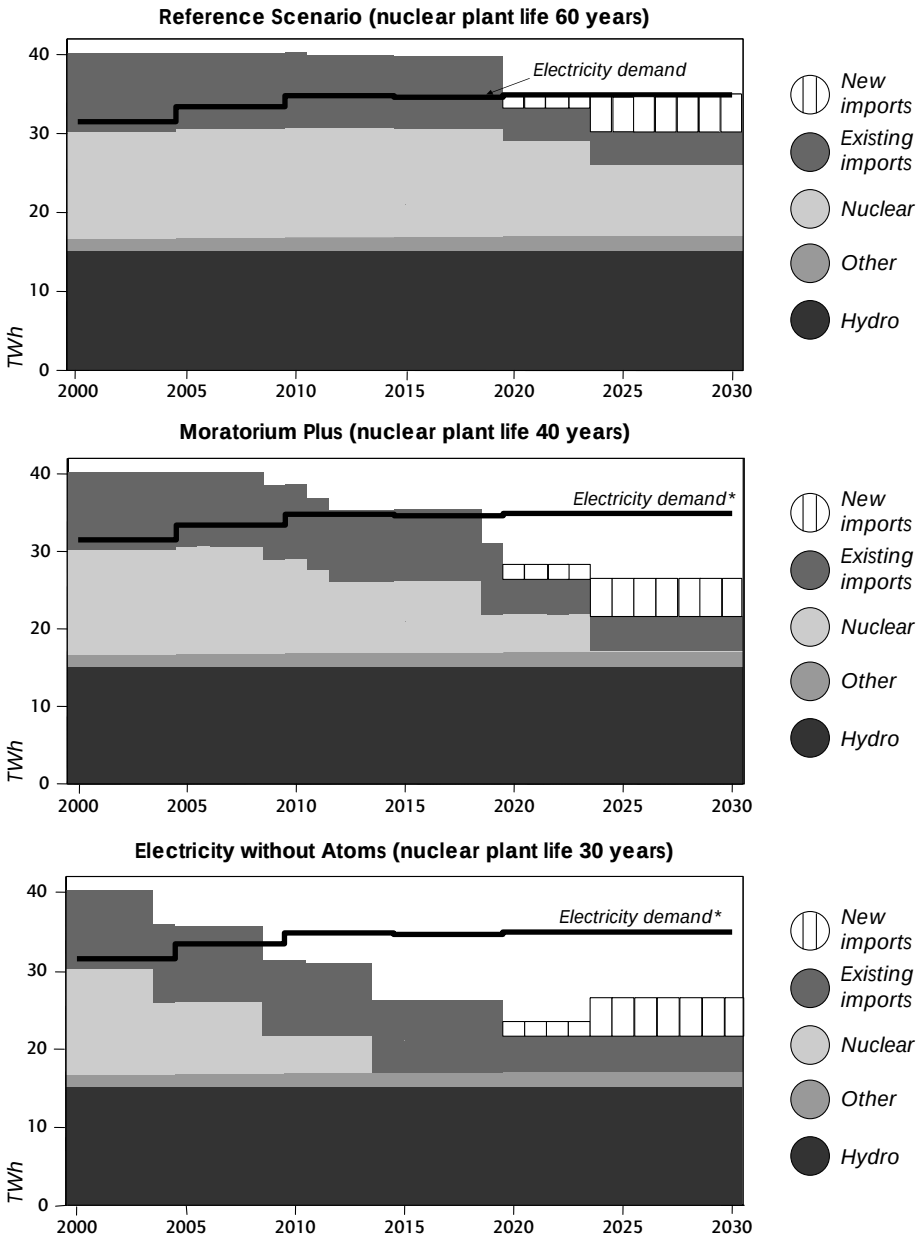
- *Reference Scenario:* Switzerland would remain a net exporter of electricity until 2015-20 mainly owing to long-term contracts with France, which are considered as "indigenous" in the scenarios because of Swiss participation in French nuclear capacities. At the end of the period, Switzerland would either have to invest in new nuclear generating capacity or become a net importer of electricity. The scenario assumes hydro and thermal power generation to remain constant and the contribution of other renewables to remain negligible.

- *Moratorium Plus:* Switzerland would remain a net exporter of electricity until 2010 and self-sufficient until 2015-20. In this scenario, the gap at the end of the period would principally be filled by imports, fossil fuel-fired CHP and to a lesser extent by additional electricity saving and renewables. The role of renewables would be small given their higher cost and hydropower generation would remain constant.

- *Electricity without Atoms:* Switzerland would have a wide gap to fill from 2010 onwards and by 2020 this would be equivalent to 30% of demand. Imports play an important role in filling the gap. New indigenous generating capacity would mainly be CHP. Renewables, saving of electricity and restrictions on electric heating are expected to make a significant contribution.

Figure 20

Electricity Supply and Demand Balance under Different Nuclear Scenarios



* does not show the impact of the additional electricity saving efforts which would be needed to help in filling the gap.

Source: SFOE.

Both phase-out scenarios induce substantially higher CO_2 emissions than the Reference Scenario (see Table 13). Böhringer *et al.* analysed the gross economic impacts of the two popular initiatives, including the additional costs of neutralising the increase of carbon emissions that would result in either case. They demonstrated that the costs of accelerating nuclear phase-out for an average household would amount to CHF 200 per annum over the next 45 years under SOA and drop to CHF 60 per annum under MOP, assuming that additional CO_2 emissions would not be neutralised. If Switzerland wants to achieve carbon-neutrality though phasing out nuclear power, larger CO_2 taxes must be levied, which will consequently increase the costs of a premature phase-out. In the case of carbon-neutrality, the costs for an average household would amount to CHF 230 per annum under SOA and CHF 110 per annum under MOP.

Table 13

CO_2 Emissions under Different Nuclear Scenarios

(Mt/annum)

	1990	*2010*	*2020*	*2030*
Reference Scenario				
(50 to 60 years of operational life)	41.8[1]	40.8	39.6	38.6
Moratorium Plus Initiative		40.8	41.5	40.9
Electricity without Atoms Initiative		41.9	42.7	40.7

[1] Corrected value (meteorological fluctuations).

Source: Böhringer, C., M. Wickart and A. Müller (December 2001), "Economic Impacts of a Premature Nuclear Phase-out in Switzerland", Centre for European Economic Research.

The Confederation proposed a new Nuclear Energy Law, partly to counter these public initiatives and partly to make long-desired modifications to the existing legal framework. The proposed law, which is currently undergoing parliamentary debate, would:

- Maintain the option to deploy new nuclear power plant technologies.
- Place no limits on the operational lifetime of a nuclear power plant.
- Define the competences of the cantons for nuclear facilities.
- Define regulations on decommissioning and radioactive waste management.
- Define the financing of decommissioning and radioactive waste management.
- Ban the reprocessing of spent fuel while allowing current contracts to be fulfilled.
- Allow a general licence for a nuclear power plant to be subject to a popular referendum.
- Allow the possibility to appeal against nuclear licences.

FUEL CYCLE AND WASTE MANAGEMENT

FUEL CYCLE

Switzerland has no domestic nuclear fuel cycle industry. Securing the supply of nuclear fuel is the sole responsibility of the nuclear power plant operators. Uranium is procured from partnership or joint venture production abroad, long-term contracts and spot market acquisitions. Enrichment, fuel fabrication and reprocessing services are purchased from foreign companies.

The owners and operators of nuclear power plants are responsible for the planning and decision-making relative to the fuel cycle, including its back-end, *i.e.* spent fuel storage and/or reprocessing. They have signed contracts with Cogéma and BNFL for the reprocessing of approximately one-third of the spent fuel expected to be unloaded during the 40-year planned lifetime of the five reactors in operation. Given the low prices for uranium and the pending decisions on the future of nuclear energy, it is unlikely that new contracts will be made in the near term. Plutonium obtained from reprocessing is recycled (as MOx fuel) in the Beznau I and II and Gösgen reactors.

RADIOACTIVE WASTE MANAGEMENT

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 Co-operative 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. It is foreseen that companies will be created for the construction and operation of centralised waste management facilities.

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. Waste management costs include costs associated with all back-end activities, namely management of operational waste and spent fuel elements once they have left the power plants and final disposal, *i.e.* R&D, construction, operation and closure of waste repositories. Future costs are estimated on the basis of careful and conservative assumptions and are periodically reviewed. The Confederation manages the Radioactive Waste Management Fund that was established in 2000 to secure the costs of radioactive waste disposal after the decommissioning of a nuclear power plant. The fund amounted to CHF 1 440 million at the end of 2001.

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 centralised facility. In 2001, a centralised interim storage facility, located on the site of the Paul Scherrer Institute (PSI) at Würenlingen, began to accept intermediate- and high-level waste. In the near future it will be able to accept all classes of waste. The facility is operated by Zwischenlager Würenlingen (ZWILAG), a utility-owned organisation, and has sufficient volume to accept all operating waste, spent fuel and high-level waste for Switzerland's five reactors over their operating lives. It does not, however, have sufficient volume to store decommissioned wastes. Should any Swiss power plant shut down and require decommissioning prior to the opening of a low- and intermediate-level waste repository, other arrangements would be necessary to store the waste, or decommissioning may need to be delayed.

A repository project for low- and intermediate-level waste had been under way at Wellenberg in the Canton of Nidwalden (central Switzerland). However, despite Federal Council approval for preliminary work on the site, voters in the canton rejected a bill that would have permitted the construction of an underground test facility. This effectively ended the project and leaves uncertainty about a long-term solution.

A repository for high-level waste will not be required before 2020. NAGRA is pursuing a comprehensive programme 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. Work on the disposal of high-level waste and spent nuclear fuels continues though its future is also uncertain given the result of the Nidwalden referendum. 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 these wastes around 2006. Identification of a site will be the subject of a later general licence procedure.

Switzerland leaves open the possibility to pursue a multinational approach to radioactive waste disposal, though no specific proposal has yet been made.

EDUCATION AND TRAINING

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 (PSI), which makes use of the reactors at Lausanne and Basel. Power plant operators also receive on-the-job and continuing training at their facilities. Given that Switzerland is a member of the European Nuclear Engineering network, it has access to facilities and courses at institutions throughout Europe.

CRITIQUE

In 1999, two new public initiatives on nuclear power, SOA and MOP, were proposed and were to be voted in May 2003. The Parliament has rejected both initiatives and is studying a Nuclear Energy Act that would update the current Law. The act could do much to clarify the future role of nuclear energy in Switzerland. The outcome of the public votes will have a significant impact on Switzerland in terms of energy security, environmental protection and economic efficiency.

In 2001, Switzerland obtained almost all of its electricity from carbon-free sources, namely hydro and nuclear. Studies demonstrate that the existing nuclear power plants are the most economic means of electricity generation in Switzerland. Phasing out nuclear power ahead of the lifetime of existing nuclear power plants will entail a high cost to the Swiss economy. Choosing not to extend the lives of fully depreciated units also means losing an opportunity cost. Phasing out nuclear power is likely to increase electricity imports or generation by natural gas. The latter will require investments and fuel for new natural gas power plants. Consequently, natural gas imports will increase, which could have implications on energy security. Furthermore, replacing nuclear power with natural gas will inevitably increase CO_2 emissions. If Switzerland intends to achieve the GHG emissions reduction target while phasing out nuclear power, it needs to introduce drastic additional policies and measures to compensate the increase in CO_2 emissions. Such policies and measures would be expensive. A government-conducted study demonstrates that under MOP, the CO_2 "incentive" tax on petrol and diesel must be almost doubled by 2030 compared with the case where nuclear is not phased out. While the impact on CO_2 emissions could be avoided if nuclear power plants were totally replaced by renewable energy sources, these options would be enormously costly. Taking all these factors into account, it is sensible that Switzerland keeps the nuclear option open.

Noting that the public vote has a decisive impact on the direction of Swiss energy policy, the government should continue to conduct analyses to identify and evaluate the potential impacts of the phasing-out of nuclear and share the results with the public prior to the vote. The government should prepare a contingency plan subject to the outcome of the popular votes and share the results with the public. Impacts that could be investigated include the following:

- Investment and operation cost of power plants using alternative fuels.
- Adequacy and availability of alternate energy fuels (*e.g.* ability to supply natural gas) and their implication for energy security.
- Economic and policy impacts of increasing reliance on energy imports. Nuclear phase-out is likely to increase gas and electricity imports, which raises concerns over supply security and price volatility in the longer term.
- Implication of nuclear phase-out on CO_2 emissions.
- Necessary policies and measures to neutralise the impact of nuclear phase-out on CO_2 emissions and their costs.
- Other environmental impacts and cost of addressing them. Besides carbon emissions, replacement energy sources for nuclear would emit air-polluting gases and particles. Their impact on the Swiss environment should be evaluated.
- Adequacy of funding for decommissioning. Decommissioning funding is collected during the plants' planned 40-year life. Early closure could present financing difficulties.
- Ability to manage decommissioned waste. Waste storage capacity in Switzerland does not take account of the waste that would be generated by decommissioning. Where and how to store decommissioned waste prior to the opening of a repository, in light of the recent rejection of the Wellenberg (Nidwalden) underground laboratory, should be investigated.

The disposal of nuclear waste remains an unsolved issue for Switzerland. Interim storage of nuclear waste from nuclear energy production exists with sufficient capacity for the expected lives of the current operating fleet; however, disposal options have not yet been defined. With the abandonment of the Nidwalden underground laboratory for the disposal of low- and intermediate-level waste, there is no defined path forward for these waste categories. Progress on the programme for the disposal of high-level waste and spent fuel continues, though the impact of the vote in Nidwalden remains uncertain. Despite this setback, the government must continue to work towards developing solutions.

Article 11 of the Convention on Nuclear Safety requires that each Contracting Party take the appropriate steps to ensure that throughout the nuclear installation's life, sufficient numbers of qualified staff with appropriate education and training are available for its safety-related activities. Switzerland appears to suffer from a shortage of students in nuclear sciences. In addition, one existing programme for nuclear education will soon close because of the retirement of the professor in charge and the decision to redirect the post to renewable energy. Without taking action, Switzerland may find itself with an insufficient number of qualified personnel to meet its

needs. Relief has been provided by an influx of trained workers from Germany but this can only be a temporary solution.

Efforts are under way to establish a new chair for nuclear energy at the ETHZ sponsored by the electricity-generating companies that use nuclear reactors. The government should support this initiative; however, more could be done to increase the number of students and education opportunities in nuclear engineering and related disciplines. As a member of the European Nuclear Engineering Network, Switzerland has access to a large number of education opportunities. Some countries offer specialised training courses that could complement those currently available at the PSI, such as the Otto Hahn/Frédéric Joliot Summer School jointly organised by Germany's Forschungszentrum Karlsruhe and the Nuclear Reactor Directorate of France's Commissariat à l'Énergie Atomique. Research opportunities that grow out of the Generation IV Programme should also be seen as a means to attract and retain students in the nuclear sciences. The government should analyse the country's requirements for new students and personnel, define current and possible future deficiencies and then develop programmes and policies to increase the number of students and education opportunities.

RECOMMENDATIONS

The government of Switzerland should:

- *Maintain the nuclear option.*
- *Ensure that the general public is fully aware of the potential impacts of the nuclear initiatives and the draft nuclear law.*
- *Continue to take actions to develop safe radioactive waste repositories.*
- *Take actions to maintain sufficient levels of technological competence.*

INDUSTRY STRUCTURE

There are approximately 900 electricity companies operating in Switzerland. The number decreased from about 1 200 in the 1990s as a consequence of mergers by many small companies trying to increase the efficiency of their operations. The Swiss Electricity Suppliers Association (VSE) estimates that a further 300 mergers might take place during the next five to ten years regardless of market reform.

There are six vertically integrated supra-cantonal companies operating in the Swiss market, namely EGL, ATEL, BKW, AXPO/NOK, EOS and CKW[25] (see Table 14), which supply about 80% 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 (see Figure 21). In some cases these operations are organised in different companies under the same holding company.

Figure 21

Power Industry Structure

<table>
<tr><th>Production</th><th>Transmission</th><th>Distribution</th></tr>
<tr><td colspan="3">BKW-FMB Energie AG</td></tr>
<tr><td colspan="3">Centralschweizerische Kraftwerke (CKW)</td></tr>
<tr><td colspan="3">Elektrizitätswerke der Stadt Zürich (EWZ)</td></tr>
<tr><td colspan="2">Nordostschweizerische Kraftwerke (NOK)</td><td rowspan="4"></td></tr>
<tr><td colspan="2">Aare Tessin AG (ATEL)</td></tr>
<tr><td colspan="2">Elektrizitätsgesellschaft Laufenburg AG (EGL)</td></tr>
<tr><td colspan="2">Energie Ouest Suisse (EOS)</td></tr>
<tr><td>Generation companies (~80)</td><td></td><td>Cantonal (~10), Regional (~20) and Municipal (~800) companies</td></tr>
</table>

Source: Country submission.

25. Elektrizitätsgesellschaft Laufenburg (EGL) in Laufenburg/Dietikon, Aare Tessin für Elektrizität (ATEL) in Olten, BKW-FMB Energie (BKW) in Bern, Nordostschweizerische Kraftwerke (NOK) in Baden, Energie Ouest Suisse (EOS) in Lausanne and Centralschweizerische Kraftwerke (CKW) in Lucerne.

Approximately 20 to 30 companies, including the supra-regional companies, import and/or export electricity. In addition, about 200 utilities, mostly regional or cantonal companies, have at least two of the production, transmission and distribution functions. The largest ones are in Zurich, Basel and Bern. The major player, the Federal Railway Company, owns several electricity plants, mainly for peak load and also has shares in some electricity-generating companies.

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

In anticipation of market opening and competition, some new types of companies have emerged. New trading companies have been established, which usually operate through the power exchanges in Germany and the Netherlands. Existing companies have reorganised their operations by forming strategic groups and holding companies[26]. For example, Swisspower is a new marketing and sales company owned by 20 large municipal utilities.

Table 14

Major Swiss Electricity Companies

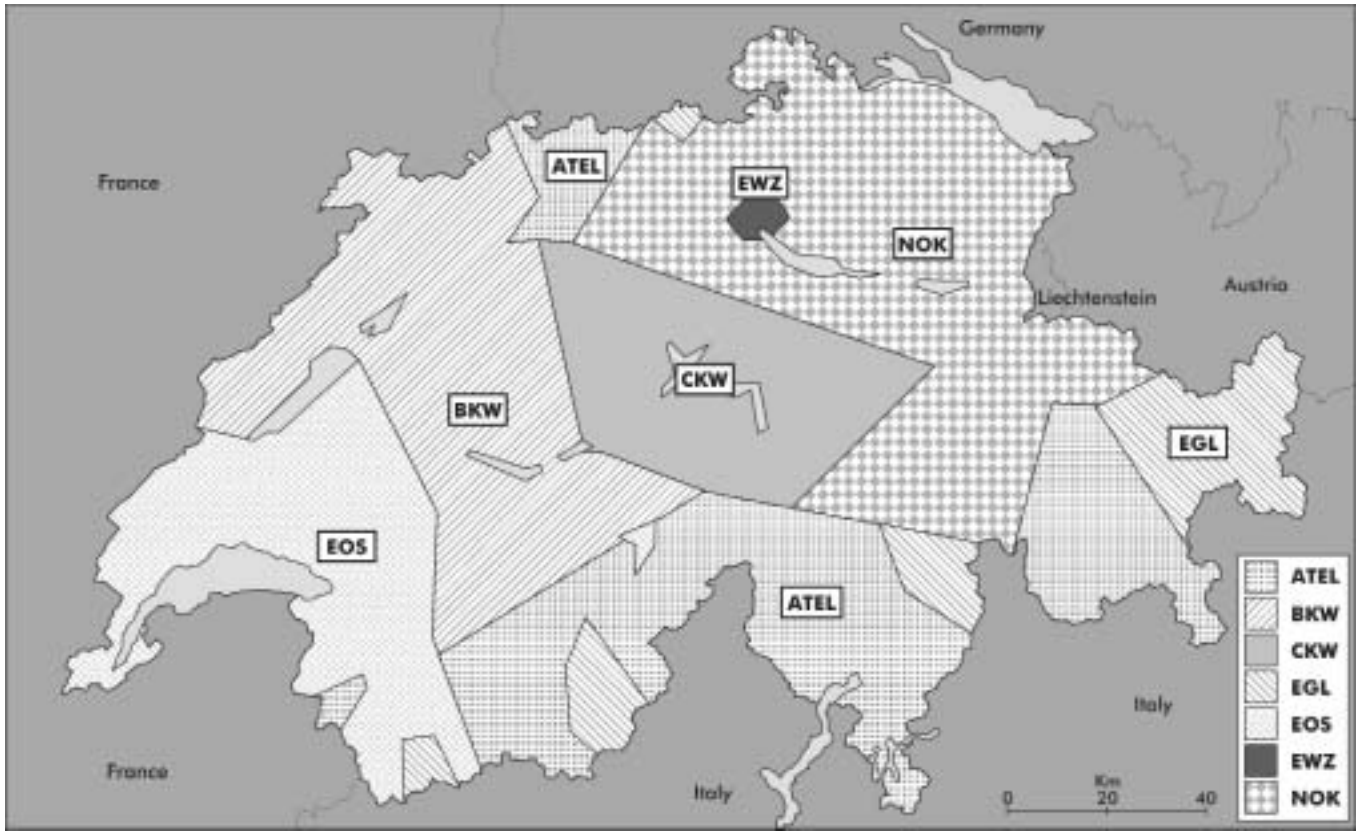
Utility[1]	*Sales*[2] *in 2001 TWh*	*Main shareholders*
EGL	66.0	WATT 81.6%, others 18.4%.
ATEL	53.0	Motor Columbus 56.7%, EBM Energie 13.2%, Elektra Baselland 7.5%, Canton of Soleure 5%, Canton of Aargau 4%, EVN AT-Maria 6.9% and others 6.7% (EDF and RWE each own 20% of Motor Columbus).
BKW	22.0	Canton of Bern 64%, E.On Energie 20%, Cantonal Bank of Bern 5%, Canton of Jura 5% and others 7%.
AXPO/NOK	20.1	Owned by many different cantons and cantonal companies.
EOS	10.4	Romande Energie 28.5%, Industrial Services Geneva 22.7%, Industrial Services Lausanne 19.7%, Electricity company Fribourg 15.6%, Electricity company Neuchâtel 5.9%, Forces Motrices Valaisannes 5.4%, others 2.4%.
EWZ	6.4	Municipal utilities of Zurich.
CKW	5.0	WATT 66%, AXPO, various cantons 17% and others 17%.

[1] NOK is involved only in generation and transmission whereas other companies are also involved in electricity distribution.
[2] Including international trade.
Source: Swisselectric and EWZ annual report.

26. AXPO is a holding company which keeps several utilities (*e.g.* NOK) within its holding structure. In April 2002 it bought out both E.On's and EnBW's shares in WATT and now controls 80% of it. Swiss Citypower represents the 16 largest municipal utilities. Avenis is EOS's trading arm and supplies the six largest western Swiss distributors.

Figure 22

Location of Major Swiss Electricity Companies



Source: Etrans.

To prepare for market reform, the six supra-cantonal companies and EWZ took action to co-ordinate their transmission system activities and to represent Switzerland in the international forums, including the Union for the Co-ordination of Transmission of Electricity (UCTE) and the European Association of Electricity Transmission System Operators (ETSO). Etrans was established in 2000 to improve transmission management. To date, Etrans has launched activities, particularly in scheduling and congestion management, as well as improving electronic data exchange with the other European TSOs (the "Electronic Highway" project).

72% of all capital invested in the Swiss electricity sector is public with 41% of total investments coming from the cantons, 29% from municipalities and 2% from the Federal Railway Company; 15% of the capital is private (banks, private industry and individuals) and the remaining 13% is foreign investments. Despite ownership changes over the past few years, no major privatisation has occurred because several plans for corporatisation of public utilities were thwarted by popular votes.

The influence of the cantons and local authorities in the power utilities varies significantly. In utilities with mixed ownership, the influence of public authorities is mostly limited to a control by a surveying board. Public or public-dominated utilities undergo far more public control. In some cases, the utilities are a part of the local authorities. This is mostly true for the very small distribution companies at municipal level. However, some cantons and municipalities have started to "depolitise" the day-to-day management of the utilities and allow them to operate more like private companies in anticipation of market reform. For example, the utilities of Basel, Bern and Zurich are publicly-owned but their management has been made fully independent and financial management partly independent, whereas tariff setting still remains under local parliament.

VSE and Swisselectric are the major organisations in the electricity sector. VSE represents the interests of 460 electricity companies that supply 90% of electricity. The six supra-regional companies have recently formed an industry association, Swisselectric, to promote their common interests.

DEMAND, SUPPLY, TRANSMISSION AND TRADE

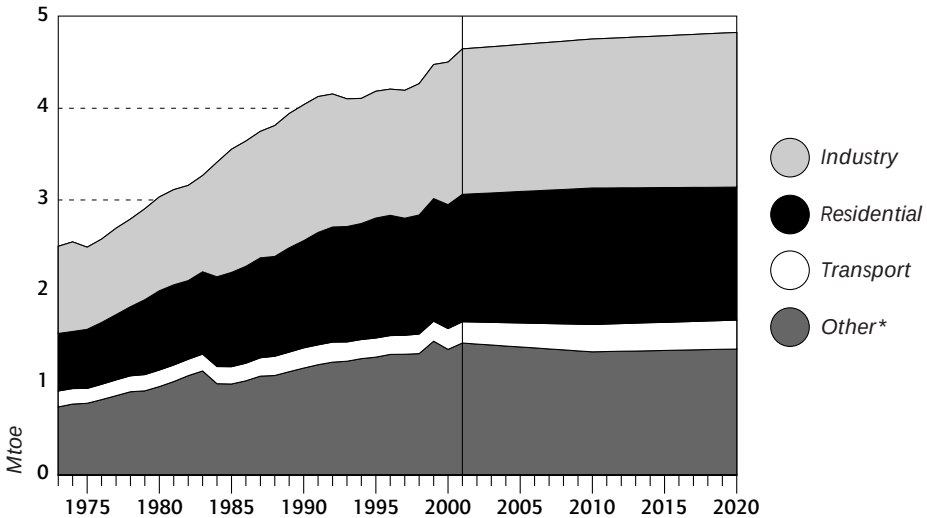
DEMAND

In 2001, electricity consumption was 54.1 TWh. About 34% of electricity was consumed in industry, 30% in the residential sector, 5% in the transport sector and 31% in other sectors, mainly in the services sector (see Figure 23).

Energy 2000's objective to limit the increase of electricity consumption to 16% between 1990 and 2000 was achieved. Electricity consumption increased by only 11.5% over this period mainly because of economic stagnation in the early 1990s. However, in 2001 electricity consumption grew by an additional 3.2%. SwissEnergy is undertaking efforts to limit the increase in electricity consumption to 5% between 2000 and 2010.

Figure 23

Final Consumption of Electricity by Sector, 1973 to 2020



* includes commercial, public service and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

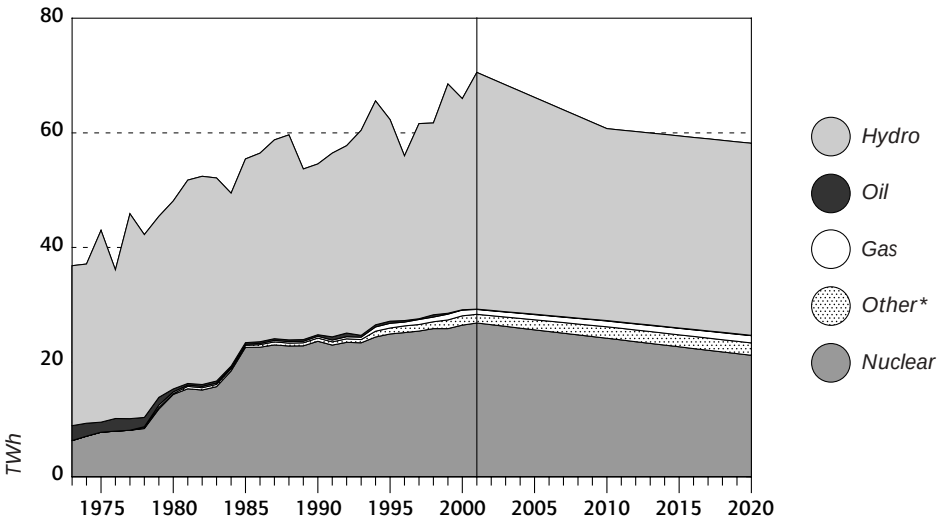
SUPPLY

In 2001, total electricity generation was 70.6 TWh. Hydropower was the most important source of electricity generation at 58.6% (see Figure 24). During 1990 to 2001, depending on the weather, its share varied between 51% and 60% of the annual total, thus having a large impact on the share of other fuels in the generating mix. Nuclear power was the second most important source of electricity, accounting for 38% of electricity generation in 2001 but declining from 43.3% in 1990. Combustible renewables and wastes increased their share from 1% in 1990 to 2.1% in 2001, and natural gas from 0.6% to 1.2% over the same period. The share of oil was 0.1% in 2001. The share of autoproducers in Swiss electricity generation is about 6% whereas 94% of electricity comes from public utilities.

Total electricity generating capacity was 17 260 MW at the end of 2001. Hydropower capacity was 13 240 MW, nuclear 3 200 MW, combustible renewables and wastes 353 MW, natural gas 325 MW, oil 128 MW and others 18 MW. At present, there are no projects to build large-scale power plants. Additional capacity is mainly expected through capacity increases at existing hydropower plants.

Figure 24

Electricity Generation by Source, 1973 to 2020



* includes solar, wind, combustible renewables and wastes.

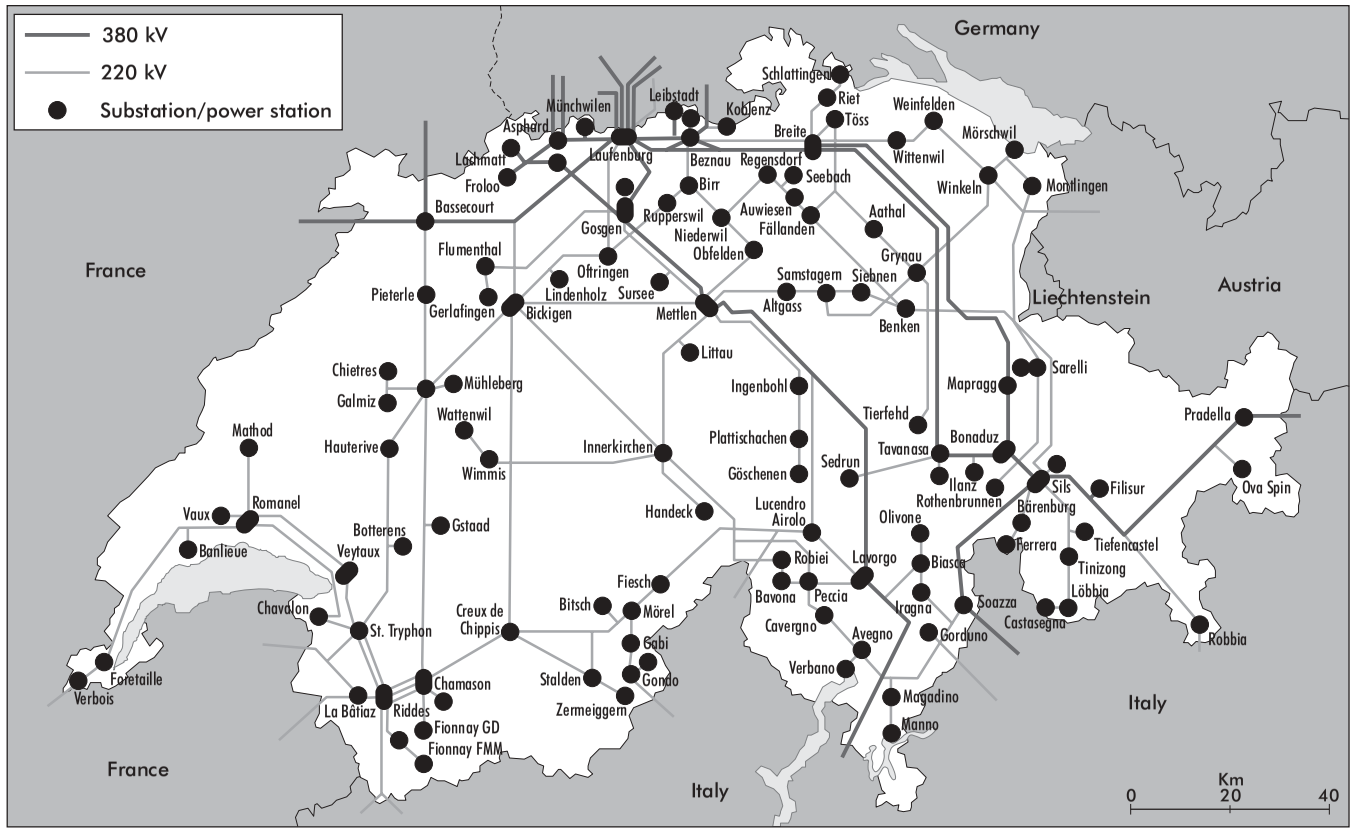
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2002; and country submission.

TRANSMISSION AND TRADE

Switzerland is an important electricity trade and transit country. It is a net exporter of electricity; most of the year it exports electricity, although it does import some during the winter peak. In 2001, the total volume of imports and exports (physical flows) amounted to 58.6 TWh. The imports came from Germany (43%), France (41%), Austria (15%) and Italy (1%) and exports went to Italy (69%), Germany (23%,), France (6%) and Austria (2%). Recently, the contractual flows have become much larger than the physical flows because a large part of the transmission capacity is reserved for Swiss companies who use it to buy electricity from neighbouring countries and sell it forward. For example, in 2001 the total contractual flows were 126.4 TWh (see Table 15).

Figure 25

Map of the Swiss Electricity Grid



Source: Etrans.

Table 15

Import and Export of Electricity, 1990 to 2001

(TWh)

	1990	*1999*	*2000*	*2001*
Physical flows				
Import	20.8	21.7	24.3	24.1
Export	22.9	32.0	31.4	34.5
Net export	2.1	10.2	7.1	10.4
Contractual flows				
Import	22.8	37.1	39.9	58.0
Export	24.9	47.3	47.0	68.4
Net export	2.1	10.2	7.1	10.4

Source: *Electricity Information 2001*, IEA/OECD Paris, 2001; and the SFOE.

Switzerland is also an important transit country given its geographical location. France transits electricity via Switzerland to Italy. The interconnection between Switzerland and Italy is a major bottleneck in the network but there is also some congestion in the interconnection between France and Switzerland, particularly in the periods of high load in the Union for the Co-ordination of Transmission of Electricity (UCTE) grid and strong loop-flows in the west to east direction. According to data submitted by IEA member countries to the European Association of Electricity Transmission System Operators (ETSO), the interconnection capacity between Switzerland and Austria is 1 400 MW, France 5 350 MW, Germany 2 750 MW and Italy 3 250 MW[27]. The interconnection at the Austrian border (Winkeln-Meiningen) has been improved by an additional 700 MW capacity that was put into operation in 2002. Additional capacity to Italy is planned for 2004 (S. Fiorana-Robbia, 1 300 MW) and 2010 (Piedolago-Airolo, 1 500 MW). The development of the transmission network is governed by the indicative Subject Plan (see Chapter 3).

PRICES

TAXES AND CHARGES

The only federal tax on electricity for non-commercial and commercial use of electricity is the 7.6% VAT. However, there are many cantonal and municipal taxes, charges and privileges which target electricity generation, transmission and distribution, such as the following:

27. This higher capacity is reported by Switzerland. The interconnection capacity reported by Italy is 2 800 MW.

- The cantons receive royalties based on the gross capacity of the hydropower plant in exchange for granting rights for the use of water.
- Contribution to the financing of public infrastructure and public lighting.
- Transfer of resources to the municipalities, including direct transfer of benefits and interest payments to the communes for capital endowment.
- Electricity delivered free of charge to municipalities.
- The cost of retrofitting elements of hydropower plants when they are returned to the municipalities and the cantons after 80 years of operation under Build-Operate schemes.
- Additional diverse fees such as those based on the amount of electricity distributed to final consumers.

The upper limit for royalties is CHF 80 per kW, with most of the cantons setting the levy at the maximum limit. According to the SFOE, water duties and concession fees are CHF 9.20 per MWh and are estimated to total CHF 482 million in 2002. In addition, other local taxes and charges on electricity are estimated at CHF 3.46 per MWh in 2002. All royalties, local taxes and charges are estimated to account for 11.1% of the average selling price of electricity in 2002. For hydropower alone, they account for 25% of the production cost. The cantons and municipalities that decide not to exploit their hydropower capacity in order to protect the environmental areas such as landscapes under national protection, are paid as compensation CHF 1 per kW by the Confederation every year[28].

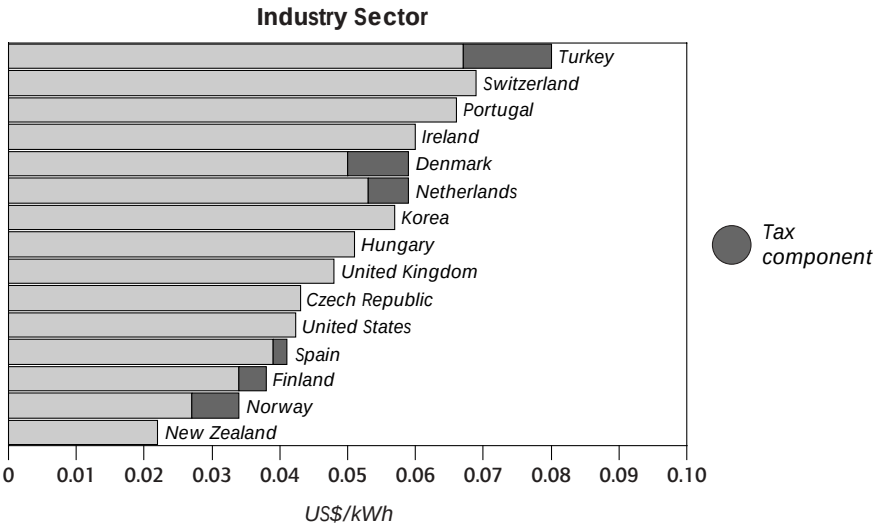
PRICES AND TARIFFS

In 2001, electricity prices for industry were the second-highest among IEA member countries (see Figure 26). Prices that included local taxes and charges but excluded national taxes were the highest in IEA member countries. Prices are particularly high for small and medium-sized industries that pay about 50% above the EU average. Prices for households were also above the average, but if purchasing power is taken into account, they are below the average. By 2000, Swiss electricity prices for both industry and households had decreased from their peak in the mid-1990s; however, in 2001 the prices levelled off (see Figure 27).

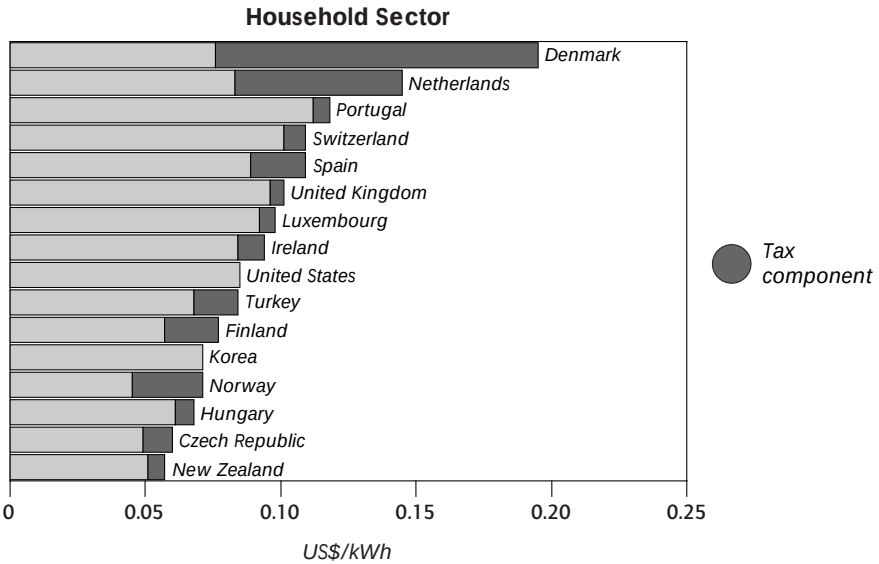
28. To finance these compensation payments, the government is entitled to a quota of the water royalties from the cantons. In 2001, six municipalities received CHF 2 million compensation and a further three cases are under consideration.

Figure 26

Electricity Prices in IEA Countries, 2001



Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Australia, Austria, Belgium, Canada, France, Germany, Greece, Italy, Japan, Luxembourg and Sweden.

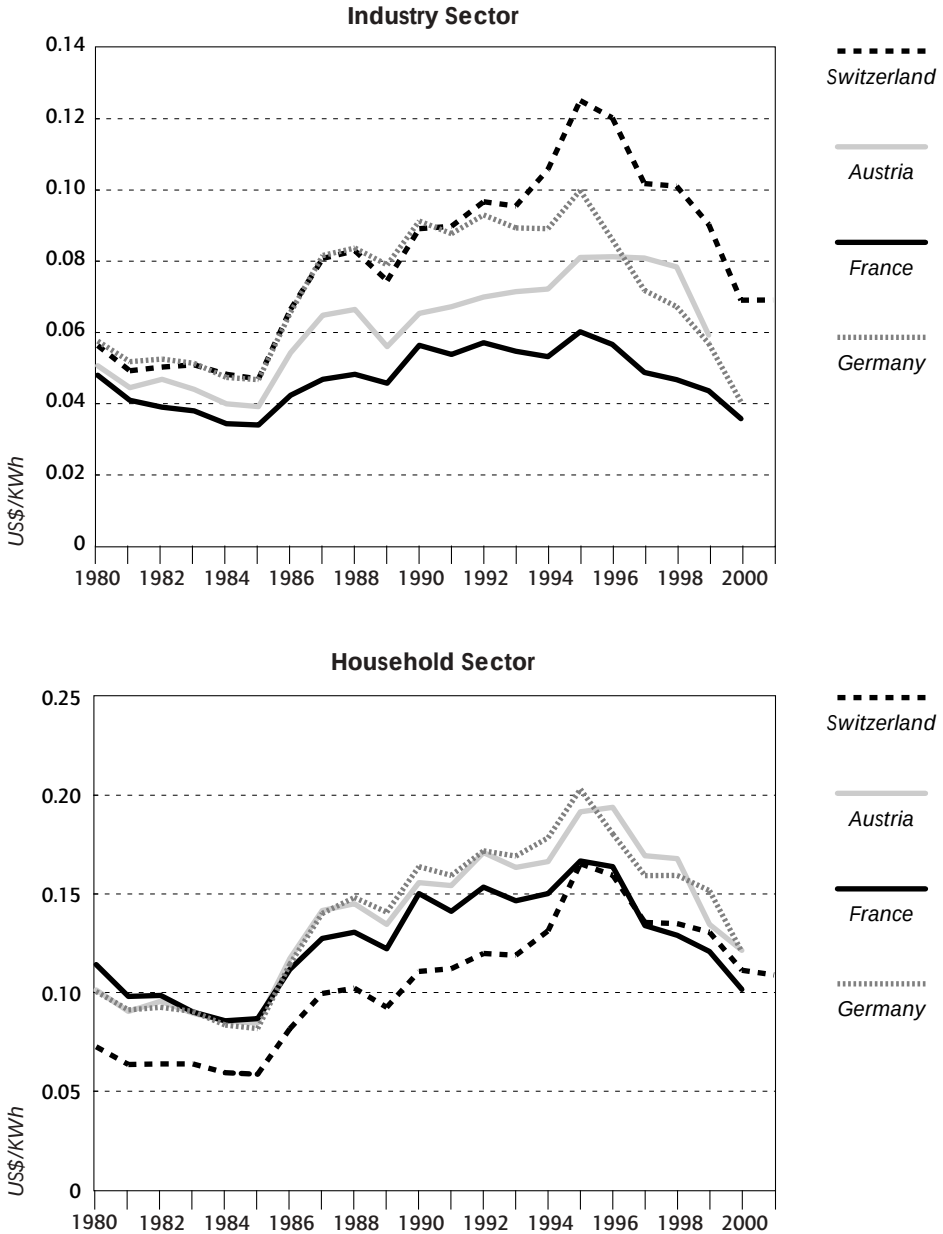


Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Australia, Austria, Belgium, Canada, France, Germany, Greece, Italy, Japan and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

Figure 27

Electricity Prices in Switzerland and in Other Selected IEA Countries, 1980 to 2001



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2002.

Electricity prices are subject to substantial regional variations. In October 2002, VSE price survey results from 53 of its members demonstrated that, in extreme cases, prices for all residential consumers were either over 40% above or 30% below the averages. 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 shareholdings.

The Price Surveillance Office is in charge of ensuring non-abusive electricity pricing. Although it has access to all price data, including confidential information on prices for large consumers, it does not have the necessary resources to carry out permanent monitoring. However, the office is currently systematically evaluating tariffs to identify excessive cases that could be candidates for further investigation. When the price is set by a company without prior approval by a local authority, the office can forbid any price increase or decide on a reduction. If a public authority decides on or has to approve a price increase (which is the case for most electricity prices), the office can issue recommendations, which utilities are not legally obliged to follow. Consumers can complain to the Surveillance Office about abusive prices.

Large generating companies anticipated the adoption of the EML and, in an effort to retain their large customers or win over new ones, entered into contracts with substantial price discounts. Such contracts cover some 20% to 25% of the Swiss electricity market. Some of these contracts were subject to the adoption of the Electricity Market Law (EML). Contracts with no opt-out clause could seriously strain the balance sheets of suppliers that bet on the market opening.

LEGISLATIVE AND REGULATORY FRAMEWORK

LEGAL FRAMEWORK

The federal laws affecting the electricity sector are the 1998 Energy Law, the 1995 Cartel Law, the 1985 Price Surveillance Law, the 1982 Law on Economic Supply and the 1902 Electricity Law. In addition, the cantons have some legislation of their own. The coverage and application of these laws to the electricity sector are described in Table 16.

LICENSING

Approval by the Confederation is needed for the siting of hydropower plants at the Swiss border and for all nuclear plants, whereas the cantons decide on all other installations. Large new plants and extensions of existing plants are subject to an environmental impact assessment. In addition, use of water resources, both during the construction and operation of hydropower plants, is subject to licences. No licences are required for imports or exports.

INDEPENDENT POWER PRODUCERS

According to the 1998 Energy Law, non-renewable electricity from independent producers has to be purchased at market prices[29]. Feed-in tariffs for producers using renewables are discussed in Chapter 7.

REGULATORY REFORM

Current legislation does not prohibit competition in the Swiss power sector, but it is prevented in the absence of third-party access (TPA) 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 EML to liberalise the electricity market. The power industry and industrial consumers welcomed the law, considering that it would reduce prices, provide a more stable energy investment climate, improve international competitiveness, harmonise the development of the Swiss power market with that of the rest of Western Europe and promote renewable energy. Major opposition to the law came from labour unions that argued that the law would lead to privatisation 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 behaviour. The opposition group collected the necessary number of signatures for a public referendum. At the public referendum held on 22 September 2002, the EML was rejected with a 52.6% majority.

29. The basis for the calculation of the market price is the power tariff of the supplier who buys the electricity from the independent power producers or the average power tariff in the canton if a power tariff does not exist. Adjustments are made for system services (13% reduction) and time of the year is taken into account. The price reflects the average price for the whole year (avoided costs) rather than marginal costs as applied to renewables.

Table 16

Legislation in the Electricity Sector and Alternatives for Electricity Market Reform[1]

Option	*Legal basis*	*Areas covered, advantages*	*Areas not covered, disadvantages*
Existing legislation	Energy Law (1998)	Legal basis for policy measures for efficient energy use and the promotion of renewable energies. Includes labelling obligation and compulsory efficiency standards for electric appliances. Regulates connection conditions for certain independent power producers (small hydropower and non-hydropower renewables, CHP, etc.).	Not electricity market-specific. No electricity market regulation.
	Cartel Law (1995)	Prevention of harmful economic or social effects due to cartels or other restrictions on competition. Legal basis for case-by-case decisions on non-discriminatory access to electricity or gas grids and prevention of market power abuse.	Not electricity market-specific. No electricity market regulation. Lengthy procedures.
	Price Surveillance Law (1985)	Prevention of abusive increases or maintenance of prices. Includes energy prices.	Decisions only on total electricity prices. Only recommendations can be given for electricity prices endorsed by cantonal or municipal authorities. No electricity market regulation.
	Law on Economic Supply (1982)	Provides for precautionary security of supply measures. Interventions where supply crises cannot be handled by the private sector. Includes the energy sector.	Applicable in crisis situations only. Not electricity market-specific.
	Electricity Law (1902)	Regulations on the safety of appliances and electric installations; regulations on procedures regarding construction permits and expropriations.	Focus mainly on technical-safety issues.

	Cantonal laws (existing or revised)	Different solutions for production and distribution planning, assignment of network/supply areas, connection conditions for end-users. By their ownership, cantonal and municipal authorities influence strategic decisions of utilities.	Neither national nor international market regulation. Large number of different solutions.
Possible new federal legislation	Market law: regulation on TPA, incentive-based transmission and distribution prices, full market opening	Based on purely economic considerations.	Possible contradiction with the EML referendum. No flanking measures. No security of supply and public service obligations.
	Supply law: control of market power, public network ownership, cost-based TPA tariffs, security of supply and public service obligations, promotion of renewable energy	TPA for commercial clients and/or distribution companies.	Possible opposition from liberal parties and industrial circles. New compromise would be needed.
Voluntary agreements on market opening	Case-by-case contracts between suppliers and network operators	..	Possible contradiction with the Cartel Law.
	Agreement among utilities (possibly including consumer associations)	..	Difficult because of conflicting interests. Possible contradiction with the Cartel Law.

[1] Theoretical alternative and initial analysis on coverage and possible advantages and disadvantages of the various options was presented by SFOE during the review team's visit.

The Electricity Market Law (EML) Proposal

EML would have:

- Given free and non-discriminatory access to the grid.
- Ensured cost-reflective pricing for grid access.
- Gradually opened the Swiss electricity market.
- Created a regulator and an independent transmission system operator.
- Continued the public service obligation.
- Introduced financial measures to modernise and improve the performance of hydropower plants.

The proposed market opening schedule was:

- Consumers of at least 20 GWh per annum and distributors, for 20% of their sales volume (30% of the markets) immediately.
- Consumers of at least 10 GWh per annum and distributors, for 40% of their sales volume (50% of the markets) three years after the initial opening.
- Full market opening for all consumers six years after the initial opening.

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. Government and interest groups are currently discussing alternatives on how to proceed after the vote. Theoretically, there are three major alternatives, namely proceeding within the existing legal framework, proposing a new federal electricity market law and developing voluntary agreements by the power industry. The government has made an initial analysis of the advantages and disadvantages of these alternatives (see Table 16) but no clear path had emerged at the time of the review team visit in November 2002.

The first attempt to challenge the existing *status quo* in the electricity market was made by WATT in 2000 when it appealed to the Federal Competition Commission (Comco) over the refusal of network access by the electricity utility of the Canton of Fribourg (EEF). WATT had agreed with Migros, the largest Swiss retailer and supermarket chain, on deliveries to two large Migros users on the monopoly area of EEF. In 2001, Comco ruled in favour of WATT and Migros arguing that EEF was abusing its dominant market power, which contradicts the Swiss Cartel Law. The ruling was confirmed by the Comco appeals commission in 2002 but this ruling did not explicitly oblige EEF to open its grid. The ruling has now been taken to the Federal Supreme Court. There is still a possibility to appeal to the Federal Council, which will base its decision not only on competition but also on wider economic considerations.

COMBINED HEAT AND POWER GENERATION AND DISTRICT HEATING

The combined heat and power (CHP) installations in Switzerland are very small, with 944 of the 978 units having less than 1 MW electric capacity. Annual electricity generation by CHP is about 1.6 TWh which corresponds to 2.4% of total electricity generation in 2001. There are almost 1 000 small district heating schemes with heat output of about 1 800 GWh, which corresponds to 2.7% of the total heating market. Most of them operate with biomass (wood) or heat pumps, but some also use waste heat or small-scale CHP. At present, there are no specific policies or programmes to promote the use of industrial CHP or district heating in Switzerland. The government does not expect CHP to gain much more importance in power generation in the short term but sees future possibilities if the "anti-nuclear" public initiatives are accepted and also in connection with other technologies such as heat pumps.

CRITIQUE

The key challenges in the electricity sector concern electricity pricing, market reform and Switzerland's transmission and transit role in Western Europe. One more important issue is the future of nuclear power, which is discussed in more detail in Chapter 8.

There is much room for improvement in electricity pricing. Electricity prices in Switzerland are high by international comparison, particularly for the small and medium-sized industrial consumers. High prices penalise the sector that accounts for most job generation and also raise concerns about international competitiveness. The generation mix, composed mainly of cheap hydro and depreciated nuclear power units, does not justify such a high price level. Many taxes, local fees and charges on electricity are increasing electricity prices, but do not fully explain the large gap between the cost of generation and the sales price. This implies inefficiencies in electricity distribution or excessive revenues collected by the municipalities. The tariff and price mechanisms should encourage the utilities to improve the efficiency of their operation; however, there are currently few incentives to cut costs.

The authorities are not monitoring prices for large consumers and there are no requirements for account or other unbundling. This lack of transparency in price setting makes it almost impossible to evaluate whether the tariffs for all consumer groups are based on cost and to ensure that there are no cross-subsidies from one consumer group to another. Price setting by local referendum further intensifies the problem.

Electricity is supplied free of charge or at prices below cost to some public consumers, which increases electricity consumption. This can jeopardise energy efficiency, increase emissions and increase prices for other consumers.

The most efficient way to address the high prices and increase efficiency in the electricity sector would be to create competition through market reform. However, prices should reflect cost for all consumer groups even in monopolistic markets with a view to maximising efficiency. As electricity market reform may be a lengthy process, interim measures should be considered. Furthermore, if market reform is only implemented in the wholesale market, the regulatory authorities are likely to have few powers to affect pricing in the retail markets – where prices are set by the distribution companies, local authorities or by referendums – making additional measures necessary.

Price monitoring and analysis have not been given sufficient importance in recent years. The government should ensure that adequate resources are provided for this task. The government could also seek to improve the price-setting mechanisms by raising awareness in the cantons and municipalities on the detrimental impact of prices that do not reflect cost. Costs that would accrue to a company under free competition could serve as the benchmark in determining appropriate prices.

The first attempt at electricity market reform was not accepted by the public despite careful planning by the SFOE and consultation with the different interest groups. The SFOE has started to investigate the reasons why the EML was rejected in order to be able to make another proposal that takes into account public concerns as well as the needs of the Swiss economy and international trade. The government, consumer associations and power industries have identified many possible reasons for the rejection. Households have little interest in electricity prices and are concerned that liberalisation might increase their electricity prices. They appear to be interested in maintaining public service rather than price decreases. There was also some anticipation that local utilities would be privatised even though this was not part of the law proposal. Another factor may have been the psychological effect of increased insecurity as a consequence of bad news, such as the bankruptcy of Swissair, the Enron scandal, electricity blackouts in California, the slow-down of world economies and terrorism. Given the wide range of possible reasons, it will not be an easy task to present new solutions.

Uncertainty about the outcome of the EML and its eventual rejection created uncertainty in the investment climate, which affects new investments in distribution and transmission capacity. Uncertainty also hampers strategic orientation of utilities as well as the utilities' marketing efforts and efficiency programmes. Prompt action is therefore necessary to clarify future orientation in market reform.

All the new approaches under discussion have their advantages and disadvantages. The key question is which one would be the most effective in ensuring the development of healthy competition while addressing public concerns. It appears that existing legislation does not provide a sufficient legal base, as demonstrated by WATT and Migros versus EEF case. Relying on international agreements might clarify Switzerland's position in respect to the EU with regard to technical aspects, but would develop little competition inside the country. The real choice appears to be between voluntary agreements and new legislation. In principle, voluntary agreements are a very market-oriented instrument. However, practical evidence from Germany shows that achieving active competition by voluntary agreements can be a very time-consuming process requiring significant effort. It appears that the fastest, simplest and most effective way to induce competition in the Swiss market is to develop new legislation, which takes into account the results of the EML vote.

The elements of the EML form a good base for a new law. Taking into account the result of the vote, the new legislation may need to focus on wholesale markets and to enable access to large-scale consumers and distribution companies without extending access to households. On the supplier side, equal access to the grid should be ensured both for new domestic and foreign entrants and incumbents through regulated TPA. Account unbundling is necessary to define TPA tariffs and to ensure that there are no cross-subsidies between captive and market consumers. An independent regulator with adequate resources and decision-making powers should be established to set the rules for market opening and to either supervise the level of transmission tariffs (light-handed regulation) or set them. The new legislation should also ensure that any efficiency gains will be transferred to captive consumers. Straightforward and effective dispute settlement mechanisms are necessary. Many countries have chosen to establish one independent Transmission System Operator (TSO) to manage the national grid and grant access. The six supra-cantonal companies and EWZ have established Etrans to co-ordinate their transmission system activities, which could be developed into an independent TSO. The fact that it is not necessary to privatise network assets to establish a TSO accommodates the labour unions' concern that the EML would increase privatisation. Access to balancing power is important, particularly for the new entrants, and fair and transparent rules for this should be established.

Switzerland is an important electricity transit country. The volume of electricity trade has significantly increased during the past few years, despite its lack of a liberalised domestic market. As an integral part of the UCTE network, access rules to the transmission networks should be in compliance with the rules of the European internal electricity market. Such rules should also be applied to congestion management. Establishment of an independent TSO would contribute to the solution of such problem.

Necessary cost should be reflected in the system access charges and hence the electricity prices.

The existing practice of reserving a large share of the transmission capacities for Swiss transmission network owners is in line with the decision of the Italian authorities to leave 50% of capacity allocation to the Austrian and Slovenian counterparts. In the absence of a legal basis, such as the rejected EML, such a solution can be judged as second-best, allowing 50% of capacity to be allocated by the Italian operator by using marked-based models. A first best solution, such as an extension of market-based mechanisms to the whole available capacity, in line with the rules to be developed for the UCTE network, requires a new legal framework. If the implementation of such new legislation is delayed, pragmatic intermediate solutions should be sought. Voluntary commitments of the transmission network owners, that would create comparable framework conditions under private law, similar to legal regulation, should be examined. Transmission should be based on fees charged for transactions, and non-discriminatory mechanisms should be created to allocate the access to interconnections. Some IEA member countries have implemented an auctioning system. To ensure effective use of the transmission assets, it is usually required that if a company after success in auction does not use the reserved capacity, it has to release it to other users.

International electricity transmission involves many issues, such as network codes and transfer fees, which need to be agreed in international forums. Representatives of the Swiss transmission system operators can only be observers in the Council of European Energy Regulators because Switzerland does not have a regulator that would have the necessary jurisdiction to adhere to the decisions taken within the council. Establishing a regulator and improved co-ordination with other European countries would facilitate better rules for electricity trade and hence enhance security of supply.

CHP capacity in Switzerland is small but accounts for the major part of thermal power generation. There are a number of reasons why CHP use is limited in Switzerland. Finding matching heat and electricity loads, which is a key factor for the competitiveness of CHP, may not be easy because few industries need heat. It may also be difficult for CHP to compete with the relatively low generation cost of hydro and nuclear power. However, the large number of small CHP installations implies that a niche market does exist. Although Switzerland's CHP plants were installed without investment subsidies, there may have been indirect subsidies in the form of feed-in tariffs in the cantons and municipalities. Given the potential energy efficiency and environmental benefits of the most efficient CHP installations, CHP should be given some further consideration. A starting point could be to carry out an updated analysis on the technical and economic potential and then consider the necessity of policies to promote CHP. In such analysis, the basis should be heat demand, not electricity generation, because the current electricity

generation mix provides for electricity supply with lower emissions. In heating or process heat applications with electricity as the by-product, CHP can potentially save primary energy compared to other technologies. Electricity and gas market reform could help CHP generators in selling their surplus electricity and finding cheaper gas.

RECOMMENDATIONS

The government of Switzerland should:

- *Ensure that adequate resources are devoted to price monitoring and protecting consumers from abusive electricity prices. Raise local authorities' awareness of economic, energy efficiency and environmental benefits of cost-reflective electricity pricing. Encourage them to phase out free electricity supplies to public consumers.*
- *After careful analysis of the vote on Electricity Market Law, continue efforts to introduce competition in electricity markets. Establish a national transmission system operator and a regulator, define the rules for TPA and allow market access for domestic and foreign suppliers, distribution companies and large consumers.*
- *Improve the possibilities for transmission network access by auctioning the capacities. Until a legal framework for market reform is in place, encourage industries to implement improvements.*
- *Study the economic potential for combined heat and power generation both in industry and space heating.*

ENERGY R&D PROGRAMMES

Energy R&D has two long-term and two short-term objectives. The government's long-term objectives are to reduce CO_2 emissions to one tonne per capita in 50 years[30] and to reduce TPES from 4 800 W to 2 000 W per capita. The short-term objectives are to reduce the environmental burden from energy production, transformation and use (without quantitative targets) and to increase technical and economic efficiency using publicly acceptable technologies.

In November 1999, the Confederation adopted the fifth Swiss Federal Energy Research Concept for 2000 to 2003. The purpose of the concept is to focus research activities on the most effective methods to reach the Confederation's energy policy objectives. It sets a framework for collaboration between the federal administration, the cantons and the local authorities. The concept also includes plans for R&D for the four-year period and estimates of required public funding. One of the main objectives of Swiss energy R&D is to achieve sustainable development through significant reductions of CO_2 emissions. The SFOE, advised by the Federal Commission for Energy Research (CORE)[31], is responsible for periodical updating of the concept, its implementation and ensuring that results find practical applications. National Energy Research Conferences are held every three or four years to bring together industry leaders, representatives of the cantonal and federal agencies, politicians and energy experts to review national priorities and recommend corrections.

To achieve the objectives, the publicly funded programmes concentrate on applied R&D as well as pilot and demonstration projects in four priority research areas, namely rational use of energy, renewable energy sources, nuclear energy and energy policies and economics. These areas are discussed in more detail below.

30. Scenarios of how to meet this long-term emissions goal rely on use of buildings and transport technologies such as heat pumps, passive solar buildings, fuel cells (stationary and for transport applications), lightweight vehicles, and natural gas and hybrid vehicles, alongside more renewable energy use for electricity and heat production.
31. CORE is composed of representatives from industry, research institutes, funding institutions and cantons.

RATIONAL USE OF ENERGY

This R&D area covers rational and more efficient energy use in all sectors but particularly in buildings, development of combustion engine processes, development of co-generation (including electricity, heating and cooling) and heat pump technologies.

SFOE's Master Programme for Buildings was launched in 1996 by merging three former programmes, namely Building Systems and Shells, Building Technology, and Solar Architecture and Daylight Utilisation. The objective of the Programme is to reduce energy consumption in buildings by 10% to 25% by 2010, depending on the building type and age, below 2000 levels. Emphasis is on upgrading energy efficiency in existing buildings. The programme continues activities in the areas of building systems and shells (*e.g.* insulation materials, planning aids), building technology (*e.g.* heating and ventilation systems, standard solutions for renewal of outdated heating installations, oil and gas burners), solar architecture and daylight use (*e.g.* transparent insulation modules, direct collection and solar air systems, computer programmes and handbooks for planners).

Combustion engine processes are being developed in close co-operation with industry. The four key activities are laser optical measures, numerical simulation of combustion processes, formation of pollutants in combustion (particularly reduction of nitrogen) and low-pollution combustion technologies (*e.g.* catalytic combustion) and retention procedures (*e.g.* for diesel soot in heavy goods vehicles).

Switzerland is active in CHP-related R&D, including electricity and heat production and cooling applications. R&D activities in this area are developing reliable and economic heat pumps for older buildings, closing the gaps in knowledge as regards alternative (especially natural) refrigerants, fuel cell use in CHP units and system optimisation. The last item implies increasing the efficiency and security of operation of heating systems.

RENEWABLE ENERGY SOURCES

This R&D area aims at reducing the cost and improving the efficiency of various technologies and includes research in hydropower, wood and other biomass, geothermal, wind, solar thermal, photovoltaics (PV) and solar chemistry, including the use of hydrogen.

R&D in hydropower concentrates on small-scale applications. The principal objective is to increase hydropower's generation volumes and economic efficiency by, for example, using small variable-speed turbines in existing and abandoned small-scale hydropower sites. Pilot and demonstration plants are being sought for the implementation of research results. In 1997, a Handbook of Small-Scale Hydropower Plants was published containing detailed information for constructors and operators.

Activities related to wood cover manually operated small-scale wood-burning furnaces and the reduction of pollutant emissions from automatic furnaces. The key R&D activities in other biomass are development and optimisation of biogas and gasification systems for agricultural, municipal and commercial waste, adaptation of motors to untreated ecological fuels (*e.g.* rapeseed oil) and adaptation of fuels to motors (*e.g.* processing biogas into combustion gas with high methane content).

The SFOE has recognised that there is a need for further research in geothermal energy in order to increase the performance of geothermal probes (GP) and to cut costs. There are many activities related to R&D in geothermal energy. R&D aims at finding backfills with better heat conduction properties, developing deeper GPs and broader probe diameters, using GPs for cooling in summer, using open probes (*i.e.* that feed groundwater directly to heat pumps) and optimising geothermal fields and energy piles. Basic measurements need to be carried out for deep-lying GPs to optimise large-scale systems from both a technical and economic point of view. Trials are carried out on drilling techniques with narrow drill-hole diameter (slim hole drillings), as this technology could cut drilling cost by 50%. In addition, R&D is carried out on hot dry rock and hot wet rock plants for producing electricity and heat.

Since wind energy cannot significantly contribute to national electricity supply, there has been some policy debate on Swiss R&D in wind technology, which resulted in the SFOE considering that wind power is principally a regional issue. To facilitate implementation, measurement programmes for wind power plants receive SFOE support. The results are stored in a wind database initiated to simplify identification and choice of suitable locations. With the commissioning of a 850 kW wind power plant on the Gütsch, near Andermatt (2 300 m altitude) in spring 2002, important additional experience is being gained on the use of wind energy in extreme climatic conditions.

In addition to more passive solar applications in buildings, there is significant R&D in active solar applications, such as systems for domestic hot water and heating, PV and thermal energy storage. R&D in solar thermal systems concentrates on developing components for practically all system types, uncovered panels (*e.g.* made of stainless steel), systems that are easier to integrate into buildings and compact, standardised systems for domestic hot water and heating in apartment buildings. A less significant R&D activity is a solar power plant of 10 to 15 kW electrical capacity with concentrating collectors and a special steam turbine to be used in developing countries. R&D in PV is concentrated on reducing costs. Activities include the development of materials and new cell technologies, systems and products for integrating PV systems into buildings and simplification of systems technology. The principal objective and main selection criterion for PV

programmes is their implementation, and development therefore takes place in close co-operation with industry. The efforts in high-temperature applications range from development of solar absorbers, high-temperature solar chemistry and hydrogen storage to photoelectric water fission. The SFOE recognises that R&D in high-temperature applications will only lead to implementation of the technologies in the longer term.

NUCLEAR ENERGY

The two topical areas for nuclear energy are fission and fusion. The majority of funds within the fission research 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 Confederation also spends a relatively minor amount of public money on R&D relating to radioactive waste, with the majority of funding coming from the 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.

ENERGY POLICIES AND ECONOMICS

This R&D area covers the following four topics to provide the energy sector and decision-makers with information on which to base their decisions:

- Public acceptance of energy policies and new technologies.
- The ecological and social impact of political measures, such as energy taxes, and of long-term energy policy planning, such as the potential replacement of nuclear power.
- Risks and costs of environmental pollution resulting from energy transformation and use (*i.e.* the environmental externalities).
- Transfer of research results into market products.

ENERGY R&D BUDGETS

Publicly funded energy R&D decreased steadily and significantly, by about 30%, from 1992 through 2000 (see Table 17). In 2001, funding increased slightly. The government aims to spend 20% of its R&D budget on pilot and demonstration projects and 20% on basic, long-range research.

Both the public and private sectors fund energy R&D. In 2001, public sector funding amounted to CHF 173 million and private sector funding to 725 million for a total of CHF 898 million. Half of the totality of private and public funding was used for R&D on rational use of energy, 33% on renewables, 10% on nuclear power and 7% on energy policies and economics.

Table 17

Government's Energy R&D Budget

(Million CHF in 2001 currency)

	1994	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002e*	*2003e*
Non-nuclear	164.8	160.4	150.7	140.4	133.7	137.6	114.0	121.7	130	141
Nuclear fission	37.1	36.4	31.9	31.7	29.2	21.3	28.5	26.9	25	24
Nuclear fusion	29.4	26.1	30.5	31.7	25.5	25.9	24.2	24.2	25	25
Total	**231.3**	**223.0**	**213.3**	**203.7**	**188.4**	**184.7**	**166.8**	**172.8**	**180**	**190**

e: estimate.

Source: SFOE.

Public funding for energy R&D is supplied by several different organisations. In 2001, approximately CHF 173 million was distributed on a percentage basis to the Board of the Federal Institutes of Technology (45%), the SFOE (21%), the cantons and municipalities (15%), the Federal Office of Education and Science (13%), the Committee for Technology and Innovation (4%) and the Swiss National Science Foundation (2%). Rational use of energy was funded at CHF 55 million (32%), renewable energy sources at CHF 52 million (30%), nuclear energy at CHF 51 million (30%), and energy policies and economics at CHF 14.6 million (8%).

The rational use of energy places emphasis on buildings, CHP and combustion processes. In 1999, these three sub-topics accounted for about 60% of rational energy use funding. Renewable energy sources places emphasis on solar energy. In 1999, solar energy received over two-thirds of renewable energy sources funding and represented about 25% of the total of publicly funded energy R&D.

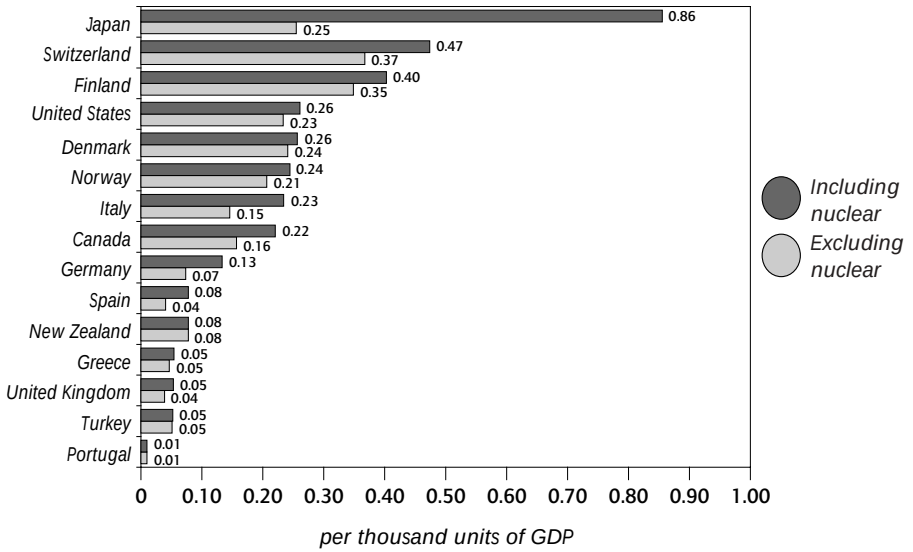
Public funding for nuclear energy research was in the order of CHF 51 million in 2001 and is projected to remain fairly constant in the near term.

Significant funding, about 40% of total costs, is provided by external sources, including Swiss utilities, EURATOM, the Federal Nuclear Safety Inspectorate and international nuclear industries. The nuclear energy R&D budget is essentially split equally between fission research, which concentrates on ensuring the safety of operating power plants and waste disposal, and fusion research, searching for a long-term alternative energy source.

Despite declining energy R&D budgets in absolute terms, the Swiss energy R&D budgets remain relatively high when compared to GDP (see Figure 28). In 2001, Switzerland ranked second among IEA member countries in total energy R&D and first in non-nuclear energy R&D.

Figure 28

IEA Government Budgets on Energy R&D per GDP, 2001



Note: Information for nuclear and non-nuclear R&D budgets per GDP was not available for Australia, Austria, Belgium, the Czech Republic, France, Hungary, Ireland, Korea, the Netherlands and Sweden.
Sources: Country submissions and *National Accounts of OECD Countries,* OECD Paris, 2002.

ENERGY R&D INSTITUTIONS

Publicly funded energy R&D is performed at many organisations. In 2001, approximately CHF 173 million went to the PSI (28%), the Federal Institute of Technology in Lausanne (22%), universities (17%), The Federal Institute of Technology in Zurich (9%), the Federal Research and Test Laboratory (2%), other federal and cantonal bodies (3%) and private-sector organisations (19%).

The Paul Scherrer Institute (PSI)

PSI is the largest national research institute and the largest energy research centre (including nuclear research) in Switzerland. Over the last few years, emphasis has shifted from particle physics and nuclear energy towards materials sciences and solid state physics as well as general energy R&D and environmental sciences. PSI's missions are:

- Conceive, design, build and operate large, complex research facilities for the scientific community.
- Carry out fundamental and applied research in solid state physics and materials sciences, in particle physics, life sciences and nuclear and non-nuclear energy, and energy-related environmental areas (reactor safety, safety studies on the disposal of radioactive wastes, new methods for energy production and storage, energy systems analysis).

INTERNATIONAL COLLABORATION

Switzerland places emphasis on the importance of international collaboration given its limited R&D resources. It participates in many of the IEA's Implementing Agreements[32]. It is also active in NEA and EURATOM. It is participating in many EU programmes such as COST and the research and development framework programmes (Joule, Thermie, EESD, BRITE-EURAM, GROWTH).

CRITIQUE

The Swiss energy R&D budget decreased constantly between 1992 and 2000 but increased slightly in 2001. While the R&D budget in comparison to GDP has been decreasing, it remains among the highest within IEA member countries. Given the numerous R&D needs arising from Swiss energy policy, the R&D budget level should at least be maintained.

The Swiss energy R&D programme is comprehensive and well thought out. The SFOE, advised by the CORE, is responsible for co-ordinating most federally directed energy-related R&D. Appropriately, it has long-term targets,

32. Switzerland participates in the following IEA Implementing Agreements: Advanced Fuel Cells, Bioenergy, Buildings and Community Systems, Emissions Reduction in Combustion, Energy Storage, Energy Technology Data Exchange, Energy Technology Systems Analysis, Greenhouse Gases, Geothermal Energy, Heat Pumping Technologies, Heat Transfer and Exchangers, Hybrid and Electric Vehicles, Hydrogen Technology, Photovoltaic Power Systems, Solar Heating and Cooling, SolarPACES, Superconductivity and in all the eight Fusion Power Implementing Agreements.

recognising that new technologies take decades to develop and bring to market and that the more immediately applied research is better undertaken in the private sector. In addition, given the relatively small size of the Swiss energy R&D establishment, SFOE has taken a prudent approach by promoting international collaboration.

The shorter-term objective for energy R&D is to support the implementation of SwissEnergy. Given the SwissEnergy's strong focus on energy efficiency and renewables, the expenditure appears to be quite well balanced between the four priority areas; however, room may still exist for further balancing. For example, additional research on the application of energy conservation measures to existing buildings could permit significant advances in reducing energy consumption.

The long-term goals of Swiss energy R&D support and even exceed commitments to reduce energy and carbon emissions; the programme supports a target of 2 000 W per person energy usage and a one tonne per person per annum CO_2 target, which should both be achieved by 2050. It is not clear whether the existing activities and R&D to meet the SwissEnergy near-term objectives are fully compatible with the long-term goals as interim steps have not been defined to allow a smooth transition from the current technologies and policies to the longer-term targets.

RECOMMENDATION

The government of Switzerland should:

- *Continue planning to facilitate the integration and alignment of near-term activities and long-term R&D objectives.*

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	2000	2001	2010	2020	2030
TOTAL PRODUCTION		**4.28**	**9.83**	**11.79**	**12.37**	**11.21**	**10.50**	**9.01**
Coal[1]		–	–	–	–	–	–	–
Oil		–	–	–	–	–	–	–
Gas		–	0.00	–	–	–	–	–
Comb. Renewables & Wastes[2]		0.24	1.02	1.60	1.67	2.03	2.10	2.03
Nuclear		1.64	6.18	6.91	7.01	6.29	5.52	4.10
Hydro		2.40	2.56	3.17	3.55	2.88	2.88	2.88
Geothermal		–	0.06	0.09	0.11	–	–	–
Solar/Wind/Other		–	0.01	0.03	0.03	0.00	0.01	0.01
TOTAL NET IMPORTS[3]		**15.23**	**15.16**	**14.26**	**15.47**	**15.87**	**16.20**	**16.47**
Coal[1]	Exports	0.02	0.01	–	–	–	–	–
	Imports	0.24	0.35	0.19	0.13	0.10	0.10	0.10
	Net Imports	0.22	0.34	0.19	0.13	0.10	0.10	0.10
Oil	Exports	0.23	0.16	0.64	0.56	–	–	–
	Imports	15.38	13.54	12.90	14.27	13.04	12.94	12.63
	Bunkers	–	0.02	0.01	0.01	–	–	–
	Net Imports	15.16	13.36	12.25	13.71	13.04	12.94	12.63
Gas	Exports	–	–	–	–	–	–	–
	Imports	0.15	1.63	2.43	2.53	2.85	2.99	3.13
	Net Imports	0.15	1.63	2.43	2.53	2.85	2.99	3.13
Electricity	Exports	0.90	1.97	2.70	2.97	0.12	..	..
	Imports	0.60	1.79	2.09	2.07	..	0.17	0.61
	Net Imports	–0.30	–0.18	–0.61	–0.90	–0.12	0.17	0.61
TOTAL STOCK CHANGES		**0.22**	**0.12**	**0.43**	**0.18**	**–**	**–**	**–**
TOTAL SUPPLY (TPES)		**19.72**	**25.11**	**26.48**	**28.02**	**27.08**	**26.70**	**25.48**
Coal[1]		0.33	0.36	0.14	0.15	0.10	0.10	0.10
Oil		15.26	13.46	12.73	13.87	13.04	12.94	12.63
Gas		0.15	1.63	2.43	2.53	2.85	2.99	3.13
Comb. Renewables & Wastes[2]		0.24	1.03	1.60	1.67	2.03	2.10	2.03
Nuclear		1.64	6.18	6.91	7.01	6.29	5.52	4.10
Hydro		2.40	2.56	3.17	3.55	2.88	2.88	2.88
Geothermal		–	0.06	0.09	0.11	–	–	–
Solar/Wind/Other		–	0.01	0.03	0.03	0.00	0.01	0.01
Electricity Trade[4]		–0.30	–0.18	–0.61	–0.90	–0.12	0.17	0.61
Shares (%)								
Coal		*1.7*	*1.4*	*0.5*	*0.5*	*0.4*	*0.4*	*0.4*
Oil		*77.4*	*53.6*	*48.1*	*49.5*	*48.2*	*48.5*	*49.6*
Gas		*0.8*	*6.5*	*9.2*	*9.0*	*10.5*	*11.2*	*12.3*
Comb. Renewables & Wastes		*1.2*	*4.1*	*6.0*	*6.0*	*7.5*	*7.9*	*8.0*
Nuclear		*8.3*	*24.6*	*26.1*	*25.0*	*23.2*	*20.7*	*16.1*
Hydro		*12.2*	*10.2*	*12.0*	*12.7*	*10.6*	*10.8*	*11.3*
Geothermal		–	*0.2*	*0.3*	*0.4*	–	–	–
Solar/Wind/Other		–	–	*0.1*	*0.1*	–	–	–
Electricity Trade		*–1.5*	*–0.7*	*–2.3*	*–3.2*	*–0.5*	*0.6*	*2.4*

0 is negligible, – is nil, .. is not available.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2000	2001	2010	2020	2030
TFC	**17.57**	**19.66**	**21.18**	**21.56**	**21.76**	**21.89**	**21.69**
Coal[1]	0.29	0.35	0.14	0.15	0.10	0.10	0.10
Oil	14.30	12.85	13.12	13.19	12.65	12.56	12.26
Gas	0.24	1.52	2.23	2.32	2.68	2.77	2.85
Comb. Renewables & Wastes[2]	0.24	0.60	0.75	0.78	1.31	1.38	1.39
Geothermal	–	0.06	0.09	0.11	–	–	–
Solar/Wind/Other	–	0.01	0.02	0.03	–	–	–
Electricity	2.50	4.04	4.50	4.65	4.76	4.83	4.83
Heat	–	0.25	0.32	0.34	0.27	0.26	0.26
Shares (%)							
Coal	*1.6*	*1.8*	*0.7*	*0.7*	*0.5*	*0.4*	*0.5*
Oil	*81.4*	*65.3*	*62.0*	*61.2*	*58.1*	*57.4*	*56.5*
Gas	*1.3*	*7.7*	*10.5*	*10.7*	*12.3*	*12.6*	*13.1*
Comb. Renewables & Wastes	*1.4*	*3.0*	*3.5*	*3.6*	*6.0*	*6.3*	*6.4*
Geothermal	–	*0.3*	*0.4*	*0.5*	–	–	–
Solar/Wind/Other	–	–	*0.1*	*0.1*	–	–	–
Electricity	*14.2*	*20.5*	*21.3*	*21.6*	*21.9*	*22.1*	*22.3*
Heat	–	*1.3*	*1.5*	*1.6*	*1.2*	*1.2*	*1.2*
TOTAL INDUSTRY[5]	**4.78**	**3.93**	**4.75**	**4.90**	**4.85**	**4.89**	**5.03**
Coal[1]	0.08	0.33	0.13	0.14	0.10	0.10	0.10
Oil	3.70	1.31	1.73	1.80	1.42	1.38	1.39
Gas	0.05	0.59	0.76	0.78	1.14	1.14	1.19
Comb. Renewables & Wastes[2]	–	0.16	0.43	0.45	0.49	0.51	0.50
Geothermal	–	–	0.01	0.01	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	0.95	1.48	1.56	1.59	1.63	1.69	1.77
Heat	–	0.05	0.13	0.14	0.08	0.07	0.07
Shares (%)							
Coal	*1.6*	*8.4*	*2.7*	*2.9*	*2.0*	*2.0*	*2.0*
Oil	*77.4*	*33.4*	*36.3*	*36.7*	*29.3*	*28.3*	*27.7*
Gas	*1.1*	*15.1*	*16.0*	*15.9*	*23.4*	*23.3*	*23.7*
Comb. Renewables & Wastes	–	*4.1*	*9.1*	*9.1*	*10.2*	*10.5*	*9.9*
Geothermal	–	–	*0.1*	*0.2*	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	*19.9*	*37.7*	*32.8*	*32.4*	*33.5*	*34.5*	*35.3*
Heat	–	*1.2*	*2.8*	*2.8*	*1.6*	*1.4*	*1.4*
TRANSPORT[6]	**4.29**	**6.29**	**7.06**	**6.87**	**7.10**	**7.43**	**7.47**
TOTAL OTHER SECTORS[7]	**8.49**	**9.44**	**9.38**	**9.80**	**9.81**	**9.58**	**9.20**
Coal[1]	0.21	0.02	0.01	0.01	0.00	0.00	0.00
Oil	6.48	5.47	4.57	4.76	4.43	4.06	3.72
Gas	0.19	0.92	1.47	1.54	1.54	1.63	1.66
Comb. Renewables & Wastes[2]	0.24	0.44	0.32	0.34	0.82	0.87	0.89
Geothermal	–	0.06	0.08	0.10	–	–	–
Solar/Wind/Other	–	0.01	0.02	0.02	–	–	–
Electricity	1.37	2.34	2.72	2.83	2.83	2.83	2.74
Heat	–	0.20	0.18	0.20	0.19	0.19	0.19
Shares (%)							
Coal	*2.5*	*0.2*	*0.1*	*0.1*	–	–	–
Oil	*76.3*	*57.9*	*48.7*	*48.6*	*45.2*	*42.4*	*40.4*
Gas	*2.2*	*9.8*	*15.7*	*15.7*	*15.7*	*17.0*	*18.0*
Comb. Renewables & Wastes	*2.8*	*4.6*	*3.4*	*3.4*	*8.4*	*9.1*	*9.7*
Geothermal	–	*0.6*	*0.9*	*1.0*	–	–	–
Solar/Wind/Other	–	*0.1*	*0.2*	*0.2*	–	–	–
Electricity	*16.1*	*24.7*	*29.0*	*28.9*	*28.8*	*29.5*	*29.8*
Heat	–	*2.1*	*2.0*	*2.1*	*1.9*	*2.0*	*2.1*

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2000	2001	2010	2020	2030
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**4.48**	**9.39**	**11.12**	**11.66**	**10.07**	**9.35**	**7.91**
OUTPUT (Mtoe)	**3.17**	**4.70**	**5.67**	**6.07**	**5.22**	**5.00**	**4.56**
(TWh gross)	36.82	54.62	65.96	70.55	60.73	58.18	53.03
Output Shares (%)							
Coal	–	*0.1*	–	–	–	–	–
Oil	*7.1*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	*0.2*
Gas	–	*0.6*	*1.5*	*1.2*	*1.7*	*2.2*	*2.7*
Comb. Renewables & Wastes	–	*1.0*	*2.4*	*2.1*	*3.2*	*3.6*	*4.2*
Nuclear	*17.1*	*43.3*	*40.1*	*38.0*	*39.8*	*36.4*	*29.6*
Hydro	*75.8*	*54.6*	*55.8*	*58.6*	*55.2*	*57.6*	*63.2*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*
TOTAL LOSSES	**2.17**	**5.09**	**5.92**	**6.04**	**5.31**	**4.81**	**3.80**
of which:							
Electricity and Heat Generation[9]	1.32	4.42	5.10	5.23	4.55	4.06	3.05
Other Transformation	0.14	0.01	–0.03	–0.02	0.00	–	–
Own Use and Losses[10]	0.72	0.66	0.85	0.83	0.76	0.75	0.74
Statistical Differences	–0.02	0.36	–0.62	0.42	–	–	–

INDICATORS

	1973	1990	2000	2001P	2010	2020	2030
GDP (billion 1995 US$)	246.18	308.43	336.14	339.10	412.46	469.33	534.04
Population (millions)	6.44	6.71	7.18	7.23	7.50	7.40	7.40
TPES/GDP[11]	0.08	0.08	0.08	0.08	0.07	0.06	0.05
Energy Production/TPES	0.22	0.39	0.45	0.44	0.41	0.39	0.35
Per Capita TPES[12]	3.06	3.74	3.69	3.87	3.61	3.61	3.44
Oil Supply/GDP[11]	0.06	0.04	0.04	0.04	0.03	0.03	0.02
TFC/GDP[11]	0.07	0.06	0.06	0.06	0.05	0.05	0.04
Per Capita TFC[12]	2.73	2.93	2.95	2.98	2.90	2.96	2.93
Energy-related CO_2 Emissions (Mt CO_2)[13]	43.6	41.5	42.9	43.8	43.4	43.5	42.9
CO_2 Emissions from Bunkers (Mt CO_2)	2.1	3.2	4.8	4.6	4.6	4.6	4.6

GROWTH RATES (% per year)

	73–79	79–90	90–00	00–01	01–10	10–20	20–30
TPES	0.2	2.1	0.5	5.8	–0.4	–0.1	–0.5
Coal	–6.3	4.5	–9.1	6.5	–4.5	–	0.3
Oil	–2.2	0.1	–0.6	9.0	–0.7	–0.1	–0.2
Gas	31.0	7.2	4.1	4.1	1.3	0.5	0.5
Comb. Renewables & Wastes	11.2	7.7	4.5	4.8	2.2	0.3	–0.3
Nuclear	11.0	6.5	1.1	1.4	–1.2	–1.3	–2.9
Hydro	2.1	–0.5	2.1	12.1	–2.3	–	–
Geothermal	–	–	4.1	17.6	–	–	–
Solar/Wind/Other	–	–	12.1	4.0	–21.3	5.2	1.8
TFC	–0.6	1.4	0.7	1.8	0.1	0.1	–0.1
Electricity Consumption	2.6	3.0	1.1	3.2	0.3	0.2	0.0
Energy Production	6.5	4.2	1.8	4.9	–1.1	–0.6	–1.5
Net Oil Imports	–1.6	–0.3	–0.9	11.9	–0.6	–0.1	–0.2
GDP	–0.4	2.3	0.9	0.9	2.2	1.3	1.3
Growth in the TPES/GDP Ratio	0.6	–0.2	–0.3	4.9	–2.5	–1.4	–1.7
Growth in the TFC/GDP Ratio	–0.3	–0.9	–0.1	0.9	–2.1	–1.2	–1.4

Please note: Rounding may cause totals to differ from the sum of the elements.

FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

1. Includes lignite and peat.
2. Comprises solid biomass, biogas, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
3. Total net imports include combustible renewables and waste.
4. Total supply of electricity represents net trade. A negative number indicates that exports are greater than imports.
5. Includes non-energy use.
6. Includes less than 1% non-oil fuels.
7. Includes residential, commercial, public service and agricultural sectors.
8. Inputs to electricity generation include inputs to electricity and CHP plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at public utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of 33% for nuclear and 100% for hydro.
10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
11. Toe per thousand US dollars at 1995 prices and exchange rates.
12. Toe per person.
13. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2001 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

Member countries* of the IEA seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives they therefore aim to create a policy framework consistent with the following goals:

1. **Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. **The environmentally sustainable provision and use of energy** is central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should where practicable have regard to the Polluter Pays Principle.

4. **More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA members wish to retain and improve the nuclear

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. **Co-operation among all energy market participants** helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention and abbreviated subsequently, this glossary provides a quick and central reference for many of the abbreviations used.

AIJ	Activities Implemented Jointly.
AEE	Agency of Renewable Energies and Energy Efficient Application of Energy.
AEnEC	The Energy Agency for the Economy.
bcm	billion cubic metres.
Carbura	Central Swiss Office for Imported Fuels and Combustible Liquids.
CCEDS	Conferences of Cantonal Energy Directors and Services.
CDM	Clean Development Mechanism.
CHP	combined production of heat and power; sometimes when referring to industrial CHP, the term "co-generation" is used.
CO	carbon monoxide.
CORE	The Federal Commission for Energy Research.
DETEC	The Federal Department of Environment, Transport, Energy and Communication.
EAE	Energy Agency for Electric Appliances.
EML	Electricity Market Law.
Energy 2000	The Energy 2000 Action Programme.
ETHZ	Federal Institute of Technology, Zurich.
ETSO	European Association of Electricity Transmission System Operators.
EU	European Union.
GDP	gross domestic product.
GHG	greenhouse gases (see footnote 9).
GP	geothermal probes.
GW	gigawatt, or one watt $\times 10^9$.
GWh	gigawatt-hour = one gigawatt $\times$ one hour.
HFC	hydrofluorocarbons.
HSK/DSN	Federal Nuclear Safety Inspectorate.

IEA	International Energy Agency.
IPCC	Intergovernmental Panel on Climate Change.
IT	information technology.
JI	Joint Implementation.
km^2	square kilometre.
KSA/CSA	Federal Commission for the Safety of Nuclear Installations.
ktoe	thousand tonnes of oil equivalent; see toe.
kWh	kilowatt-hour = one kilowatt × one hour.
m	metre.
m^2	square metre.
m^3	cubic metre.
mcm	million cubic metres.
MOP	Moratorium Plus.
Mt	million tonnes.
Mtce	million tonnes of coal equivalent (one Mtce = 0.7 Mtoe).
Mtoe	million tonnes of oil equivalent; see toe.
MW	megawatt, or one watt × 10^6.
MW_e	megawatt of electrical capacity.
MW_{th}	megawatt of thermal capacity.
MWh	megawatt-hour = one megawatt × one hour.
MWp	peak-megawatts.
NAGRA	National Co-operative for the Disposal of Radioactive Waste.
NEA	OECD Nuclear Energy Agency.
NGOs	non-governmental organisations.
NMVOC	non-methane volatile organic compound.
NO_x	nitrogen oxide.
OECD	Organisation for Economic Co-operation and Development.
PFC	Perfluorocompounds.
PM_{10}	small particles, diameter under 10 micrometers.
ppm	parts per million.
PPP	purchasing power parity.
PSI	Paul Scherrer Institute.
PV	photovoltaics.
R&D	research and development, especially in energy technology; may include the demonstration and dissemination phases as well.
SAEFL	Swiss Agency for the Environment, Forests and Landscape.
SAFE	Swiss Agency for Efficient Energy Use.

SO_2	sulphur dioxide.
SFOE	Swiss Federal Office for Energy.
SMEs	small and medium-sized enterprises.
SOA	Electricity without Atoms.
SwissEnergy	The SwissEnergy Programme.
TFC	total final consumption of energy.
TJ	terajoule, or one joule $\times 10^{12}$.
Toe	tonne of oil equivalent, defined as 10^7 kcal.
TPA	third-party access.
TPES	total primary energy supply.
TRECs	tradable renewable energy certificates.
TSO	transmission system operator.
TW	terawatt, or one watt $\times 10^{12}$.
TWh	terawatt-hour = one terawatt $\times$ one hour.
UCTE	Union for the Co-ordination of Transmission of Electricity.
UNFCCC	United Nations Framework Convention on Climate Change.
VAs	voluntary agreements.
VAT	value-added tax.
VCs	voluntary commitments.
VOCs	volatile organic compounds.
VSE	Swiss Electricity Suppliers Association.
VSG	Swiss Association for Natural Gas Industry.
WHO	World Health Organization.

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