International Energy Agency

Energy Policies of IEA Countries

Switzerland

2012 Review

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Switzerland has taken bold decisions to gradually phase out nuclear power and to reduce by a fifth its greenhouse gas emissions by 2020 with domestic measures only. These are challenging objectives, and the country now needs to identify the most viable ways to meet them at least cost and minimum risk to energy security.

In the absence of nuclear power, maintaining sufficient electricity capacity will require strong policies to promote energy efficiency and renewable energy. Such measures have already been outlined, but they will likely not be enough. For baseload generation, gas-fired power plants would be the simplest option. Treating their CO_2 emissions the same way as in the neighbouring countries would be a strong positive incentive for investors.

Because Switzerland's energy-related CO_2 emissions come mostly from oil use in transport and space heating, action is most needed in these areas. Commendably, the country is making polluters pay by using a CO_2 tax for financing decarbonisation efforts in space heating. Stronger efforts will be needed to reduce emissions from private car use, however.

Since the 2007 IEA energy policy review, Switzerland has made clear progress in electricity market reform. Moving to a fully open market by 2015 would be a further positive step. The system of regulated end-user prices, however, is subsidising electricity consumption at a time when low-carbon power supply is becoming more constrained and expensive. It should be reconsidered. Switzerland should also continue to take an increasingly European approach to developing its electricity infrastructure, to its own benefit and to that of its neighbours.

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

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France
Germany
Greece
Hungary
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Italy
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Netherlands
New Zealand
Norway
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Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

International Energy Agency

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1. EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

EXECUTIVE SUMMARY

Switzerland has taken major decisions not to replace existing nuclear reactors and to reduce by a fifth its greenhouse gas (GHG) emissions by 2020 using only domestic measures. These are challenging objectives, and the country now needs to identify the most viable ways to meet them at least cost and at minimum risk to its energy security.

NUCLEAR PHASE-OUT

The accident at the Fukushima Daiichi nuclear power plant in March 2011 had a far-reaching impact on energy policy in Switzerland: in May 2011, the government (Federal Council), followed by the parliament in September, decided not to allow replacement of existing nuclear reactors and therefore to gradually phase out nuclear power at the end of the current plants' lifetime, while redefining the country's energy policy.

Since nuclear energy provides 40% of Switzerland's electricity generation, the decision to phase it out is very significant. The decision to do so gradually, as the plants reach the end of their operating life, is a cautious one. Although the notion of "operational lifetime" of nuclear power plants (NPPs) does not exist in Switzerland, the actual end of operation could occur in the period from 2019 to 2034, with the largest plants retiring towards the end of this period. It may take even longer, as according to the Swiss law, NPPs may operate as long as they meet the safety criteria.

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

ENERGY STRATEGY 2050

Following the phase-out decision, the government adopted an energy strategy for 2050, which aims at substantially reducing final energy and stabilising electricity use. Reaching these strategic goals will likely require great effort, especially as Switzerland's population and economy are expected to continue to grow. Electricity demand, in particular, is generally closely linked to economic growth, and electricity demand may actually increase in several sectors in the coming decades, for example because of potential widespread penetration of electricity-using innovations, such as heat pumps and electric vehicles.

The government is now preparing legislative proposals in line with the strategy, to be submitted for wide public consultation later in 2012 and to parliament in mid-2013. The new legislation is scheduled to enter into force at the beginning of 2015. The medium-

term policies and measures would primarily focus on improving energy efficiency and increasing electricity generation from hydropower, but also from other renewable sources and, as a last resort, from natural gas.

Over the longer term (after 2020), a gradual overhaul of energy and CO_2 taxation is mooted. The current promotion of renewable energy and buildings refurbishment through a grid levy and partial CO_2 tax revenue earmarking would be gradually substituted by an overall energy tax, which would have a "steering" effect on energy demand.

Implementing these plans will require a range of new incentives, including financial and institutional ones. An increase in the CO_2 tax and the feed-in tariffs is foreseen and the eligibility of individual technologies for remuneration will be increased. The government is currently working on combining long-term policy goals with programmes and policy milestones that keep pace with each NPP shut-down.

In the absence of nuclear power, maintaining sufficient electricity capacity will require strong policies to promote energy efficiency and renewable energy. Such measures have already been outlined, but they will likely not be enough. New baseload capacity and imports are options on the supply side. For baseload generation, gas-fired power plants would be the simplest option. Treating their CO_2 emissions the same way as in the neighbouring countries, *i.e.* as part of an emissions trading scheme, would give a strong positive incentive for investors.

Changing the energy system in the decades to come will also require efforts in energy technology research, development and demonstration. The government should maintain plans to double public funding for these activities, with an emphasis on development and demonstration, for example systems management and efficiency of electricity networks.

ELECTRICITY MARKET REFORM

Since the last IEA in-depth energy policy review in 2007, Switzerland has made clear progress in electricity market reform. The Electricity Supply Law, in force since 2008, initiated the first stage of electricity market liberalisation. End-users with an annual consumption of more than 100 megawatt-hours (MWh) are free to choose their supplier. Subject to a possible referendum, market opening would be extended to all customers by 2015. This would be a positive step.

Commendably, Switzerland has also created an independent regulator (ElCom), with sufficient authority and resources. Non-discriminatory access to the grid is now ensured, and grid tariffs are fixed by the regulator. The ownership of transmission grid assets will be transferred to Swissgrid, the transmission system operator, by the end of 2012 which will create highest independency of the transmission network. Moreover, market transparency regarding final prices has been improved since ElCom publishes very detailed price information by canton and municipality.

Whatever the choice for replacing nuclear power, large investments in generating capacity will be needed. Major investments will also be needed in transmission (including cross-border) and distribution grids, even without the nuclear phase-out, because of ageing infrastructures, increasing cross-border flows and load from new hydro facilities. The procedures for permitting new generating capacity, including storage, and for new power lines, should be simplified and shortened. As the electricity industry is capital-intensive, investors need clarity over the long term. This implies a need for stable political decisions and legislation.

CO_2 emissions from gas-fired power should be treated as much as possible as in the neighbouring countries where the power sector is within the EU Emissions Trading Scheme, ensuring no overall increase in European CO_2 emissions. The current domestic compensation obligation deters investments and therefore reduces the options for replacing nuclear power in a timely manner, which in turn potentially weakens security of electricity supply over time.

To encourage more investments in generating capacity, the regulatory framework of the retail and wholesale markets should be reconsidered. As end-user prices are regulated close to generating cost and below spot market prices, consumption is subsidised and incentives for investing in generating capacity are reduced. It is no wonder that very few customers have switched from regulated tariffs to market contracts.

Furthermore, the wholesale market price should be able to drive investment decisions. To play this role, the wholesale market must be sufficiently transparent and liquid. Further cross-border integration, based on efficient cross-border capacity management and market coupling with implicit auctions of cross-border capacity, should be continued and accelerated. Generation transparency should be improved, with the publication of comprehensive data related to capacity availability and utilisation.

As a result of Switzerland's geographical location in Europe, the country has significant cross-border electricity flows and its reservoir and pump-storage hydropower plants could represent a battery for the wider region. The country should continue to pursue more effective regional integration to developing its electricity infrastructure, to its own benefit and to that of its neighbours. The efforts to join the Central-West Europe market coupling are very welcome, as that would allow for the optimisation of the allocation process for cross-border capacity and closer market integration in Europe.

The combination of regulated low end-user prices and integrating regional electricity markets could pose a potential concern for Switzerland's security of electricity supply, but it could also be turned into an opportunity for the country. As the domestic retail electricity prices are distorted, as in many countries, power exports may be preferred at the expense of serving domestic consumers. With increasing cross-border market integration, this may over time lead to domestic supply shortages and other reliability issues. If domestic end-user prices better reflected regional wholesale prices, such concerns would be reduced. On average, electricity would cost more for end-users, but in order to increase the acceptability of higher prices, particularly for energy-intensive, trade-exposed enterprises, Switzerland could introduce measures to buffer their impact.

Switzerland could thus benefit more from its hydropower capacity for exports and at the same time encourage efficiency improvements in both electricity generation and use. Cost-reflective pricing would also enable to create clear incentives for efficient, timely and innovative investment, as well as operational and end-use responses. Moving to such a system could be gradual, starting with the eligible customers.

ENERGY RELATIONS WITH THE EUROPEAN UNION

Switzerland has been negotiating an agreement on electricity with the European Union in order to ensure full compatibility between Swiss and EU market rules. This makes sense, given Switzerland's strong integration in the European electricity market. The IEA welcomes efforts to bring these negotiations to a successful close.

The Energy Strategy 2050 implies an even closer integration with the European Union, as cross-border electricity flows will increase and heavier reliance on gas imports is likely. Ambitious efficiency policies are more effective, if closely aligned with those of the European Union. In this context, it makes sense for Switzerland to envisage future negotiations on other energy issues, such as natural gas, energy infrastructures and efficiency.

DECARBONISING HEATING AND TRANSPORT

Switzerland has set a national target to reduce GHG emissions by 20% from 1990 to 2020. Because the country's energy-related CO_2 emissions come mostly from oil use in transport and space heating, action is most needed in these areas. Commendably, the country is making polluters pay by using a CO_2 tax for financing decarbonisation efforts in space heating and process heat. Stronger efforts will be needed to reduce emissions from road transport, however.

Now that the 2020 target has been set, the government needs to introduce new and/or strengthened policies and measures without delay. It should also thoroughly examine the implications of a strictly domestic 20% reduction target and ensure more even marginal abatement costs across sectors.

Turning to end-use sectors, road transport is the largest CO_2 emitter in the country and has the most potential for further cost-effective emissions reductions. The fleet-wide CO_2 limits for new passenger cars will take full effect in 2015 which is an important initiative. As an incentive measure, the government should also consider raising transport fuel taxes, possibly in a revenue-neutral manner.

The government has for years worked on improving the public transport system, already of a very high standard. Efforts to shift freight traffic from road to rail have also been successful, but potential for further improvements still remains. Switzerland's distance-related heavy vehicle fee has been copied in several other countries.

Emissions in the buildings sector are also high, owing to a large share (more than 50%) of oil in heating. Replacing oil heating by heat pumps or renewable energy sources, for example, makes sense for both CO_2 reduction purposes and as a means to shielding heating costs from changes in international oil price developments. Here, the building refurbishment programme is a very useful tool. The IEA welcomes the plans to accelerate the programme and increase its budget. Incentives for energy-saving renovations in rented dwellings have been improved and could be raised further, a crucial matter in a country with a high share of tenants.

Since the 2007 in-depth review, the cantons have adopted more stringent and harmonised standards for energy efficiency in new buildings, reaching the levels of the voluntary Minergie labelling system. This work to gradually increase stringency deserves credit and should continue.

The government should allocate sectoral emissions reduction targets evenly to limit differences in abatement costs across sectors. The CO_2 Law's main instrument is the CO_2 tax. It is a rational approach and the tax has already helped reduce oil use for space heating and in industry processes.

Switzerland has a tradition of light-handed regulation and gives priority to "effective and voluntary" private-sector measures. "Effective and voluntary" measures are those like

the CO_2 tax scheme, where market players are exempted from the tax if "voluntarily" fulfilling pre-agreed targets. Many past purely voluntary schemes, *e.g.* car fleet efficiency or appliances, have proved ineffective and have been replaced by minimum efficiency performance standards. As the need to reduce CO_2 emissions is becoming more urgent, price-based instruments may have to be more extensively used. A broader use and higher rates of CO_2 taxes would encourage investments in new technologies and innovation.

PUBLIC AWARENESS

Several aspects of Switzerland's energy policy suggest a likelihood of higher energy prices: CO_2 emission reductions, nuclear phase-out, even if a gradual one, investments in electricity grids and capacity and convergence with price levels in surrounding countries. Higher prices have often also proved to be a useful instrument for meeting energy and climate policy goals. On the other hand, electricity market opening and energy efficiency measures may help reduce this pressure on prices. The IEA encourages the government to continue informing the general public on energy policy issues to increase understanding of the reasons for possible price rises, particularly important in a country with a strong direct democracy.

OIL AND GAS SECURITY

Oil and gas supply continues to be secure. Oil supply is well diversified, both by country of origin and import route. Natural gas is also supplied by several countries through various routes. As a landlocked country with no domestic production of fossil fuels, Switzerland consistently holds emergency stocks much in excess of those required by the IEA. Oil stocks are also part of gas security. As Switzerland does not possess large-scale gas storage, dual-fired users are obliged to hold large stocks of fuel oil. Switzerland's oil and gas security policy is fundamentally sound.

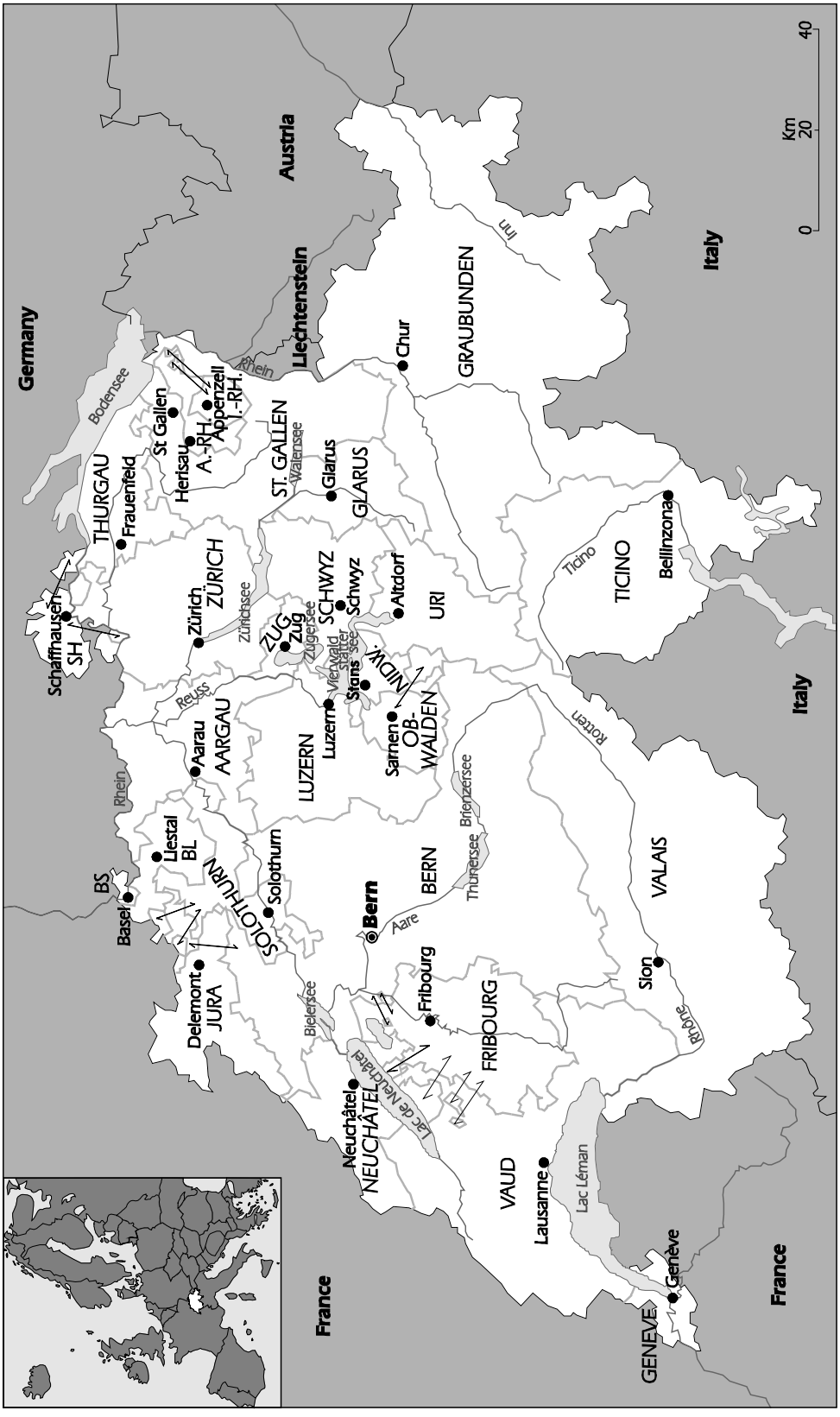
KEY RECOMMENDATIONS

The government of Switzerland should:

- ☐ *Develop the legal and regulatory framework regarding the Energy Strategy 2050 to provide stable long-term conditions for energy market participants.*
- ☐ *Adopt a detailed strategy for reducing domestic CO_2 emissions in a cost-effective way.*
- ☐ *Work to improve incentives for investment in electricity grids and generating capacity, including by deregulating end-user prices, shortening and simplifying licensing procedures, and encouraging closer cross-border market integration.*
- ☐ *Pursue closer integration with European energy markets and closest possible alignment of its energy policies with those of the European Union.*

PART I
POLICY ANALYSIS

Figure 1. **Map of Switzerland**



2. GENERAL ENERGY POLICY

Key data (2010)

TPES: 26.2 Mtoe (oil 40%, nuclear 26%, hydro 12%, natural gas 12%, biofuels and waste 9%, other 1%) +4.8% since 2000

TPES per capita: 3.4 toe (IEA average: 4.7 toe)

TPES per GDP: 0.09 toe per 1 000 USD GDP (IEA average: 0.15 toe per 1 000 USD GDP)

Electricity generation: 66 TWh (hydro 55%, nuclear 40%, biofuels[1] and waste 4%, natural gas 2%)

Electricity generation per capita: 8.8 MWh (IEA average: 9.5 MWh)

Inland energy production: 12.6 Mtoe, 48% of TPES

COUNTRY OVERVIEW

The Swiss Confederation (hereafter Switzerland) is located in the centre of Europe, and borders on Germany, France, Italy, Austria and Liechtenstein. It has a surface area of 41 285 km^2 (square kilometres), of which two-thirds is mountainous terrain. Switzerland has a population of 7.8 million. Its valleys and lowlands are densely populated. The country has three official languages; German is the mother tongue for 64% of the population, French for 20% and Italian for 7%.

Independent since 1291, Switzerland has stayed out of wars during the past two centuries and has built up a reputation for prosperity and economic stability. Per-capita gross domestic product (GDP) (around USD 43 400 at purchasing power parity in 2011) is higher than in the big European economies, and unemployment has remained at less than half the European Union (EU) average. The economy is dominated by services (71% of GDP in 2011). Industry (28% of GDP) is concentrated, among others, on pharmaceuticals and customised engineering products, such as machines, precision instruments and watches. Owing to a lack of mineral resources, heavy industry is scarce. Agriculture accounts for only 1% of GDP. Following the international financial crisis, annual GDP growth amounted to -1.9% in 2009, 2.7% in 2010 and around 2% in 2011.

Switzerland comprises 26 largely autonomous cantons, including six half-cantons, each with a constitution and an assembly. All policies not explicitly assigned to the federal level are the responsibility of the cantons. At the federal level, the country has a bicameral parliament (Federal Assembly). It consists of the Council of States (46 seats; two representatives from each canton and one from each half-canton) and the National Council (200 seats; members are elected by popular vote on the basis of proportional representation).

1. Biofuels and waste = solid and liquid biofuels, biogases, industrial waste and municipal waste.

Switzerland has a strong tradition of direct democracy. Popular votes are common at national, cantonal and municipal levels. The Federal Constitution requires constitutional changes, accession to supranational organisations or international security treaties to be submitted for public consultation. Furthermore, popular votes can be held on all binding decisions, including laws, taken by the parliament. Thus, the federal government pays particular attention to holding wide and open consultations with the cantons and the relevant interest groups before submitting a bill to parliament.

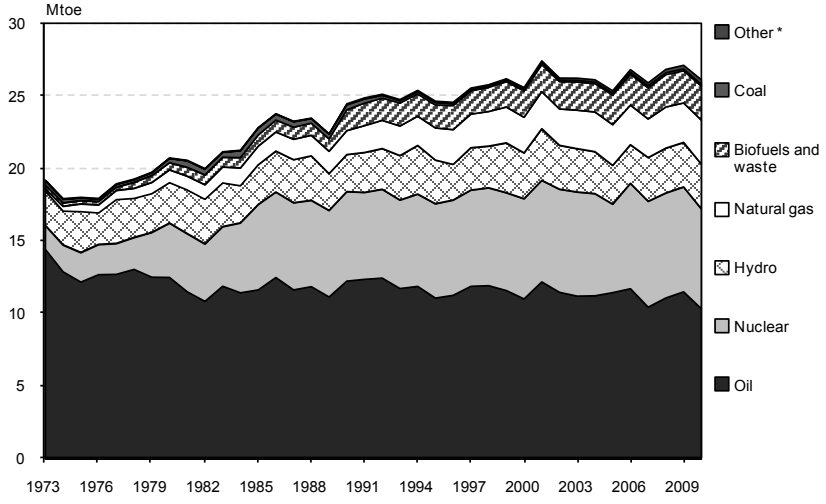
Also typical to Switzerland is the tradition for light-handed regulation. In drafting laws, the federal government and the cantons are obliged to follow the subsidiarity principle, which gives priority to private-sector measures over government intervention.

SUPPLY AND DEMAND

SUPPLY

In 2010, Switzerland's total primary energy supply (TPES) was 26.2 million tonnes of oil equivalent (Mtoe), reflecting an increase of 0.5% per year over the last decade (Figure 2). Economic growth averaged 1.7% per year over the period.

Figure 2. **Total primary energy supply, 1973 to 2010**



* Negligible.

Sources: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011 and country submission.

Fossil fuels accounted for 53% (13.5 Mtoe) of TPES in 2010. Switzerland ranks third-lowest among IEA countries in the level of fossil fuels in the energy mix: IEA average share of fossil fuel in TPES is 80%. Switzerland has a significant share of oil in TPES at 40%, but very low shares of natural gas (12%) and coal[2] (less than 1%) compared to IEA averages of oil (35%), gas (25%) and coal (20%). Nuclear also makes a large contribution

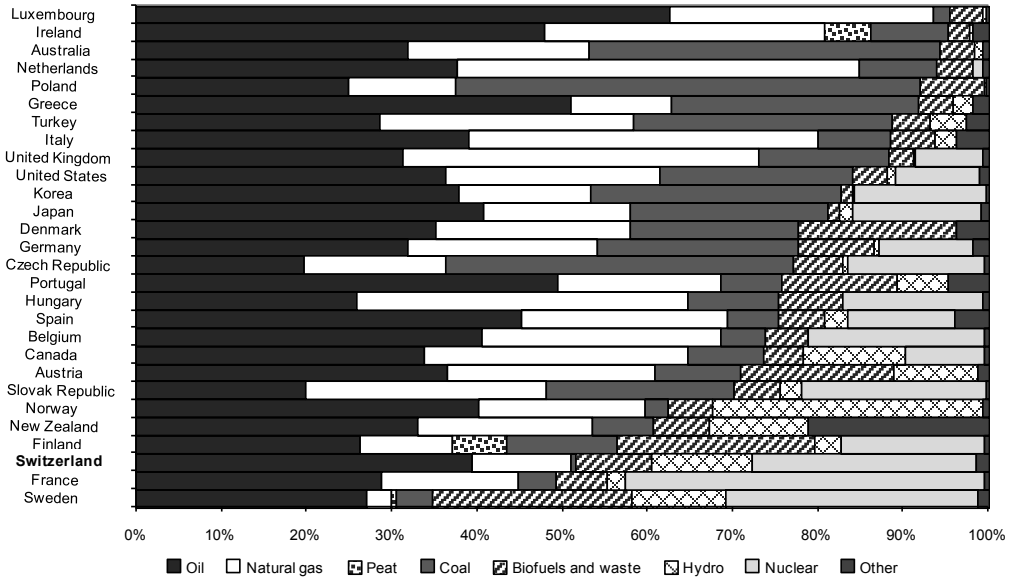
2. This report does not include a specific chapter on coal, because of coal's minor importance in Switzerland. In 2010, coal consumption was 0.15 Mtoe, corresponding to 0.6% of TPES. This is the lowest share among the IEA member countries. All coal is imported and practically all of it is used in the cement industry. Consumption is not expected to increase in the future.

to Switzerland's energy mix; 26% of TPES in 2010, the third-largest share among IEA countries after France and Sweden. Renewable energy sources accounted for 22% (5.8 Mtoe) of TPES in 2010, mainly hydro (12% of TPES) and biofuels (9%). Other renewable sources, such as solar and wind, have a much smaller share.

Over the last decade energy supply from the three largest energy sources, oil, nuclear and hydro, has been relatively constant. Most of the growth in energy supply was from increases in natural gas, biomass and waste, and geothermal (heat pumps) (Figure 2).

Switzerland does not produce any fossil fuels; therefore its inland energy production is limited to nuclear and renewables. In 2010, the country's self sufficiency, measured as the share of domestic energy production in TPES, was 48%. This share places Switzerland in the average of IEA countries, similar to Finland and France.

Figure 3. **Total primary energy supply in IEA countries by source, 2010**



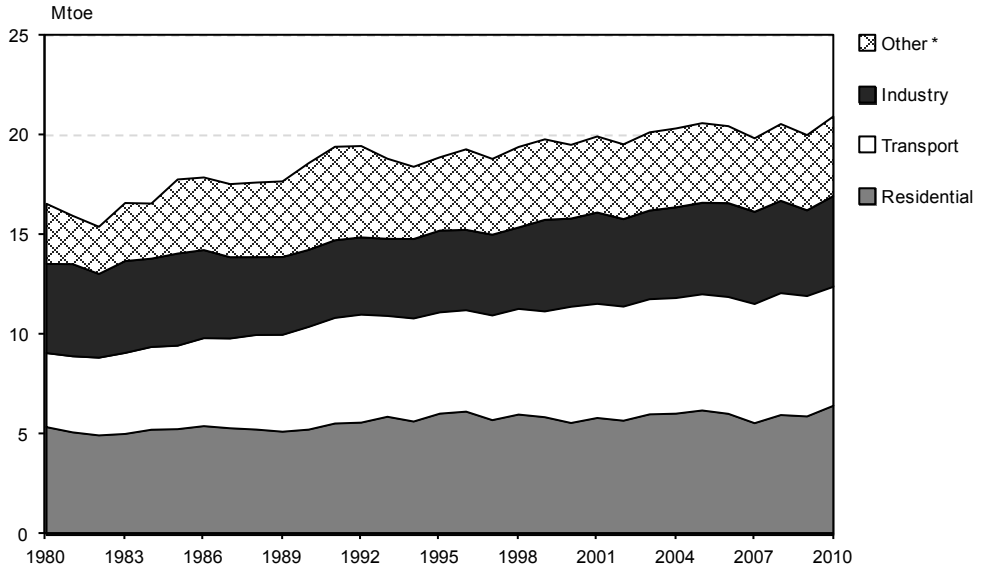
***"*Other* includes geothermal, solar, wind and ambient heat production.

Source: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011.

DEMAND

Total final energy consumption (TFC) was 21 Mtoe in 2010 (Figure 4). The residential sector is the largest consumer, accounting for 31% of TFC (6.5 Mtoe). Transport consumed 29%, industry 21% and the commercial sector 19%. Final energy consumption in the residential sector is higher than the IEA average of 20% and lower in industry with an IEA average of 32%. Final energy consumption has increased by 7.5% since 2000, following a similar pace over several decades. More than four-fifths of the increase in TFC over the last decade is attributable to the residential-commercial sector and some 15% to the transport sector. TFC in industry remained almost stable. In its projections for 2020, the government expects energy demand to decrease slowly by a few percent.

Figure 4. **Total final consumption by sector, 1980 to 2010**



* Other includes commercial, public, service, agricultural, fishing and other non-specified sectors.

Sources: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011 and country submission.

INSTITUTIONS

Energy policy is a split responsibility between the federal state and the twenty-six cantons. Federal energy policy making has been strengthened in recent years (in matters such as standards and labels), chiefly by means of the 1998 Energy Law and its subsequent amendments. In other domains such as buildings, cantons have clung to their prerogatives and consented to harmonised regulations and standards.

The **Department of the Environment, Transport, Energy and Communications** (DETEC) is the lead ministry in charge of Switzerland's energy policy, in both its formulation and implementation. The harbouring of the energy and environmental portfolios under a single ministry is intended to strengthen sustainability concerns in energy policy making. Within DETEC, the **Swiss Federal Office of Energy** (SFOE) is responsible for the day-to-day managing of energy policy.

The **Federal Council** (federal government) is a collective executive body. It comprises representatives from five political parties representing some 85% of the electorate. The six Departments (ministries) other than DETEC are closely consulted, particularly if an energy policy proposal impacts their remit: this is mostly the case for the Department of Economic Affairs, the Department of Finance (for fiscal issues), the Federal Office of the Environment (FOEN), the Federal Office for Transport and the Federal Office for Spatial Development (the latter three under DETEC), the Federal Office for Agriculture (for biofuels), etc. Draft laws are therefore adopted collectively by the Federal Council before being submitted to parliament.

Cantons are consulted during federal energy policy and law making processes. They have much leeway to adopt their own energy laws, policies and measures, within the bounds set by federal legislation. As a result, there is a diversity of cantonal policies and measures.

More information about key institutions in individual sectors of energy policy can be found in the sectoral chapters in Part II of this report.

KEY POLICIES

Switzerland's energy policy is guided by Article 89 of the Federal Constitution, which calls for sufficient, reliable, diversified, cost-effective and environmentally sound energy supply, and emphasises the importance of energy efficiency.

NUCLEAR PHASE-OUT

In the aftermath of the accident at the Fukushima Daiichi nuclear power plant (NPP), the Federal Council – Switzerland's federal government – decided to suspend the authorisation procedure for three new NPPs and to decommission the existing NPPs at the end of their life time as well as to redefine the Swiss energy policy. The government took this decision on the grounds of a most probable negative outcome of the planned referendum on new NPPs. Under the 2005 Nuclear Power Law, any new NPP permit had to be granted by parliament; in Switzerland, any parliamentary decision or law may be challenged by referendum. Nuclear opponents had already announced that they would launch such referendums. According to the pre-Fukushima Daiichi permitting schedule for the three NPP applications, these referendums were expected in 2013/14.

This new energy policy has been approved by the Lower House of Parliament in June and by the Upper House in September 2011. The government has now elaborated an Energy Strategy 2050. A legislative package with measures in energy, fiscal, research and other related policies will be submitted for broad public consultation later in 2012 and to parliament in mid-2013. The package is expected to enter into force at the beginning of 2015. Progress in implementation is to be regularly monitored.

In order to ensure the security of supply, the government, as part of its new Energy Strategy 2050, is placing emphasis on increased energy savings (energy efficiency), the expansion of hydropower and new renewable energies, and, if necessary, on fossil fuel-based electricity production (mainly in gas-fired combined-cycle power plants for peak supply, but also combined heat and power production for baseload in winter) and imports. Furthermore, Switzerland's power grid should be expanded without delay and energy research strengthened.

ENERGY STRATEGY 2050

In order to cover the shortfall in the electricity supply caused by the decision not to replace the nuclear power plants, Switzerland's energy strategy has to be revised. The government has therefore set the following priorities:

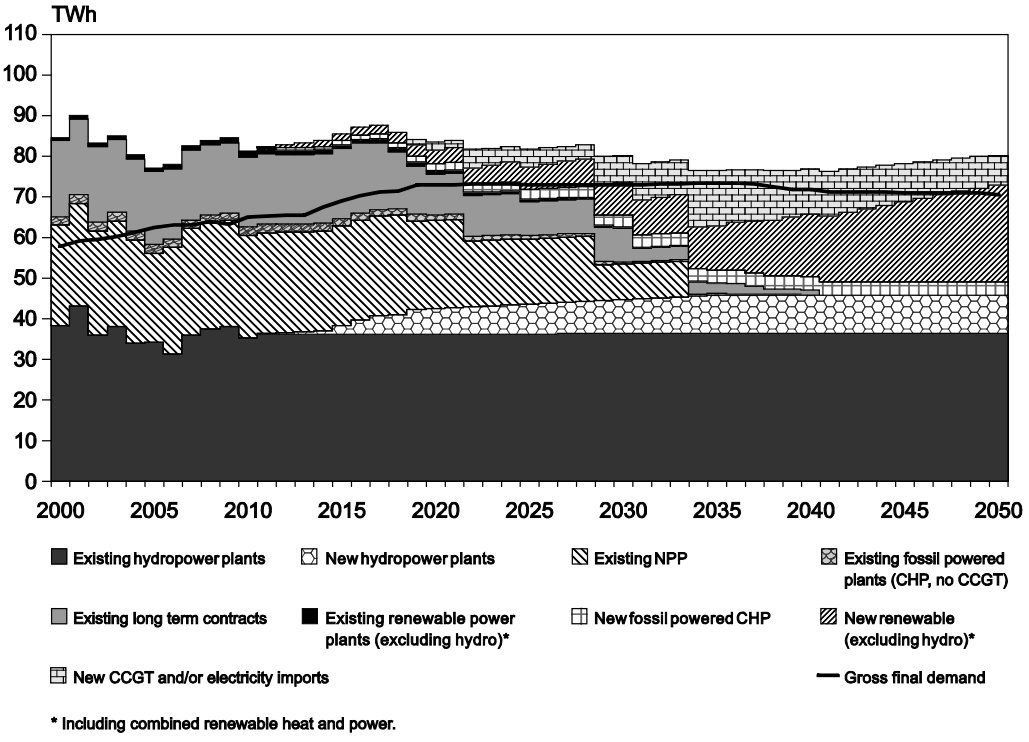
- **Reduction in energy consumption**. The new energy outlook shows that demand for electricity could rise to around 90 terawatt-hours (TWh) a year by 2050, if tighter measures are not taken (2010: around 60 TWh). The main reasons for this are population growth, increasing duplication of household appliances (for example a second TV), new appliances and applications, greater living space per person, the continued deployment of heat pumps, but also the increasing electrification of transport. Also, the expansion of pumped storage requires additional pumping energy. In order to stabilise electricity demand at some 75 TWh towards the end of the decade, the government intends to encourage the economical use of energy in general and of electricity in particular. Enhanced efficiency measures include minimum requirements for appliances (best practice, energy label) and other regulations, bonus-malus mechanisms (efficiency bonus), measures to raise public awareness (strengthening of SwissEnergy) and measures regarding the production of heat.

- **Broadening of electricity supply**. Hydropower and new renewable energies should be bolstered in particular. Their share in the current energy mix needs to be expanded significantly. That is the main aim of the cost-reflective feed-in tariff. However, in order to meet demand, fossil fuel-based electricity generation needs to be expanded, primarily by constructing gas-fired combined-cycle power plants intended to provide peak load, but also combined heat and power plants for baseload in winter. The government is retaining its climate policy objectives. The increasing share of irregular power production (wind, solar) requires a restructuring of the pool of power plants to ensure the necessary storage and reserve capacities. Furthermore, the conflict of interests between efforts to mitigate climate change, protect the waterways and the countryside and spatial planning has to be resolved constructively.
- **Maintaining electricity imports**. Imports will continue to be necessary to ensure security of supply and to cover temporary fluctuations. However, the government is of the opinion that Switzerland should continue to remain as independent as possible in terms of electricity production.
- **Expansion of electricity transmission grid**. The rapid expansion of the electricity transmission grid and the transformation of transmission networks into smart grids are absolutely essential for future domestic production infrastructures and electricity imports. These “intelligent” grids allow direct interaction between consumers, the network and power producers and offer great potential with regard to optimising the electricity system, delivering energy savings and consequently bringing down costs. Switzerland's power grid should be optimally integrated into the European grid and the future European “supergrid”.
- **Strengthening energy research**. The restructuring of the energy system needs to be supported by the strengthening of energy research. To that end, the energy research portfolio in the Federal Institute of Technology (ETH) domain and at the universities of applied sciences should be reviewed and cooperation between universities, business and centres of technological expertise encouraged. A plan of action on “Coordinated Energy Research Switzerland” with relevant roadmaps should be drawn up for efficiency enhancing technologies, power grids and the storage and distribution of electricity. The necessary federal funding for pilot schemes and demonstration facilities should also be provided. These efforts are to be coordinated with measures contained in the Cleantech Masterplan (see Chapter 8).
- **Confederation, cantons, cities and communes will lead by example**. They should meet their own electricity and heating needs through renewable sources of energy and apply the principle of 'best practice’ in all fields. The private sector should also play its part in taking measures to reduce commercial energy consumption and strengthen Switzerland's position as a location for business by coming up with innovative, energy-saving products. The energy industry should seize the opportunity to play an active part in reshaping the national energy system and make the necessary investments.
- **Beacon projects guide the way**. Pilot and demonstration projects developed by various industries and groups should provide valuable experience for Switzerland's future in terms of energy. The fields of Smart Buildings, Smart Cities, Smart Grids and district heating networks are key in achieving an optimisation of the energy system, and thus in contributing to a reduction in energy consumption, emissions and costs.
- **Encouraging international co-operation**. International co-operation in the field of energy should be further intensified. Efforts should be made to conclude an

agreement on electricity with the European Union by the end of 2012. In addition, contacts with neighbouring countries should be intensified. Furthermore, Switzerland actively participates in the efforts by the International Atomic Energy Agency (IAEA) to improve nuclear safety in the wake of the Fukushima Daiichi accident.

SFOE had commissioned scenario analysis of electricity generation by source to 2050. Preliminary results are shown in Figure 5. It is to be noted that while the population and the economy are expected to continue to grow, electricity demand is expected to stabilise around 2020 and to begin a slow decrease towards 2050.

Figure 5. **Electricity generation to 2050 by source in the Energy Strategy 2050**



Source: Prognos, 2012.

SECURITY OF SUPPLY

Oil supplies to Switzerland are well diversified, both by country of origin and by import route. Switzerland consistently holds more oil stocks than required under the IEA stockholding obligation. Natural gas is also supplied by several countries through various routes, although most gas flows through Germany. Security of gas supply is further enhanced given that more than 40% of the contract volume is interruptible. In addition, the gas industry is obliged to maintain compulsory stocks of heating oil to cover at least four-and-a-half months of gas consumption of industrial customers with dual-fired capacity.

Security of electricity supply has repercussions beyond Switzerland's borders, given the country's role in electricity trade and transit in Europe. Reforming the electricity market and establishing a regulator and a transmission system operator (TSO) have improved electricity security. Large investments to upgrade ageing electricity networks will be needed, regardless of the decision to phase out nuclear power.

CLIMATE POLICY

The Swiss commitment to meeting the Kyoto target is to reduce GHG emissions by 8% below the 1990 level by 2008 to 2012. The country has also set itself a national target to reduce GHG emissions by 20% from 1990 to 2020.

Since 1990, emissions have remained flat, which makes meeting the 2020 target challenging. The government plans to meet this target largely through supporting building refurbishments to move away from oil in space heating. Funding for these measures comes partly through the CO_2 tax on heating and process fuels, introduced in 2008. Measures in the transport sector include a CO_2 limit for new passenger cars and an obligation for fuel importers to partly offset the emissions from the transport sector.

MARKET REFORM

Electricity market reform has been significantly advanced under the 2008 Electricity Supply Law. The law contains necessary elements for effective market liberalisation: an independent regulator, an independent system operator, regulated third-party grid access, and freedom to choose the supplier. The market has been opened to consumers of more than 100 MWh per year, corresponding to roughly half of total demand in the country. Because of low regulated end-user prices, few customers have switched supplier. Customers who had switched to market contracts before the enactment of the 2008 Electricity Supply Law, can return to the regulated prices. This is likely to reduce incentives for investing in electricity infrastructure. Full market opening has been set for 2015, but is subject to a possible referendum. Electricity market reform includes a planned revision of the Electricity Supply Law by 2015. Closely related to market reform is a bilateral agreement with the European Union on electricity, which is being negotiated since 2007.

Table 1. **Energy taxes and levies in Switzerland, 2011**

Energy source	Levies				
	VAT for households	Excise tax, CHF/litre	Compulsory stockpiling levy, CHF/litre	CO_2 tax CHF/t CO_2 (level since 2010)	Levy for financing the feed-in tariff and system services, CHF/kWh
Light fuel oil	8%	0.003	0.0042	36	
Diesel	8%	0.759	0.0042		
Gasoline	8%	0.731	0.0042		
Natural gas for transport use	8%	0.48	0.0146 CH/kWh		
Natural gas for stationary use	8%	0.0009	0.0146 CH/kWh	36	
Coal	8%	-	-	36	
Electricity	8%	-	-		Levy for financing the feed-in tariff: CHF 0.45 cents, CHF 0.9 cents from 2013. System services: CHF 0.45 cents. Partial exemption for energy intensive industry
Hydropower	"Water royalty" of CHF 0.012/kWh (countrywide average)				

Source: Swiss Federal Office of Energy.

Box 1. **The SwissEnergy programme**

A major policy instrument for increasing energy efficiency and the use of renewable energy is the SwissEnergy programme. Running initially from 2001 to 2010, the programme has been extended to 2020. It aims to reduce fossil fuel use and CO_2 emissions as required by the CO_2 Law and it also has targets for electricity generation and heat production from renewable sources.

The programme is also to promote specific efforts aimed at achieving the goal of a "2 000 watt society", and thus to make a significant contribution towards the following national energy and climate policy objectives by 2020:

- Reduction of end-energy consumption by enhancing energy efficiency.
- Reduction of CO_2 emissions and the consumption of fossil energy by at least 20% by 2020 versus the 1990 levels.
- Increase in the proportion of renewable energy in overall energy consumption by at least 50% from 2010 to 2020. The increase in electricity demand is to be met through renewable energy to the greatest possible extent.

In the last few years, several tasks formerly vested with SwissEnergy have become a legal obligation: promotion of renewables has shifted from a programme-type activity supplementing a modest and inadequate feed-in tariff to a comprehensive feed-in system, whose enforcement and continuity is guaranteed by law. Many minimum efficiency performance standards, previously introduced in the form of voluntary agreements (cars, some appliances), codes of conduct (some energy-using products) are now legally mandated (and by and large aligned with those of the European Union). Hence, the role of SwissEnergy is shifting towards that of a facilitator for the above-mentioned regulations and laws.

SwissEnergy is managed by the Swiss Federal Office of Energy (SFOE). It includes a wide array of projects, most of them voluntary. The projects are normally run in close co-operation between SFOE, cantons, municipalities, industry and environmental and consumer associations. Programme results are subject to detailed monitoring and verification. To bolster the implementation of the Energy Strategy 2050, SwissEnergy's funding is due to increase from CHF 26 million in 2012 to CHF 55 million in 2015. Additional funding is to be sourced from third parties (trade and industry, cantons and municipalities). The share of third-party funding is expected to gradually increase.

The intention is that projects supported by SwissEnergy should be able to become established on the market over the long term, and this goal is to be achieved with the aid of targeted project management, the limitation of the timeframe for the funding of each project, and where possible the specification of reduction paths.

The gas market remains essentially unreformed as at the time of the previous IEA review of Switzerland's energy policy (in 2007). The gas industry has voluntarily moved to improve conditions for competition. Rules for third-party access (TPA) to the grid exist and are currently being enhanced. The sector continues to be characterised by strong vertical integration and supply is dominated by long-term contracts. The government will closely monitor the industry's self-regulation and consider further reform if self-regulation proves ineffective and inadequate in the face of other developments, including international ones.

CRITIQUE

Since the 2007 IEA in-depth review of Switzerland, there have been several significant global events and developments affecting the three pillars of energy policy: security of supply, economic growth and environmental sustainability, and with implications for Switzerland. These events and developments include:

- The most severe global economic crisis in decades, initiated in 2008, and still not entirely overcome in the first half of 2012. Switzerland has been less affected by the economic crisis than other OECD economies. In late 2008, it adopted a relatively modest stimulus package, which included measures targeted on the energy sector. With the onset of the Euro crisis, the strength of the Swiss franc vs. the euro has become a major challenge for the Swiss economy.
- The accident at the Fukushima Daiichi nuclear power plant in March 2011 had a far-reaching impact on energy policy in Switzerland: in May 2011 the Federal Council, followed by parliament in the course of the summer, decided to gradually phase out nuclear power at the end of the current plants' lifetime, expected between 2019 and 2034, and to redefine the country's energy policy.
- The political turmoil in North Africa and the Middle East: in 2008 already, Switzerland was directly impacted when, because of a diplomatic incident, the Qaddafi regime retaliated against Switzerland by drastically cutting oil supplies; these were largely replaced by supplies from other sources.

Since nuclear energy covers 40% of Switzerland's electricity production, the decision to gradually phase it out has significant implications for the country's energy situation. The decision to do so gradually as the plants reach the end of their operating life will inevitably limit the economic consequences, as well as allow time to initiate replacement energy supply. However, no easy solutions are available, and decisions must be taken after considering all options. Long-term policy goals should be combined with programmes and policy milestones that keep pace with each NPP shut-down**.**

A package of renewable energy, improved efficiency, new gas-fired capacity, import of electricity and reduced oil consumption in the heating sector could, however, provide most of the solutions. Such a package would require a range of new incentives, including financial as well as institutional ones.

In addition to how to replace nuclear power, the government needs to clarify a number of other topics, including:

- post-2012 national climate targets and the role of gas-fired power;
- the feasibly exploitable potential of renewable energy, and the level and structure of green electricity supports;
- ensuring sufficient grid investments; and
- the need for financial mechanisms to address uncertainty in the energy policy.

Investor certainty should be improved by detailed road mapping towards targets, and policies and measures both to reduce GHG emissions and to fill the electricity supply gap resulting from the phase-out of nuclear power.

In working to meet its energy security and climate policy targets, Switzerland can resort to its potential for more renewable energy and higher energy efficiency. The country is well endowed to exploit this potential, through strengthening existing policies and measures and introducing new ones.

Switzerland has a long tradition of using revenue-neutral taxation to steer demand and should use it more to increase energy efficiency. However, with partial earmarking of CO_2 tax revenues for the building refurbishment programme as from 2010, Switzerland has recognised that some investment help is needed at times to complement demand steering through price signals. Switzerland has a tradition of light-handed regulation and gives priority to "effective and voluntary" private-sector measures. "Effective and voluntary" measures are those like the CO_2 tax scheme, whereby market players are exempted from the tax, if they "voluntarily" fulfil pre-agreed targets. Many past purely voluntary schemes, *e.g.* car fleet efficiency or appliances, have proved ineffective and been replaced by minimum efficiency performance standards. As the need to reduce CO_2 emissions is becoming more urgent, price-based instruments may have to be used more broadly. A broader use and higher rates of CO_2 taxes would encourage investments in new technologies and innovation.

Several aspects of Switzerland's energy policy suggest the need for, and may result in, higher energy prices: CO_2 emissions reductions, nuclear phase-out – even if gradual – investments in electricity grids and capacity, and convergence with price levels in surrounding countries. On the other hand, market opening in electricity and energy efficiency measures may help reduce this pressure on prices. The government is encouraged to continue informing the general public on energy policy issues so as to increase understanding of the reasons for possible price rises, particularly important for a country with a strong direct democracy.

Switzerland's geographical location means that its hydropower plants could represent a battery for the region. The electricity sector should be seen and developed more from a regional perspective, not least because of uncertainty over future power supply. Finalisation of a treaty on electricity with the EU would potentially benefit Switzerland, as would linking to the EU Emissions Trading Scheme. Further research and development would underpin the goals of the Swiss government, particularly in managing energy systems.

RECOMMENDATIONS

The government of Switzerland should:

- ☐ *Develop a road map containing different scenarios to deal with the consequences of nuclear phase-out, taking into account the cost to the Swiss economy, energy security and environmental implications, and including all technologically and economically feasible options.*
- ☐ *In working out the new Energy Strategy 2050, consider a package of new gas-fired capacity, renewable energy, improved efficiency, imports of electricity and reduced oil consumption in the heating and transport sector.*

- ☐ *Address, as a matter of urgency, uncertainty over:*
  - *post-2012 national climate targets and the role of gas-fired power;*
  - *the feasibly exploitable potential of renewable energy, and the level and structure of green electricity supports to achieve this;*
  - *adequacy of transmission and distribution grid investments.*
- ☐ *Examine financial mechanisms to address uncertainty in the energy policy.*
- ☐ *Consider increasing end-user energy prices, in a revenue-neutral way, to better support the goals of new energy policy.*
- ☐ *Enhance public awareness of the benefits and challenges of different energy sources in view of the need for energy security, CO_2 reductions and economic efficiency.*
- ☐ *Work to agree with the European Union on closer co-operation and integration in energy and climate policies.*

3. CLIMATE CHANGE AND ENERGY EFFICIENCY

Key data (2010)

Total GHG emissions[3]**:** 54 Mt CO_2-eq (+2.2% from base-year)

Target for 2008-12: -8% from 1990 level

CO_2 emissions from fuel combustion: 43.8 Mt (+5.9% from 1990)

CO_2 emissions by fuel: oil 75%, gas 16%, coal 1%, other 8%

CO_2 emissions by sector: transport 39%, households 26%, industry 13%, services and agriculture 13%, electricity and heat generation 6%, other 2%

Total final consumption (TFC): 21 Mtoe (oil 52%, electricity 24%, natural gas 13%, biofuels and waste 6%, heat 2%. other 2%) +7.5% since 2000

TFC by sector: residential 31%, transport 29%, industry 21%, commercial 19% (IEA average in 2009: residential 20%, transport 32%, industry 32%, commercial 16%)

CLIMATE CHANGE OVERVIEW

As a signatory to the Kyoto Protocol, Switzerland has committed to reducing its GHG emissions by 8% from 1990 to 2008-12. Since 1990, emissions have remained relatively unchanged. Beyond 2012, Switzerland has a target of reducing GHG emissions by 20% from 1990 to 2020.

According to Switzerland's 2012 national inventory report to the United Nations Framework Convention on Climate Change (UNFCCC), total GHG emissions in 2010, excluding land use, land-use change and forestry (LULUCF), amounted to 54.2 million tonnes of CO_2-equivalent (Mt CO_2-eq), which is 2.2% more than in the base year and 3.4% more than in 2009. In 2010, carbon dioxide (CO_2) accounted for 84.7% of GHGs, methane (CH_4) for 7.0%, nitrous oxide (N_2O) for 5.9% and the F-gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) for 2.4%.

CO_2 EMISSIONS FROM FUEL COMBUSTION

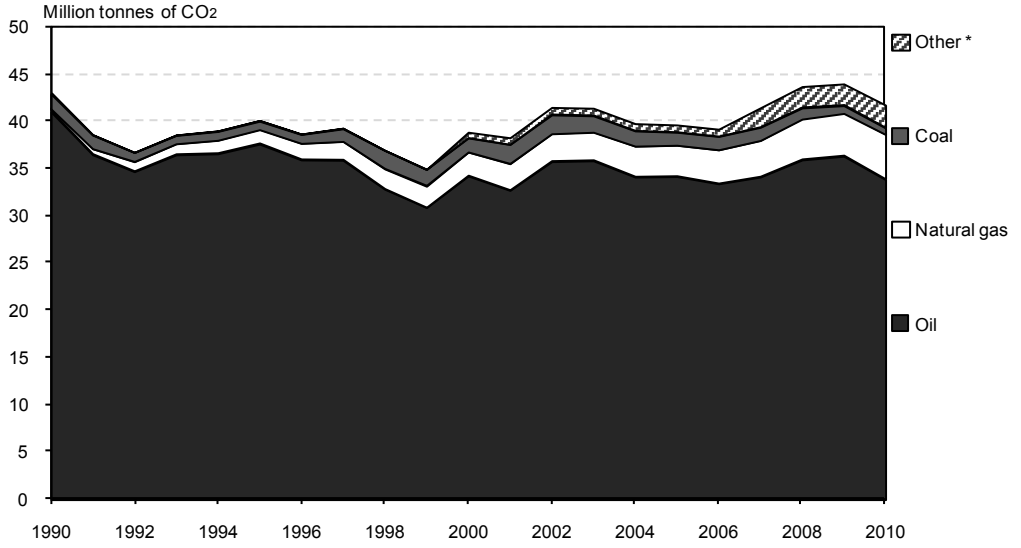
SOURCES OF CO_2 EMISSIONS

In Switzerland, fuel combustion was responsible for 81% of all GHG emissions in 2009 and carbon dioxide (CO_2) emissions from fuel combustion were 42.4 million tonnes (Mt). CO_2 emissions increased by 3% to 43.8 Mt in 2010. Since 1990, CO_2 emissions from fuel combustion have increased by 5.9%.[4]

3. Excluding land use, land-use change and forestry.

4. The analysis in this section is based on estimates done by the IEA by using the Intergovernmental Panel on Climate Change's default methods and emission factors.

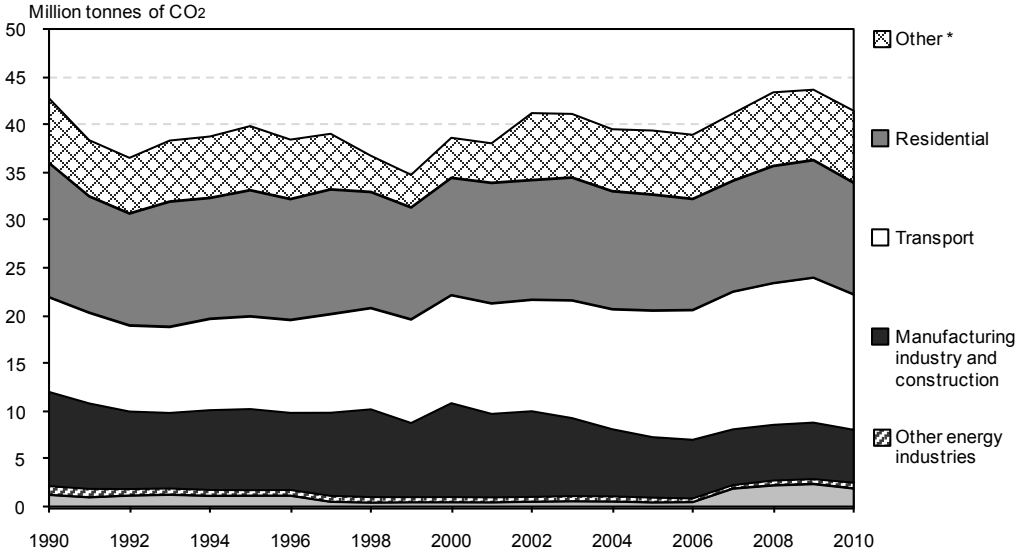
Figure 6. **CO_2 emissions by fuel, 1990 to 2010**



* *Other* includes industrial waste and non-renewable municipal waste (negligible).

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD, Paris, 2011.

Figure 7. **CO_2 emissions by sector, 1990 to 2010**



* *Other* includes emissions from commercial and public services, agriculture/forestry and fishing.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD, Paris, 2011.

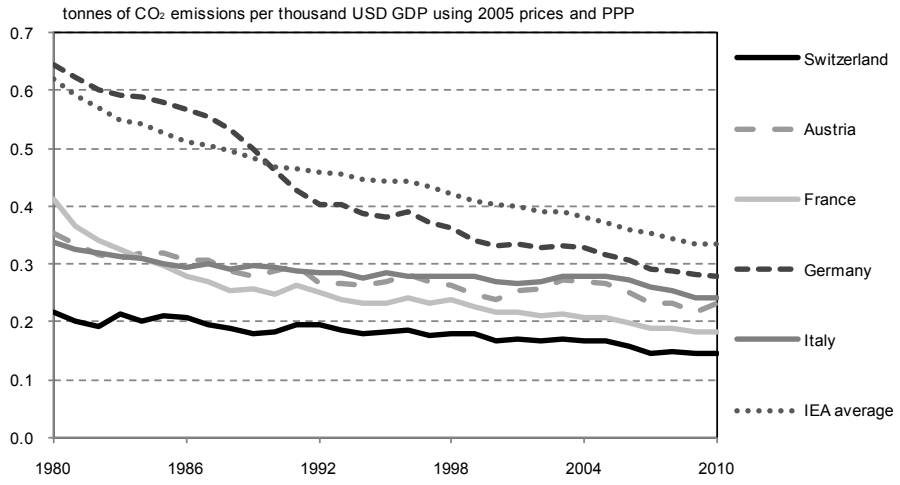
Oil is by far the dominant source of CO_2 emissions, accounting for 75% of the total in 2010 (see Figure 6). Since 1990, CO_2 emissions from oil have declined by 4%, while emissions from natural gas have increased from 3.8 Mt to 7 Mt, an 86% increase. In 2010, they accounted for 16% total emissions. CO_2 emissions from coal are low and stable, accounting for 1% in 2010. The remaining 8% of energy-related CO_2 emissions originated from burning waste from non-renewable sources.

Transport, the largest emitter of energy-related CO_2 emissions in Switzerland, accounted for 39% of emissions in 2010 (see Figure 7). CO_2 emissions from the transport sector have increased by 18% since 1990. The residential sector accounted for 26% of CO_2 emissions in 2010, a decline of 11% from 1990. CO_2 emissions in the commercial sector are 18% lower than in 1990 and accounted for 13% of the total in 2010. The electricity and heat generation sector accounted for 6% of CO_2 emissions, an increase of 39% since 1990.

CARBON INTENSITY

Energy use in Switzerland produces the lowest CO_2 emissions per unit of GDP in IEA member countries, matched only by Sweden. At 0.15 tonnes of CO_2 per USD 1 000 of gross domestic product (GDP) on a purchasing power parity (PPP) basis, carbon intensity in Switzerland was 56% lower than the IEA average in 2010 (see Figure 8). Two main factors explain this. On the one hand, the Swiss economy is dominated by services, and within the manufacturing sector, process industries play only a minor role. On the other hand, the carbon intensity of energy supply is low, as renewable and nuclear energy have a high share in total primary energy supply (TPES). Switzerland had also one of the lowest CO_2 emissions per capita in the IEA member countries in 2010, amounting to 5.6 tonnes and 48% less than the IEA average of 10.8 tonnes.

Figure 8. **Energy-related CO_2 emissions per GDP in Switzerland and in other selected IEA countries, 1980 to 2010**



PPP = Purchasing power parity.

Sources: *Energy Balances of OECD Countries, IEA/OECD*, Paris, 2011; *National Accounts of OECD Countries*, OECD, Paris, 2011.

CLIMATE CHANGE POLICIES AND MEASURES

Switzerland's policy on abating CO_2 emissions from fuel use rests on the Law on the Reduction of CO_2 (CO_2 Law) which came into force in 2000. A revised law will enter into force at the beginning of 2013. The CO_2 law sets targets for reducing emissions by 2010. A variety of voluntary measures exists to meet these targets. The law mandates the introduction of a CO_2 tax, if voluntary measures prove insufficient. The main domestic measures are outlined below. The flexibility mechanisms under the Kyoto Protocol are used by the private sector to meet part of their emissions reductions.

At the federal level, climate change policy is the responsibility of the Federal Office for the Environment (FOEN), which is part of DETEC. Other government offices involved are those for energy, transport, agriculture, forestry, finance and foreign affairs. Cantons and interest groups participate in decision making through non-binding consultations on proposed laws, ordinances and strategies.

2000 LAW ON THE REDUCTION OF CO_2

The centrepiece of Swiss climate policy is the CO_2 Law that came into force in May 2000. The law limits CO_2 emissions from fossil fuel use for heating and transport to 10% below 1990 levels over the period 2008-12. The overall target is further divided into a reduction target of 15% on heating and process fuels and 8% on transport fuels. The primary instruments to reach the targets are:

- voluntary actions in various areas;
- subsidiary CO_2 tax on heating and process fuels as well as transport fuels, if voluntary actions fail to deliver sufficient results;
- measures in other policy areas that are relevant to climate change mitigation; and
- emissions trading (cap and trade) and complementary use of flexible mechanisms.

CO_2 LAW FROM 2013 TO 2020 AND TARGETS TO 2020

In December 2011, parliament adopted a revised CO_2 Law, covering the period until 2020. Although still named CO_2 Law, the revised law has a broader scope than the previous law as it covers all Kyoto GHGs. It sets a target to reduce GHG emissions by 20% by 2020 compared to 1990; reductions are to be achieved only domestically.

In absolute terms, the 20% reduction corresponds to 10.6 Mt CO_2-eq. Without new measures, emissions would decrease by 2.1 Mt CO_2-eq. The remaining 8.5 Mt CO_2-eq is expected to come as follows:

- **buildings**: about 4.9 Mt CO_2, from the CO_2 tax (2 Mt CO_2-eq) and the building refurbishment programme (2.9 Mt CO_2-eq);
- **transport**: about 2.9 Mt CO_2-eq, mainly from CO_2 intensity limits to new passenger cars (1.7 Mt CO_2-eq) and an offset obligation on fuel importers (expected to amount to 1.2 Mt CO_2-eq in 2020);
- **industry**: 0.5 Mt CO_2-eq, mainly from CO_2 targets and emissions trading; an additional 0.3 Mt CO_2-eq are to be covered by emissions certificates from abroad; and
- **other measures** (*e.g.* agriculture): 0.2 Mt CO_2-eq.

MEASURES AND INSTRUMENTS (2008 TO 2020)

CO_2 tax on heating and process fuels

The 2000 CO_2 Law gives priority to voluntary measures, but stipulates that the government will introduce a CO_2 tax on heating and process fuels if the voluntary measures are deemed insufficient to meet the targets. A mid-term review indicated that the targets were unlikely to be met. A tax on CO_2 emissions from stationary fuels came

into effect in 2008 at a rate of CHF 12 per tonne of CO_2. In 2010, given that Switzerland's emissions were not on track, the tax was increased to CHF 36 per tonne of CO_2. Initially, the tax was introduced on a revenue-neutral basis and redistributed to employers and the population. Since January 2010, however, a third of the annual revenue (at most CHF 200 million) is earmarked for the building refurbishment programme (see below).

According to the CO_2 Law, certain large consumers may be exempted from the CO_2 tax, if they make a formal and binding commitment to the government to limit their emissions. About 950 companies have made such a binding commitment and are thus exempt from the CO_2 tax. About 430 of these 950 companies take part in the Emissions Trading System (see below). Another 1 000 companies have voluntary reduction targets and are not exempt from the CO_2 tax.

The revised CO_2 Law stipulates that the CO_2 tax rate may be gradually increased to up to CHF 120 per tonne of CO_2 from CHF 36 per tonne of CO_2 today. The new law also contains the possibility to increase funding for the building refurbishment programme. As already under the 2000 CO_2 law, large emitters may be exempted from the CO_2 tax, if they make a formal and binding commitment to the government to limit their emissions. Most of these companies are participating in Switzerland's emission trading scheme.

As under the 2000 law, fossil-fired power plants are exempted from the CO_2 tax. Instead they must completely offset their emissions. With the revision of the CO_2 Law, parliament increased the limit of emissions reductions that may be realised abroad to 50% of the total (compared to 30% earlier).

Climate Cent initiative

The Climate Cent is a voluntary private-sector initiative to reduce CO_2 emissions attributed to the transport sector and thus avoid the introduction of a CO_2 tax on transport fuels. In use since October 2005, the Climate Cent is a surcharge of CHF 0.015 per litre on gasoline and diesel. It is levied both on imports of gasoline and diesel, and on crude oil used to produce gasoline and diesel at the Swiss refineries. The surcharge finances CO_2 emissions reductions. Climate Cent revenues and abatement programmes are managed by the private-sector Climate Cent Foundation.

Under an initial agreement from 2005 to 2009 with the government, the Climate Cent Foundation had to mitigate 1.8 Mt CO_2 per year, of which at least 0.2 Mt CO_2 had to originate in Switzerland, and at most 1.6 Mt CO_2 could be obtained from abroad. In February 2009, the volume was raised by 0.6 Mt CO_2 per year (of which at most 0.4 Mt CO_2 from measures abroad), as initial abatement projections in the transport sector proved over-optimistic. Finally, in January 2012, the Climate Cent mitigation obligation was raised by another 1 Mt CO_2 per year, increasing the total to 3.4 Mt CO_2 per year (of which at most 0.4 Mt CO_2 have to be reduced within Switzerland).

Emissions reduction measures within Switzerland focus on three areas: refurbishing buildings; financing energy efficiency and renewable energy projects in transport, space heating, process heat and waste heat; and acquiring allowances from companies that exceed their voluntary reduction targets under the CO_2 law.

From 2013, the voluntary Climate Cent will be replaced by a legal obligation on oil importers to offset directly a part of the CO_2 emissions from transport fuel use. The

offset will be financed by a levy that shall not exceed CHF 0.05 per litre of fuel. The government will define the share of transport emissions to be offset (between 5% and 40%) and to which extent offsetting can be performed domestically and abroad.

Building refurbishment programme

Buildings account for around 40% of CO_2 emissions in Switzerland. Two-thirds of them are heated with fossil fuels. Some 1.5 million buildings are in need of refurbishment, but the refurbishment rate is only around 1% per year.

Energy-related building refurbishment was boosted with support from the Climate Cent programme, which earmarked CHF 185 million to finance up to 10% of the cost per project. This programme was replaced by the government and cantons' Building programme 2010-20. It was developed by the federal government and the cantons, which are responsible for practical implementation.

The main purpose of the Buildings programme is to reduce energy use and CO_2 emissions from buildings. It is financed via a share of one-third of CO_2 tax revenues (at most CHF 200 million per year) and funds from the cantons.

This financing structure defines its two components:

- A uniform federal, nationwide programme for the improvement of building shells. The federal government provides up to CHF 133 million per year from the CO_2 tax revenues.
- Various cantonal programmes for promoting renewable energy, the use of waste heat and the optimisation of energy systems. The federal government provides up to CHF 67 million from CO_2 tax revenues. This amount is supplemented by at least an equal extent by the cantons. For this purpose, the cantons have included CHF 80 to 100 million per year in their budgets.

This means that, for the period 2011-20, up to CHF 300 million a year are available for investments in energy efficiency and the use of renewable energy in buildings, mainly for space and water heating purposes.

With the revision of the CO_2 law, parliament increased the maximal available amount from CHF 200 million to CHF 300 million per year. Therefore up to CHF 400 million a year could possibly be invested in energy efficiency and the use of renewable energy in buildings.

Since 2010, about 48 000 applications of support were received – far more than expected. To avoid a liquidity squeeze and to increase the CO_2 savings, the programme was adapted twice since 2010. The programme is estimated to result in a yearly cumulative reduction up to 2.2 Mt CO_2 by 2020.

In its Energy Strategy 2050, the government proposes to increase financing for the building refurbishment programme even further, to a total CHF 600 million annually, starting from 2015. To that effect, the CO_2 tax rate would need to be at least doubled and cantonal contributions may need to be ramped up, too.

CO_2 intensity limits for new cars

Switzerland's CO_2 emission targets for newly registered vehicles came into effect in January 2012 and are based on the EU regulation. In the first phase, a fleet average of 130 grams of CO_2 per kilometre (km) is set. A portion of the fleet will have to meet this

standard during the phase-in period 2012-15 when 100% of the fleet is covered. Forecasts suggest that this will also foster an increase in electric vehicles. Although several municipalities and utilities have launched pilot projects for electric vehicles, the federal government does not specifically promote electric vehicles. The government forecasts a rather modest uptake of electric vehicles by 2020.

Given an approximate car fleet replacement rate of about ten years, progress towards decarbonisation of road transport could be faster than in, for example, the domestic heating sector.

Regulations for combined-cycle power plants

According to a decree that came into force in January 2008, combined-cycle power plants only obtain construction and operation permits if their CO_2 emissions are fully compensated. Originally, the compensation had to be achieved domestically to at least 70%, with supplementary use of emission certificates. The share of domestic compensation was to be reduced to 50%, in case of an imminent electricity shortage.

The obligation for fossil-fired power plants to fully compensate CO_2 emissions is maintained under the revised CO_2 Law. However, the minimum share of domestic compensation has been lowered to at least 50% of the emissions.

However, depending on the outcome of negotiations on linking with the EU-ETS (see below), emissions regulation for power plants may be modified.

Emissions trading

The Swiss emissions trading system applies to companies that have assumed a legally binding commitment to reduce their energy-related CO_2 emissions and thus accept a target for 2008-12. In return, these companies are exempt from the CO_2 tax. About 430 companies take part in the emissions trading scheme.

Companies are set an annual emissions target. Corresponding to their emissions targets, companies are granted tradable emission permits free of charge. Each year, companies must surrender to the national emissions trading register (a body under the FOEN) the quantity of allowances corresponding to their actual emissions. Depending on the balance of actual emissions versus the emissions target, companies can either sell or buy allowances. Many companies have agreed to sell their surplus emission allowances to the Climate Cent Foundation. The foundation can then count these emission allowances as domestic reduction. Up to 8% of the company's total reductions can be obtained from abroad.

Companies can also save the excess allowances for the post-2012 commitment period. If they are short of required permits, they must pay the CO_2 tax retroactively for each tonne of CO_2 emitted since the exemption was granted.

An assessment of the 2010 emissions shows that the companies emitted about 2.85 Mt of CO_2, considerably less than the permitted total amount of 3.42 Mt. In exceeding their reduction target, they continued the trend set in 2008 and 2009, when the exempted companies also outperformed their target by a good 0.4 to 0.5 Mt CO_2.

Since spring 2011, Switzerland has been negotiating with the European Union on linking the two emissions trading systems. Before being able to join the EU ETS, Switzerland will need to create the premises for an operational CO_2 market. On the basis of existing

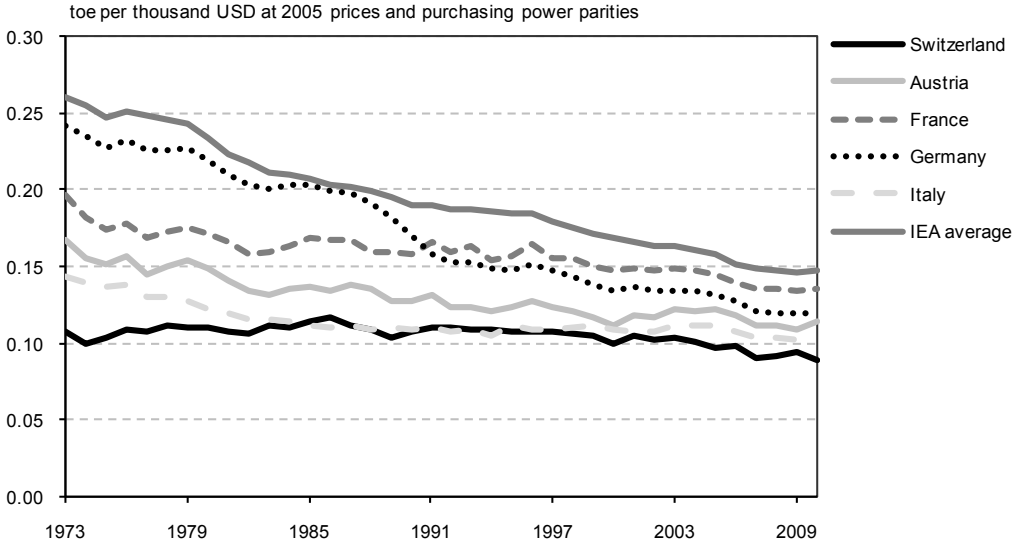
legislation, this is only possible through the introduction of a sufficiently high CO_2 tax. Linking with the EU ETS would offer the Swiss participants more liquidity and more cost-effective emissions reduction potential.

ENERGY EFFICIENCY OVERVIEW

Switzerland's energy intensity is the second-lowest among IEA countries.[5] In 2010, the country needed 0.09 toe of primary energy per each 1 000 USD of GDP, compared to an IEA average of 0.15 (see Figure 9). The intensity is low partly because the Swiss economy has a large component of high value-added services and a low level of heavy industry. Its economic structure and energy consumption patterns have been fairly stable from 1990 to 2010. Energy intensity, adjusted for purchasing power parity (PPP), improved on average 1.0% per year over the two decades. A contributing factor to this improvement in final energy intensity has been increased energy efficiency.

The 2008 Action Plan for Energy Efficiency aims to reduce fossil fuel use by 20% by 2020 and to cap electricity demand growth at 5% between 2010 and 2020. It includes 17 broad measures, with the majority of energy savings projected to come from the residential and commercial sectors. On the base of this plan, the government decided minimal energy performance standards (MEPS) for 13 categories of electrical appliances. In 2011, the government took a decision to gradually phase out nuclear power as the existing plants reach the end of their lifetimes. In order to narrow the projected supply/demand gap (nuclear power currently generates 40% of electricity), Switzerland will decide new energy efficiency measures in order to implement the Energy Strategy 2050.

Figure 9. **Energy intensity in Switzerland and in other selected IEA countries, 1973 to 2010**



Note: toe = tonnes of oil equivalent.

Sources: IEA, *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011; OECD, *National Accounts of OECD Countries*, OECD, Paris, 2011.

5. Energy intensity is calculated as the ratio of total primary energy supply per unit of gross domestic product (GDP) adjusted by purchasing power parities. It measures how much energy is required to produce a unit GDP.

ENERGY DEMAND

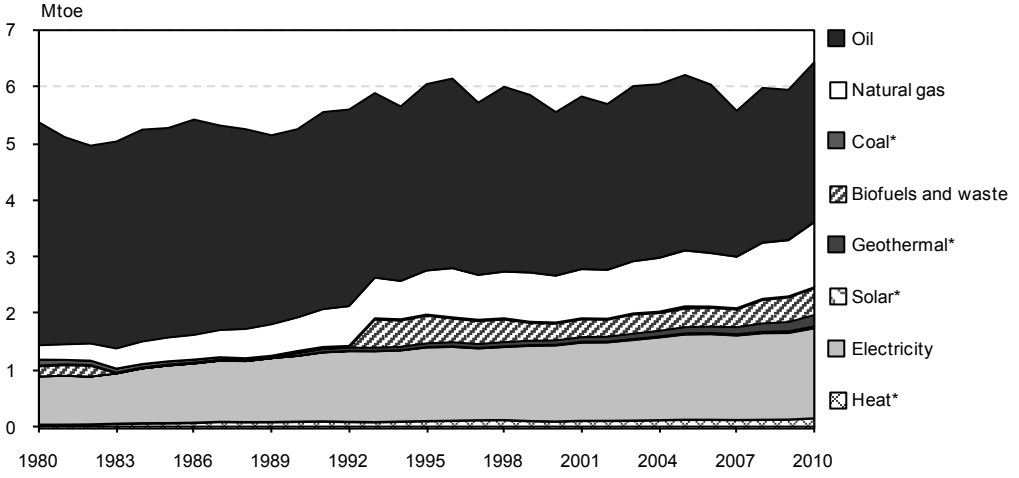
Total final consumption (TFC) of energy in Switzerland was 21 million tonnes of oil equivalent (Mtoe) in 2010, higher than ever before. TFC has increased by an average of 0.7% per year over the last decade. This compares with an IEA average annual decrease in consumption of 0.2% in the same period. Switzerland is one of the few IEA member countries where population continues to grow and its economy has performed relatively well in recent years. The government projects TFC to be around 20 Mtoe in 2020, 4% lower than current levels.

In its Energy Strategy 2050 models, the government projects TFC to be around 20 Mtoe in 2020, 4% lower than current levels. Electricity demand will continue to grow in the coming few years, but is expected to stabilise from 2015 on, following the introduction of efficiency measures proposed under the Energy Strategy 2050.

The residential sector is the largest energy consumer in Switzerland, representing 31% (6.5 Mtoe) of total final energy use. It accounts for 60% of the growth in TFC over the last decade. Electricity consumption in the residential sector increased significantly from 0.86 Mtoe in 1980 to 1.6 Mtoe in 2010. Natural gas and renewable energy have increased their share in residential energy consumption as well (see Figure 10).

The outlook calls for a slight decrease in the TFC growth rate to 2020. Only three IEA countries (Denmark, Hungary and the United Kingdom) have a larger share of final energy consumption in the residential sector.

Figure 10. **Final consumption of energy in the residential sector, 1980 to 2010**

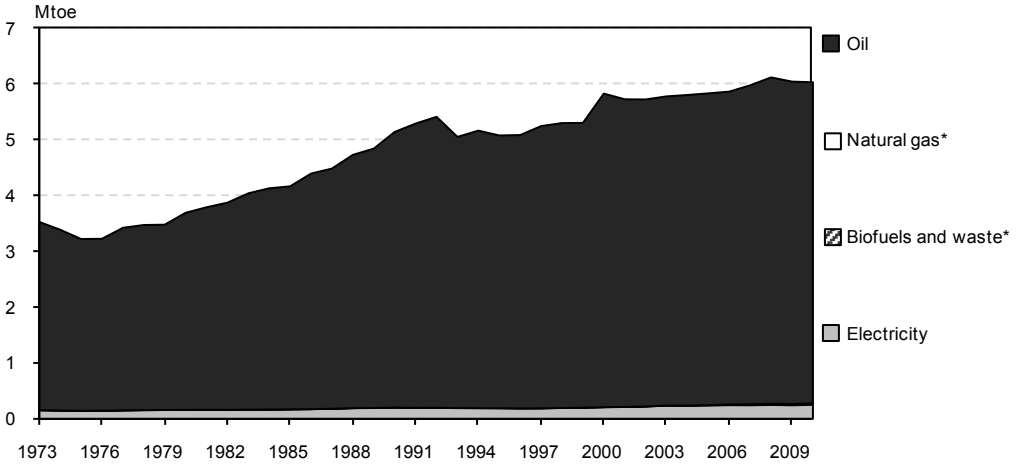


* Negligible.

Source: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011.

Transport is the second largest energy consuming sector, accounting for 29% of TFC (6.0 Mtoe) in 2010. Energy for transport peaked in 2008 and has since fallen by 1.4% (see Figure 11). Oil accounts for 95% of transport energy, electricity 4.5%, natural gas 0.3% and biofuels 0.1%. The government forecasts transport energy demand to decrease by 9% to 2020.

Figure 11. **Final consumption of energy in the transport sector, 1973 to 2010**

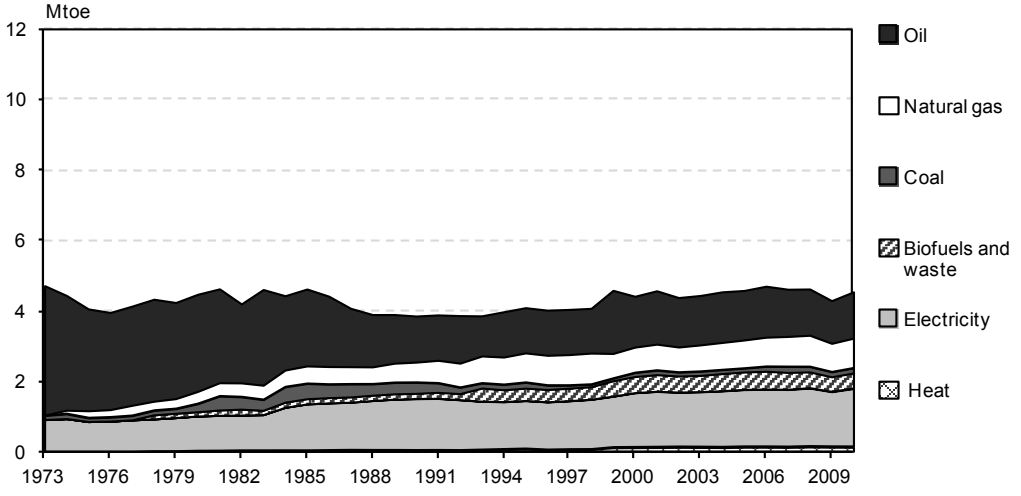


* Negligible.

Source: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011.

Among the IEA member countries, Switzerland ranks fourth-lowest in the share of industry, with energy consumption at 21% in 2010 compared with the IEA average of 32%. Electricity is the largest energy form, accounting for 37% of industry consumption. Oil accounted for 27% of the total, natural gas for 19%, biofuels and wastes for 10% and other energy sources for 6% (see Figure 12).

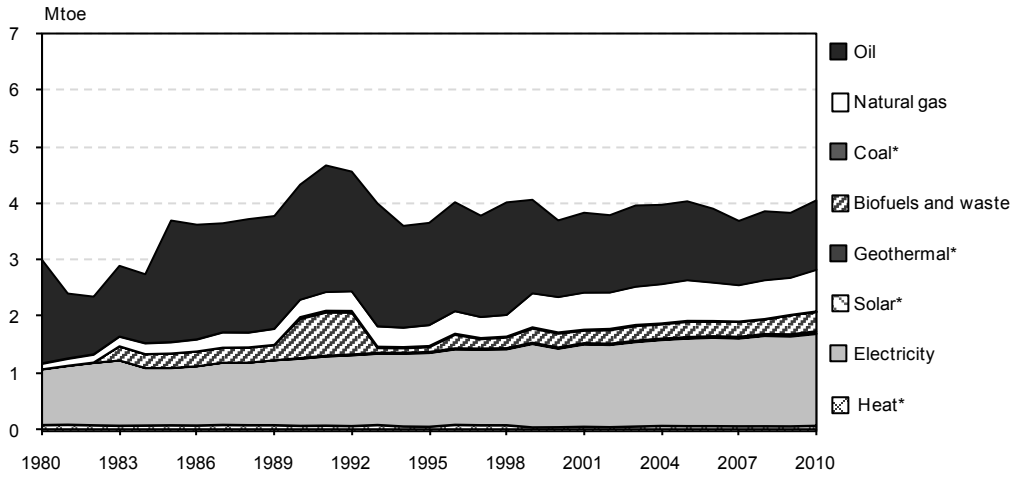
Figure 12. **Final consumption of energy in the industry sector, 1973 to 2010**



Source: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011.

The commercial sector, which also includes public services and agriculture/forestry, accounted for 19% (4 Mtoe) of TFC in 2010 (see Figure 13). Electricity was the largest energy carrier, accounting for 39% of the total, followed by oil (30%), natural gas (18%), biofuels and wastes (9%) and other (4%).

Figure 13. **Final consumption of energy in the commercial sector, 1980 to 2010**



Source: IEA, *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011.

ENERGY EFFICIENCY POLICY AND INSTITUTIONAL FRAMEWORK

Switzerland is a highly decentralised federal state. Energy efficiency efforts are generally in close co-operation between the federal government, the 26 cantons, municipalities, industry and consumers. The Energy Law of 1998 is the principal legal foundation for energy efficiency. It gives the federal government responsibility for energy labelling and the right to set minimum energy performance standards for vehicles, systems and appliances. Cantons are entrusted with building regulations, and must create favourable conditions for increasing energy efficiency and use of renewable energy in buildings. Generally, the federal government emphasises broad public information campaigns, whereas the cantons focus on advice. The federal government finances R&D and promotes professional training in energy efficiency as well as advice, in co-operation with the cantons.

Energy efficiency programmes concentrate on the priority areas of building modernisation; efficient appliances and motors; rational use of energy and waste heat in industry, and efficient and low-emission mobility. The most important cross-sectoral measure is the CO_2 tax on stationary fuels. The SwissEnergy programme plays a crucial role regarding information, professional training and counselling. The programme's impact and effectiveness are evaluated regularly.

In 2008, the government approved the Action Plan for Energy Efficiency that aims to reduce fossil fuel use by 20% by 2020 and to cap electricity demand growth at 5% between 2010 and 2020. Most of its measures are in force and are highlighted below under Sectoral policies and measures.

Energy efficiency improvements have a central role in the Energy Strategy 2050, which the government has been developing to prepare for the loss of electricity from the gradual phase-out of nuclear power. The measures set out in the Energy Efficiency Action Plan are thus being revised and strengthened and expected to be implemented as part of the Energy Strategy 2050.

The main institutions for energy efficiency are the Swiss Federal Office of Energy (SFOE) through the SwissEnergy programme and the cantons for the building sector. The Federal Office for the Environment (FOEN) is responsible for the CO_2 tax and the Swiss Emissions Trading System. The Federal Office for Spatial Development has responsibilities overall planning in the transport area while the Federal Offices of public transportation and roads are in charge of the respective implementation.

SECTORAL POLICIES AND MEASURES

BUILDINGS

Switzerland revised the energy efficiency standards in 2008 to limit the heat demand in new buildings to 60 kilowatt-hours (kWh) per square metre and to 90 kWh per square metre for buildings to be refurbished. Both limits are about 30% stricter than previous limits and mainly impact thermal insulation. For new buildings, a maximum 80% of total heat demand may be covered from non-renewable energy sources so that the heat demand will not exceed 48 kWh per square metre. The remaining 20% must be renewable energy or compensated with more energy efficiency, for example with more insulation. Following the formulation of the Energy Strategy 2050, current policies and measures will be strengthened and intensified. Energy efficiency in buildings is being improved through the building refurbishment programme (see the "Climate Change Policies and Measures" section in this chapter).

Building regulations are the responsibility of the cantons. In recent years, they have adopted more stringent standards and have been harmonising their building codes according to the model regulations, *Mustervorschriften der Kantone im Energiebereich* (MuKEn). All cantons are expected to have adopted the basic module of the MuKEn 2008 into their legislation by 2012. The effects of MuKEn 2008 are expected to increase energy savings from 3.1 petajoules (PJ) to 4.3 PJ per year. In September 2011, the cantons stipulated that electric space heating must be replaced by other systems within ten years from 2015 (estimated savings of 7 PJ from 2009 level) and electric water boilers must be replaced by renewable energy sources (estimated savings of 5.5 PJ from 2009 level).

Box 2. **MuKEn basic module elements**

- maximum limit for space heating demand;
- maximum limit on use of non-renewable energy;
- elimination of new or replacement electric space heating in residences;
- consumption-based billing of space and water heating;
- energy certification of buildings;
- voluntary efficiency agreements with large companies;
- use of waste heat from fossil fuel-fired electricity plants; and
- electricity use standards in offices.

Voluntary energy efficiency labelling

A popular voluntary labelling system for high-efficiency buildings, called Minergie, is supported by the cantons, the federal government and the private sector. The label is applicable for new and renovated buildings and it comes in several levels of standards (Minergie, Minergie-P, Minergie-A and the add-on -ECO that can be added to each of the other standards). They all set an overall limit on energy use for heating, hot water, ventilation and air conditioning. This maximum annual weighted energy consumption for new residential buildings is 38 kWh per square metre (heated gross floor area) and for renovated residential buildings it is 60 kWh per square metre.

Standard solutions for meeting the Minergie requirements include improved insulation and, for space and water heating, installing heat pumps, wood-fired systems or waste heat systems. Minergie-Modules have also been developed for individual building components, such as walls, roofs and floors, windows, exterior doors, and equipment such as lighting, wood stoves, solar collectors and sun screens. By April 2012, some 25 000 buildings with a total floor area of 25 million m^2 had been Minergie-certified. However, the share of Minergie buildings has declined recently, since the Minergie standard has been "caught up" by the MuKEn 2008.

Energy efficiency improvements in rental dwellings

As some 60% of the population are tenants, incentives to invest in renovation of rental dwellings are essential for improving the energy efficiency of the existing housing stock. Since 2008, an amendment of the rental law aims to make it easier for owners to pass on the costs from energy-related investments to the tenants.

The amendment specifies that certain energy-saving renovation efforts of living spaces and premises undertaken by the owner are to be treated as value-enhancing investments that entitle to rent increases. These include efforts to *i)* use energy efficiently; *ii)* reduce energy losses linked to the structure of the building; *iii)* reduce emissions from technical equipment; *iv)* use renewable energy; and *v)* replace energy-inefficient household appliances. The reference used to estimate the "additional investment" by the owner that would justify a rent increase concerns the costs that exceed pure reconstitution or maintenance costs.

It is, however, not always clear whether the renovations can be justified as "value-enhancing", especially as concerns small renovation projects. In the case of large renovation projects, typically 50% to 70% of the total renovation costs can be declared as "value-enhancing".

APPLIANCES, LIGHTING, EQUIPMENT AND MOTORS

The 2008 Action Plan for Energy Efficiency sets out minimum requirements for electric devices and accelerated target agreements for specific categories of appliances (Best Practice strategy), which were elaborated with the private sector and take account of the product standards of the European Union (EU), Switzerland's largest trading partner. Adopted in 2009, for the first time it stipulates energy use regulations for electric appliances, thereby expanding the energy labelling obligation in effect since 2003. The measures have an energy-saving potential of 960 gigawatt-hours (GWh) per year, corresponding to energy costs savings of around CHF 150 million. They include:

- **Minimum requirements for household appliances with energy labelling**: from 2011, new freezers and refrigerators have to be energy class A+; washing machines class A; ovens class B. Laundry dryers have to be energy class A from 2012. Some appliance regulation has been aligned with EU regulations; for others, such as fridges and freezers, tumblers, combined washing-drying-machines and ovens, Switzerland is ahead of the EU.
- **Minimum requirements for electronic devices**: stand-by use in consumer electronics and information technology must be reduced according to European Union regulation from January 2010. In off-mode, the limit is 1 watt (W), in stand-by mode the limit is 2 W. From 2013, the maximum use will be set at 0.5 W for off-mode and 1 W for stand-by mode. Since January 2010, the maximum stand-by use of power supply units is limited to 0.5 W while in operation. The stand-by mode of complex set-top boxes is limited to between 6 W and 8 W from January 2010 and from 2012 on there will be a total energy consumption (TEC) limit.
- **Minimum requirements for electric lighting**: lamps must be energy efficiency class E or higher from 2009. From September 2010, EU regulation has been adopted in Switzerland. A gradual tightening of efficiency requirements will take place, such that from September 2012, clear lamps have to be at least class C, other lamps class A.
- **Minimum requirements for electric motors**: since a voluntary agreement from 2004 between the government and the concerned industry sector failed to attain its targets, regulation was introduced. From January 2010, energy efficiency category IE1 was required; from July 2011 category IE2; thereafter, Switzerland is following the EU legislation to be gradually tightened in 2015 and 2017.
- **Minimum requirements of energy labels** for certain categories of appliances.

Several new regulations and adaptations of existing regulations came into effect in January 2012:

- Efficiency requirements for television sets, circulation pumps for heating and warm water circuits, fluorescent lamps, high-intensity discharge lamps *(i.e.* streetlights) and ballasts.
- Adaptations in the appliance categories of washing machines, information technology appliances, set-top boxes and electric motors.
- Further development of energy labels, including a more precise differentiation within the A category. Energy labels will become mandatory for television sets, and will be adapted to the new label for refrigerators and freezers, washing machines and dish washers.

The two important organisations for promoting energy-efficient appliances are the Swiss Agency for Electric Appliances (EAE) and the Swiss Agency for Efficient Energy Use (SAFE).[6] The EAE maintains a database on labelled appliances. SAFE runs a website with energy-efficient appliances, including non-labelled ones, in each appliance category. Both get funding from the SwissEnergy programme.

6. *Energie-Agentur-Elektrogeräte and Schweizerische Agentur für Energieeffizienz*.

INDUSTRY

In addition to industry's own efforts to use energy rationally to save costs, Switzerland's CO_2 legislation is a driving force for efficiency improvements. The 2000 CO_2 law provides that large energy consumers can be exempt from the CO_2 tax on heating and process fuels, if they agree with the government to restrict their CO_2 emissions to a certain level and, subsequently, meet their declared target. Under the revised CO_2 law, the possibility to be exempted from the CO_2 tax is maintained for the period 2013 to 2020.

Target agreements

The Energy Agency for Industry (EAEc) is responsible for preparing and concluding voluntary agreements, known as target agreements. Its main objectives are to promote the reduction of CO_2 emissions and increase the level of energy efficiency through the implementation of economically viable measures. Together with its affiliated companies, it formulates specific company-related targets and combines these to form an overall objective. EAEc offers its affiliated companies a comprehensive range of products and services relating to target agreements, practical support and monitoring.

Two levels of participation are available for companies: voluntary target agreements and binding target agreements which enable them to gain exemption from the CO_2 tax. Companies choose to participate in one of four models (energy, benchmark, small/medium-sized companies and transport), each of which defines energy-efficiency targets in a variety of ways. These models are used to develop a universal target agreement. Target agreements are intended to save about up to 15% of energy in ten years, their expiry date is provisionally set for 2012 (in line with Kyoto commitment period). New target agreements will be established for the period from 2013 to 2020.

Voluntary agreements can be converted into legally binding CO_2 emission targets, allowing companies to participate in emissions trading and be exempt from the CO_2 tax. In collaboration between the company and the EAEc, an action plan is developed and a reduction target is defined. These are audited by FOEN and SFOE to become legally binding commitments that grant exemption from the CO_2 tax. In case of non-compliance, the company has to pay the CO_2 tax plus any interest retroactively for the entire period since it was granted an exemption.

Under the revised CO_2 law, large CO_2 emitters are exempted from the CO_2 tax and participating in the emission trading scheme. For small and medium companies, the possibility to apply for an exemption of the CO_2 tax is maintained. The companies have to agree on a legally binding CO_2 emission targets.

Canton target agreement

Large-scale consumers (>5 GWh of annual heat consumption or >0.5 GWh electricity consumption) must systematically take measures to improve their energy efficiency. They may choose between two options: conclude either a voluntary target agreement with the canton or a universal target agreement with EAEc, and thus bear responsibility for implementing the necessary measures. Alternatively, they may choose the minimum requirements of an energy consumption analysis. In both cases, they have to meet criteria concerning the degree of efficiency they have to achieve. These criteria are defined at the cantonal level. The canton of Zurich, for example, specifies that the companies must increase energy efficiency by at least 2% per year.

Voluntary measures (SwissEnergy Programme):

- information platforms (*e.g.* www.proofit.ch, for SMEs);
- process integration in process engineering;
- optimisation of energy consumption in SMEs in co-operation with industry associations; and
- new measures according to the Energy Strategy 2050, such as energy management systems.

Efficient use of electricity

Tender calls for projects and programmes for more efficient use of electricity in industry and households are a new measure. It was launched by SFOE in 2010 and has a budget of CHF 9 million. Tender-winning projects and programmes are financed via the grid levy on electricity that is also used to fund the feed-in tariffs. For 2011, the budget was CHF 15.3 million and 31 projects and 13 programmes were approved. The budget for 2013 will be about CHF 20 million.

Companies and organisations (programme owners) may apply for the implementation of efficiency measures within the scope of an annual call for tenders. The main criterion is the cost/benefit ratio (promotion funding per saved energy quantity). In order to qualify, projects and programmes must meet additional criteria, including that the applicant's financial contribution towards a project is at least CHF 20 000 and promotion funding is equivalent to a maximum of 40% of the investment costs.

TRANSPORT

Private cars are by far the dominant form of travel in Switzerland (see Table 2). However, the country has one of the highest shares of public transportation in IEA countries, and the second-highest of rail, after Japan. Public transportation volumes are also increasing fast. From 1990 to 2009, railway use increased by 46% and bus use almost doubled, while traffic volume by private cars increased by 16%.

Switzerland has a million more registered passenger cars than in 1990, an increase of one-third. Car density has risen from 442 in 1990 to 515 per 1 000 residents in 2009, slightly more than the EU15 average of 503.

Table 2. **Modal split of passenger transport on land, 2009**

	Car	Bus	Train	Tram and metro
Share (%)	76.2	5.7	16.7	1.5

Source: *EU Transport in Figures. Statistical Pocketbook 2011.*

Passenger vehicles: performance standards

The main measure in the 2002 to 2008 period was a voluntary agreement with the car importer association to reduce average fuel consumption of new cars from 8.4 litres/100 km in 2000 to 6.4 litres/100 km in 2008. This was not achieved and the agreement was not renewed. Measures for fuel consumption are now implemented as part of CO_2 emission targets.

The emission targets for newly registered vehicles will come into effect in July 2012 and are based on those defined by the EU. In the first phase, a fleet average of 130 grams of CO_2 per kilometre is set. A portion of the fleet will have to meet this standard during the phase-in period from 2012 until 2015 when 100% of the fleet is covered. The weight of the imported fleet affects an importer's target; a heavier fleet is assigned a higher emission target, *i.e.* less restrictive. The target value applies to each car importer; per vehicle, excess emissions are sanctioned by a penalty for each excess gram of CO_2. From 2012 to 2018, the first gram of CO_2 above target will be penalised at CHF 7.5, the second gram at CHF 22.5, the third at CHF 37.5. Excess emissions beyond them will incur a sanction of CHF 142.5. From 2019, the maximum sanction will apply to all excess emissions.

The emission targets relate to the average emission value of an importer's car fleet. Different importers may pool their imports in order not to exceed target values. Small importers of less than 50 vehicles per year have to apply emission targets to each car.

Passenger vehicles: energy labels

As part of the mentioned agreement with car importers, the government introduced compulsory energy labelling for new passenger cars in 2003. According to a best-practice strategy, it classifies vehicles into seven energy efficiency categories according to fuel consumption and weight. The energy categories are adapted regularly to technological progress to assure that only the top seventh of vehicles are in the A category.

In 2010, the government rejected the introduction of a broader "eco-label" based on energy efficiency and the level of overall pollution, but decided to enhance the energy label. In 2011, the energy label was revised from a tank-to-wheel to a well-to-wheel approach and includes alternative drive trains. The new energy label will be adapted yearly, rather than every two years. It came into effect in August 2011.

Passenger vehicles: merit rating for vehicle tax in cantons

Motor vehicle taxes are assessed by the cantons on the basis of criteria such as weight or cubic capacity. An increasing number of cantons have introduced bonus systems on annual taxes for efficient vehicles such as electric, hybrid, fuel cell, natural gas and vehicles in the A and B energy efficiency categories. The federal government supports a differentiation of cantonal vehicle taxes by suggesting the use of the energy efficiency label as a reference for tax rebates and fees.

Freight transport

In 2009, the transport of goods by road accounted for 55% of total tonne-kilometres in 2009, while rail accounted for 45%. The share of rail is high and reflects Switzerland's successful policy of shifting freight from road to rail.

Shifting from road to rail is the government's main policy in freight transport, in particular in the trans-Alpine transport. The 1999 Modal Shift Law aimed to cut the number of heavy-duty vehicles crossing the Swiss Alps. The policy did succeed in reducing their number from around 1.4 million in 2000 to 1.26 million in 2010. The legally binding target is to further reduce it to 650 000 per year by 2018, after the

Gotthard base tunnel, at 57 km the world's longest railway tunnel, has been opened. The government concluded in December 2011 that additional measures are needed in order to reach this target.

Since 2001, vehicles weighing more than 3.5 tonnes are subject to a heavy-vehicle fee (HVF). The HVF aims to internalise all road freight transport costs. The HVF is vehicle-specific and based on weight, mileage and pollutant emissions. The current rate varies from CHF 2.26 cents to 3.07 cents per tonne and kilometre, depending on the pollutant emissions level of the vehicle. Combined with the increased weight limit for lorries (from 34 tonnes in 2001 to 40 tonnes since 2004), the HVF has raised energy efficiency by triggering fleet renewal and better logistics.

One-third of the HVF revenue is earmarked for infrastructure projects in the cantons and two-thirds of the revenue goes to the federal government for major public transport projects, including new trans-Alpine rail routes, the "Rail 2000" rail infrastructure modernisation programme, links to European high-speed networks and rail noise control.

Other selected measures

- In co-operation with SwissEnergy, EcoCar, an association of four organisations, promotes energy-efficient vehicles and vehicle technologies, such as electric and gas-powered vehicles. The use of electric vehicles is being promoted at the federal level through support for basic research and by promoting the introduction of efficient vehicles onto the market.
- Labelling for tyres: the government encourages car dealers to voluntarily apply the EU label for car tyres. The label indicates energy efficiency (rolling resistance), road grip on wet roads and noise pollution.
- Since 2006, Eco-drive courses are a prerequisite for obtaining a driver's licence. SwissEnergy promotes additional EcoDrive measures.

CRITIQUE

By international comparison, Switzerland has low GHG emissions per capita and unit of GDP. Among the IEA member countries, Switzerland also has the second-lowest energy intensity. The Swiss economy relies heavily on high value-added services, and energy-intensive industry is scarce. At the same time, energy supply relies relatively strongly on nuclear and renewable energy, and energy use has become more efficient, thanks to several recent measures.

Under the Kyoto Protocol, Switzerland has to reduce its GHG emissions by 8% from 1990 to 2008-12. To reach this goal, the CO_2 Law of 2000 stipulates a 10% reduction of CO_2 emissions from fossil fuel use in the same time-frame, but this target will very likely be missed. GHG emissions have remained almost the same since 1990, as emission reductions in the residential and industrial sectors have been offset by increases in the transport sector. The binding Kyoto target, however, can be reached by using the Kyoto flexible mechanisms.

The parliament adopted a GHG reduction target for 2020 in December 2011 as part of the revision of the CO_2 Law. The target is a 20% reduction from the 1990 levels, to be

reached solely by domestic measures. The target may be increased to up to 40% in case an international climate regime is adopted. Up to three-quarters of the additional 20% reduction may be achieved abroad. This sounds quite ambitious, considering that emissions today are roughly at the 1990 levels and marginal abatement costs are relatively high. At the same time, abatement costs vary widely across sectors. Furthermore, waiving the option of using international flexible mechanisms, which are generally more cost-effective than domestic measures, unnecessarily increases abatement costs in case the mechanisms continue beyond 2012. Now that the 2020 target has been set, the government needs to introduce new and/or strengthened policies and measures without delay. It should also thoroughly monitor the implications of a strictly domestic 20% reduction target and ensure more even marginal abatement costs across sectors.

Improving energy efficiency is a key means for reducing CO_2 emissions. Switzerland's 2008 Action Plan for Energy Efficiency aims to reduce fossil fuel use by 20% by 2020 and to cap growth in electricity demand at 5% between 2010 and 2020. Following the nuclear phase-out decision, measures foreseen in the action plan will be revised and strengthened as part of the implementation of the Energy Strategy 2050. Higher-impact efficiency measures are to enter into force as from 2015, underpinning the government's projections about a 4% decline in TFC by 2020 and a stabilisation of electricity demand. These are audacious projections, particularly against a background of continued growth of the population and the economy and expanding use of electricity *e.g.* for heat pumps, pumping for hydro-storage or electric vehicles.

Turning to end-use sectors, road transport is the largest GHG emitter in the country and has the most potential for further cost-effective emissions reductions. The government has for years worked on improving the public transport system, already of a very high standard. Efforts to shift freight traffic from road to rail have also been successful, but potential for further improvements still remains. Switzerland's distance-related heavy vehicle fee has been copied in several other countries.

New and planned measures in the transport sector include CO_2 per kilometre performance requirements on new passenger cars, which is in line with the European Union regulation aiming at an average emission of 130g per kilometre for newly sold cars in 2015. The ambitious long-term project to improve the rail system is very welcome, also because it will help to decarbonise freight transport.

Current and planned measures in the transport sector are necessary, but may not be sufficient. The government should consider increasing transport fuel prices, possibly in a revenue-neutral manner. The authorities should also consider introducing or intensifying the following measures: raising taxes on vehicle purchase, registration and use; increasing road and parking pricing; reducing parking space. Plans by the federal, cantonal and municipal governments to further develop public transport are to be commended.

Emissions in the buildings sector are also high, owing to a large share (more than 50%) of oil in heating. Replacing oil heating by heat pumps or renewable energy sources, for example, makes sense. Here, the building refurbishment programme is a very useful tool. It should be accelerated and its budget increased. Incentives for energy-saving renovations in rented dwellings have been improved and could be raised further, a crucial matter in a country with a high share of tenants.

Since the 2007 in-depth review, the cantons have adopted more stringent and harmonised standards for energy efficiency in new buildings, reaching the levels of the voluntary Minergie labelling system. This work to gradually increase the stringency

should continue. In September 2011, the cantons decided that electric space heating must be replaced by other heating systems within ten years from 2015, while electric water boilers have to be replaced by renewable energy systems. This will help the country save electricity and should therefore make the nuclear phase-out policy easier to implement. Cost and CO_2 emissions, however, may become an issue.

Another positive development is the introduction of the Cantonal Certificate on Buildings Energy Use (GEAK), introduced in 2009, as it helps make energy performance a criterion in selling and renting both new and old buildings. In light of the challenges ahead, Switzerland should also consider legal obligations for efficiency improvements in existing buildings.

Concerning the industrial sector, the government should work to finalise negotiations with the European Union on linking the Swiss and the European Union emissions trading schemes, as this would likely reduce abatement costs for the Swiss companies. Fossil-fired power plants should also be included in this ETS. Although Switzerland currently does not have any large fossil-fired plants, the nuclear phase-out decision means that new generating capacity using other energy sources will be needed to fill the supply gap, possibly already before the end of this decade. Under the current policy, however, power plants would have to compensate for all of their CO_2 emissions domestically, and this practically excludes fossil-fired plants as an option. Such exclusion is likely to reduce energy security in Switzerland.

In the area of appliances, equipment, lighting and motors, measures for higher efficiency include minimum performance requirements, energy labelling and, with industry, voluntary target agreements (Best-Practice strategy). These measures are elaborated in co-operation with the private sector and, importantly, the performance requirements are also aligned with those of the European Union, Switzerland's largest trading partner. The government's policy of gradually raising the minimum efficiency requirements for appliances, equipment and products is essentially sound, as voluntary measures would be too weak. The "voluntary measures" with industry (*i.e.* the CO_2 tax exemption as a reward for emissions reductions) have been very successful and should be continued.

Finally, Switzerland should continue its efforts to fully implement the IEA policy recommendations for improving energy efficiency (see Box 3). In particular, more attention should be paid to fostering energy management (EM) capability through the development and maintenance of EM tools, training, certification and quality assurance. Switzerland would also benefit from quickly implementing planned policies, particularly those related to placing energy efficiency obligations on energy utilities, hastening the phase-out of inefficient street lighting technologies and setting mandatory minimum energy performance requirements for network-connected devices, such as TVs, computers and set-top boxes.

Box 3. **IEA 25 energy efficiency policy recommendations**

To support governments with their implementation of energy efficiency, the IEA recommended the adoption of specific energy efficiency policy measures to the G8 summits in 2006, 2007 and 2008. The consolidated set of recommendations to these summits covers 25 fields of action across seven priority areas: cross-sectoral activity, buildings, appliances, lighting, transport, industry and power utilities. The fields of action are outlined below.

Box 3. IEA 25 energy efficiency policy recommendations (continued)

1. The IEA recommends action on *energy efficiency* across sectors. In particular, the IEA calls for action on:

- data collection and indicators;
- strategies and action plans;
- competitive energy markets, with appropriate regulation;
- private investment in energy efficiency; and
- monitoring, enforcement and evaluation.

2. Buildings account for about 40% of energy used in most countries. To save a significant portion of this energy, the IEA recommends action on:

- mandatory buildings codes and minimum energy performance requirements;
- net-zero energy consumption in buildings;
- building energy labels or certificates; and
- energy performance of building components and systems.

3. Appliances and equipment represent one of the fastest growing energy loads in most countries. The IEA recommends action on:

- mandatory minimum energy performance standards and labels;
- test standards and measurement protocols; and
- market transformation policies.

4. Saving energy by adopting efficient *lighting technology* is very cost-effective. The IEA recommends action on:

- phase-out of inefficient lighting products;
- energy-efficient lighting systems.

5. To achieve significant savings in the *transport sector,* the IEA recommends action on:

- mandatory vehicle fuel-efficiency standards;
- measures to improve vehicle fuel efficiency;
- fuel-efficiency non-engine components;
- transport system efficiency.

6. In order to improve energy efficiency in industry, action is needed on:

- energy management;
- high-efficiency industrial equipment and systems;
- energy efficiency services for small and medium-sized enterprises; and
- complementary policies to support industrial energy efficiency.

7. *Energy utilities* can play an important role in promoting energy efficiency. Action is needed to promote:

- utility end-use energy efficiency schemes.

Box 3. IEA 25 energy efficiency policy recommendations (continued)

Implementation of IEA energy efficiency recommendations can lead to huge cost-effective energy and CO_2 savings. The IEA estimates that, if implemented globally without delay, the proposed actions could save around 7.6 Gt CO_2 per year by 2030. In 2010 this corresponded to 17% of annual worldwide energy consumption. Taken together, these measures set out an ambitious road-map for improving energy efficiency on a global scale.

RECOMMENDATIONS

The government of Switzerland should:

Climate change

- ☐ *Introduce without delay new and/or strengthened policies and measures for meeting the 2020 GHG target.*
- ☐ *Avoid creating disparities in marginal abatement costs across sectors.*
- ☐ *Thoroughly examine the implications of a strictly domestic 20% reduction target.*
- ☐ *Monitor the effectiveness of the new measures to reduce CO_2 emissions in the transport sector beyond 2012 and intensify them, if necessary. In particular, consider raising the CO_2 emissions offset obligation of fuel importers and promoting electric vehicles.*
- ☐ *Work to finalise negotiations with the European Union on linking the Swiss and the EU emission trading schemes; include power generation in the Swiss emissions trading system.*
- ☐ *Strengthen incentives for building refurbishments, for example by raising the revenue-neutral CO_2 tax and the budget of the building refurbishment programme.*

Energy efficiency

- ☐ *Continue efforts to harmonise and strengthen minimum energy performance requirements for new and renovated buildings and consider legal obligations for efficiency improvements in existing buildings.*
- ☐ *Continue to gradually raise the minimum efficiency requirements for appliances, equipment and products.*
- ☐ *Formulate, with industry, the new framework for voluntary measures (CO_2 tax exemption as a reward for emissions reductions and efficiency gains) after 2012.*
- ☐ *Foster energy management (EM) capability through the development and maintenance of EM tools, training, certification and quality assurance.*
- ☐ *Quickly implement planned policies, particularly those related to placing energy efficiency obligations on energy utilities, hastening the phase-out of inefficient street lighting technologies and setting mandatory minimum energy performance requirements for network-connected devices.*

PART II
SECTOR ANALYSIS

4. OIL

Key data (2010)

Production: none

Share of oil: 40% of TPES, 0.1% of electricity generation

Net oil imports: 11.7 Mtoe (crude oil from Azerbaijan 36%, Kazakhstan 26%, Libya 17%, Nigeria 11%, Algeria 8%)

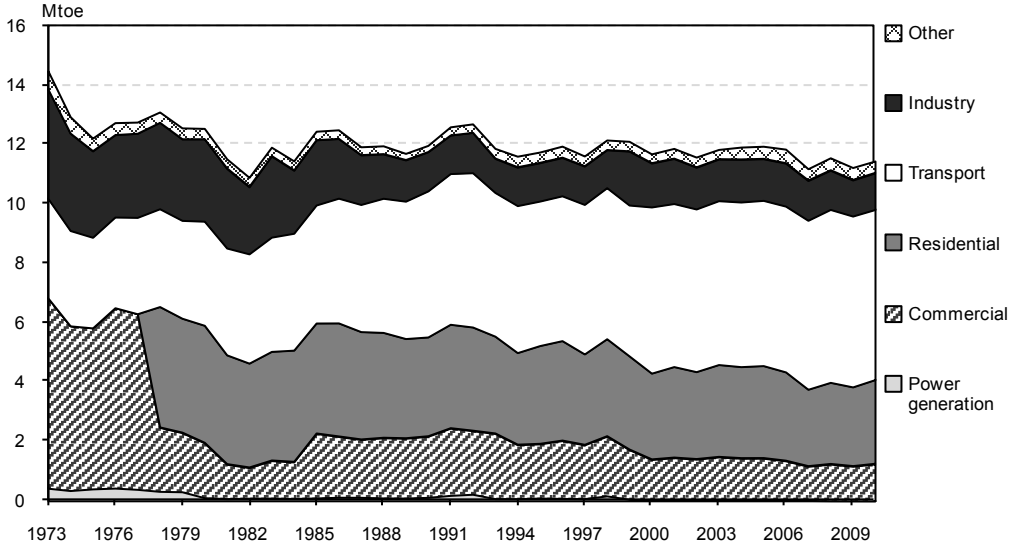
Total final consumption: 11 Mtoe (0.26 million barrels/day) (transport 52%, residential 26%, commercial 11%, industry 11%)

SUPPLY AND DEMAND

SUPPLY

Oil is by far the largest energy source in Switzerland. In 2010, oil supply was 10.4 million tonnes of oil equivalent (Mtoe), accounting for 39% of total primary energy supply (TPES). Switzerland's share of oil in TPES is higher than in most IEA member countries, which averaged 36% in 2010. Both the amount of oil consumption and share of oil in TPES have been relatively stable at about 11 Mtoe, or 40% of TPES over the last decade.

Figure 14. **Oil supply by sector*, 1973 to 2010**

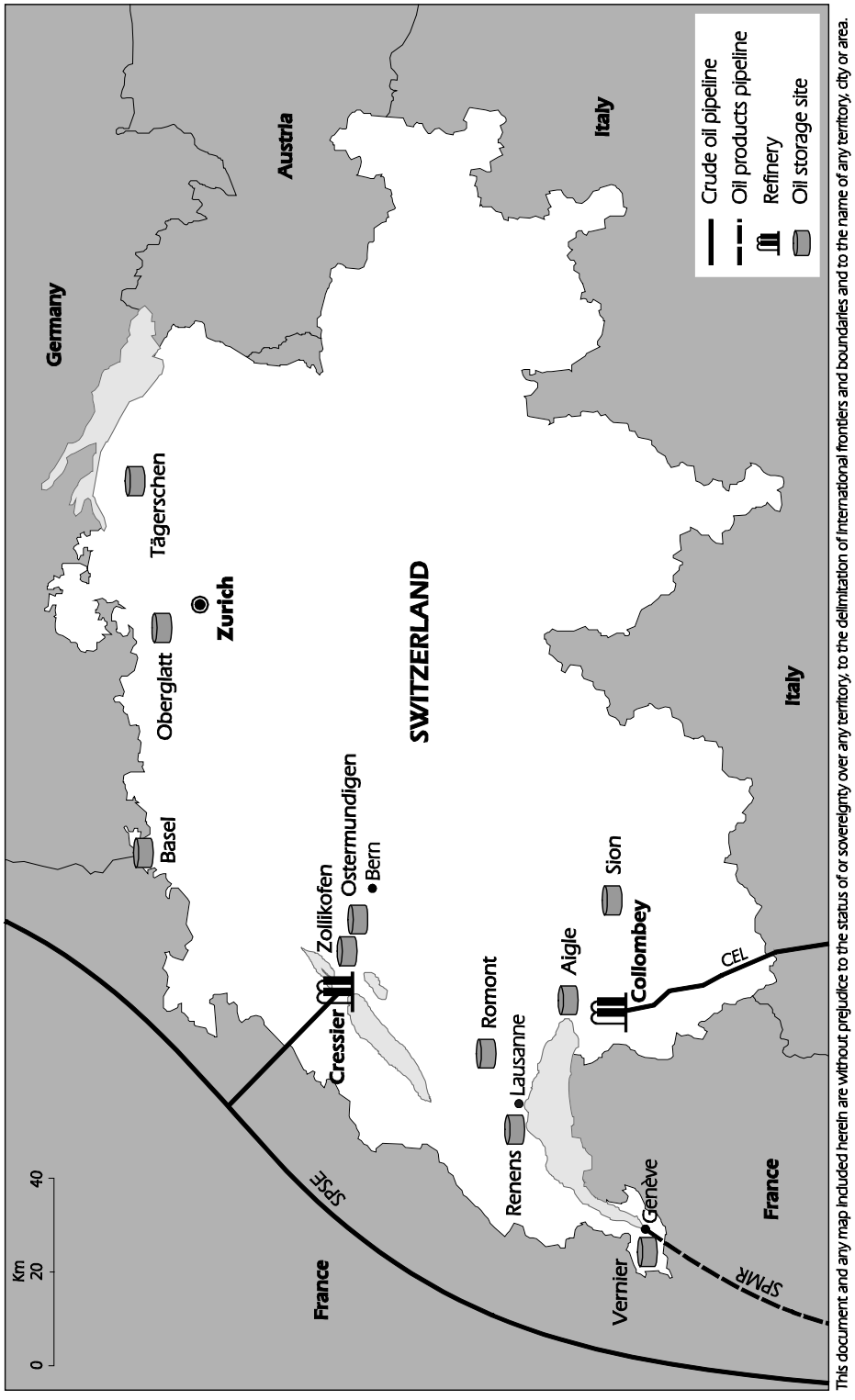


* Total primary energy supply by consuming sector. *Other* includes other transformation and energy sector consumption. *Industry* includes non-energy use. *Commercial* includes commercial, public services, agriculture/forestry, fishing and other final consumption.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

INFRASTRUCTURE

Figure 15. **Map of the Swiss oil supply infrastructure, 2011**



Source: IEA.

Switzerland imports all of its oil. In 2010, net oil imports were 11.7 Mtoe, consisting of 38% crude oil and 62% refined oil products. The split in the share of crude and refined products in oil has been fairly stable since 2000. Crude oil imports in 2010 were from Azerbaijan (36%), Kazakhstan (26%), Libya (17%), Nigeria (11%) and Algeria (8%). Since the 2007 IEA in-depth review, crude oil imports from Azerbaijan and Kazakhstan have significantly increased, while imports from Libya fell from 49% in 2006 to 17% in 2010 and from Nigeria at 28% down to 11% over the same period. All refined oil products are imported from European Union countries. In 2010, Switzerland imported oil products from Germany (55%), the Netherlands (13%), Italy (12%) and France (10%). It exported 0.4 million tonnes of refined oil products mainly to Belgium (38%), France (30%), the Netherlands (14%) and Germany (10%).

DEMAND

Transport is the largest oil-consuming sector, accounting for 52% of Switzerland's total final consumption of oil in 2010. This share has gradually increased over the last decade. Oil consumption in the residential sector was 26% of the total in 2010 and 3% lower in volume terms than in 2000. Oil still accounts for around 54% of the energy used in space heating, but this share is gradually diminishing and set to decline further. The industry sector accounted for 11% of total final consumption of oil in 2010, and its oil use was 2% less than in 2000.

In 2011, motor gasoline accounted for 30% of total oil product demand, followed by heating oil (26%), automotive diesel (21%) and kerosene-type jet fuel (14%). Although the diesel price in Switzerland is one of the highest in OECD countries, demand for diesel has increased by 80% since 2001, while demand for motor gasoline has declined by 21%. The main reason for this shift is the rapid market penetration of diesel vehicles in the last decade (from less than 3% in 2000 to 18% in 2010). At the same time, demand for heating oil has declined by some 40%, partly driven by policy and tax.

The five-year outlook by CARBURA, Switzerland's stockholding organisation, indicates that the total demand for oil products would decrease by 4% from 2011 to 2016, while demand for transport diesel would increase by 11% and for jet fuel by 7%. The decline in total demand would stem from gradual decrease in motor gasoline and heating oil use. In recent years, the government has introduced several policies to stimulate a move away from oil-based space heating.

REFINING

Switzerland has two refineries, Cressier and Collombey, with a total crude distillation capacity of around 125 thousand barrels per day (kb/d). The Cressier refinery has a crude distillation capacity of 68 kb/d. Crude oil supply arrives via the SPSE pipeline from the marine shipping terminal in Fos-sur-Mer in the south of France. The refinery was operated by Petroplus Refining, but the company went bankrupt in early 2012. In May 2012, the refinery was acquired by a group of investors, including Vitol, the oil trading company. The Collombey refinery has a crude distillation capacity of 57 kb/d. Crude oil arrives from the port of Genoa, Italy, by pipeline crossing the Alps. Collombey is operated by Tamoil.

In 2010, total crude throughputs at the two refineries averaged 93 kb/d, which indicates that the overall capacity utilisation rate was about 74%. In the same year, the refined product output from the two domestic refineries totalled 97 kb/d. The composition of production from these refineries was gas/diesel oil (48%), gasoline (32%), residual fuel oil (7%) and liquefied petroleum gas (6%).

With the exception of residual fuels, domestic refinery production is not sufficient for meeting demand in the country. In 2010, domestic production of gas/diesel oil was able to meet 40% of domestic demand, while gasoline amounted to some 35%, requiring imports to meet the remaining share. Domestic refinery gross output has gradually decreased from 108 kb/d in 2008 to 97 kb/d in 2010.

STORAGE

Switzerland possesses a total storage capacity of about 49.7 million barrels (7.9 million cubic metres), which is mostly used for industry compulsory stocks (34.6 mb or 5.5 mcm). The oil industry has 72 above-ground tank farms, spread over the country, but mostly located around the areas of high population density between Geneva and Lake Constance. Most of those tank farms are run by joint ventures of oil importers.

Storage capacity has been reduced during the past 15 years, because of the lowered level of compulsory stocks as well as the decline in oil consumption. Recently three tank farms with a capacity of less than 1.6 mb or 250 thousand cubic metres, were closed.

Using the IEA methodology for calculating emergency reserves, Switzerland's daily net imports in 2011 were around 232 kb. To meet the 90-day commitment, about 19 to 24 million barrels of oil stocks are required, which is equivalent to between 3.1 and 3.9 mcm of oil storage capacity.

Total stocks in Switzerland were about 35 mb at the end of February 2012. These stocks were mainly composed of middle distillates (64%) and motor gasoline (32%). As Switzerland has no public stockholding, all storage capacity is held within the supply chain. Crude oil is stored only in the two refineries for commercial purpose, as there is no obligation to hold crude oil. Compulsory stocks are held in accordance with stockholding contracts which stipulate that the full delivery of the volumes must be guaranteed.

PIPELINES AND OTHER TRANSPORTATION

Crude oil and petroleum products are imported mainly by pipelines, rail tank cars and Rhine barges. Pipeline imports were the most important, accounting for 44% of total oil imports in 2010.

Switzerland has one pipeline for oil products and two pipelines for crude oil. The SAPPRO pipeline, with an authorised capacity of around 30.3 kb/d (1.5 Mt per year), connects with the French SPMR pipeline coming from Fos-Lavera at Saint-Julien-en-Genevois. The utilisation rate of this pipeline was around 43% in 2010. The pipeline supplies diesel, heating oil, gasoline and kerosene to the terminal and tank farms in Geneva. The network runs around 12 km in Switzerland.

Concerning crude oil pipelines, the Oléoduc du Rhône runs from Genoa, Italy to the Collombey refinery. The pipeline has a capacity of around 61 kb/d (3 Mt per year), and its utilisation rate in 2010 was 79%.

Another crude pipeline is the Oléoduc du Jura Neuchâtelois, which branches off from the Société du Pipeline Sud Européen (SPSE) pipeline at Gennes in France to supply the Cressier refinery. Its capacity is around 91 kb/d or 4.5 Mt per year, and its utilisation rate was 54.4% in 2010. The commercial viability of the pipeline is tributary to the SPSE pipeline from Lyon to Karlsruhe (with an authorised maximum flow of 1.4 mb/d or 70 Mt per year), whose utilisation rate has decreased by some 21%.

There are three oil ports in Basel to ship oil products on the Rhine by barges. In 2011, 2.5 Mt (around 50.5 kb/d) of oil products were unloaded in those oil terminals.

MARKET STRUCTURE

The number of importers significantly decreased from 88 in 1990 to 60 in 2011. Among the 60 importers, the seven largest ones (BP Switzerland, Total Suisse, ESSO Schweiz GmbH, Shell, Tamoil, Eni Suisse and Petroplus) supplied 67% of total imports in 2010.

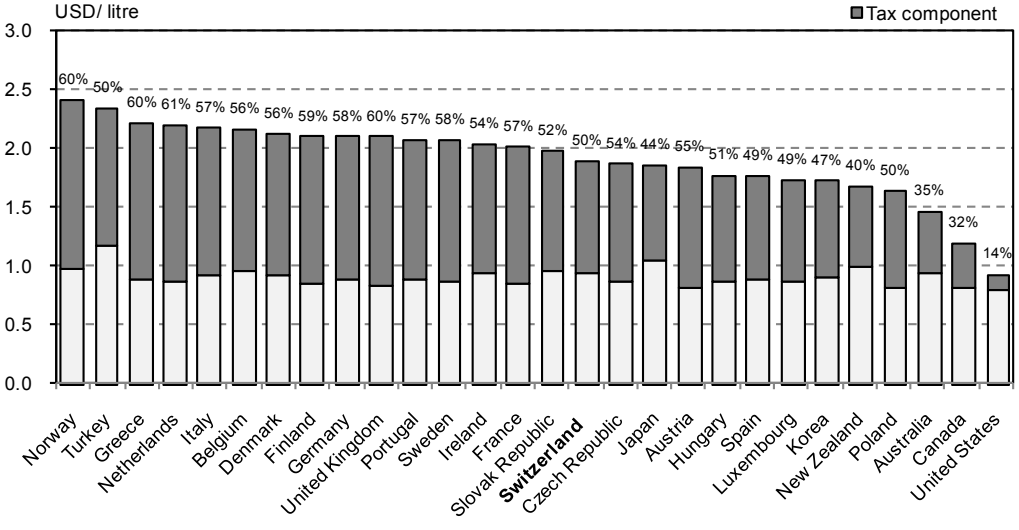
The retail market is fully open to competition, and 19 oil retail companies operate 3 626 filling stations in Switzerland as of January 2011. The largest are Avia (690 stations), Agrola (427), BP (400), Shell (324), Tamoil (318) and Ruedi Rüssel (305). In autumn 2011, Socar, the State oil company of Azerbaijan, Switzerland's largest crude supplier, acquired Esso Switzerland's network of 170 stations. The deal is to be concluded in the third quarter 2012.

There are 17 small producers of biodiesel, although their share in oil supply is below 0.1%.

PRICES AND TAXES

The oil products market is fully liberalised. Wholesale and retail prices are mainly influenced by the relevant quotation prices and exchange rates, which are driven by the global market fundamentals and expectations. Government role in pricing is limited to determining the level of the excise tax and of the value-added tax. In addition, contributions to the so-called Guarantee Fund ("Emergency Fund") are levied on imports of oil products in order to finance the stockpiling system. In the fourth quarter of 2011, the share of all tax components in the retail price was nearly 50% for both unleaded gasoline and automotive diesel prices (for non-commercial purposes), and about 17% for light fuel oil.

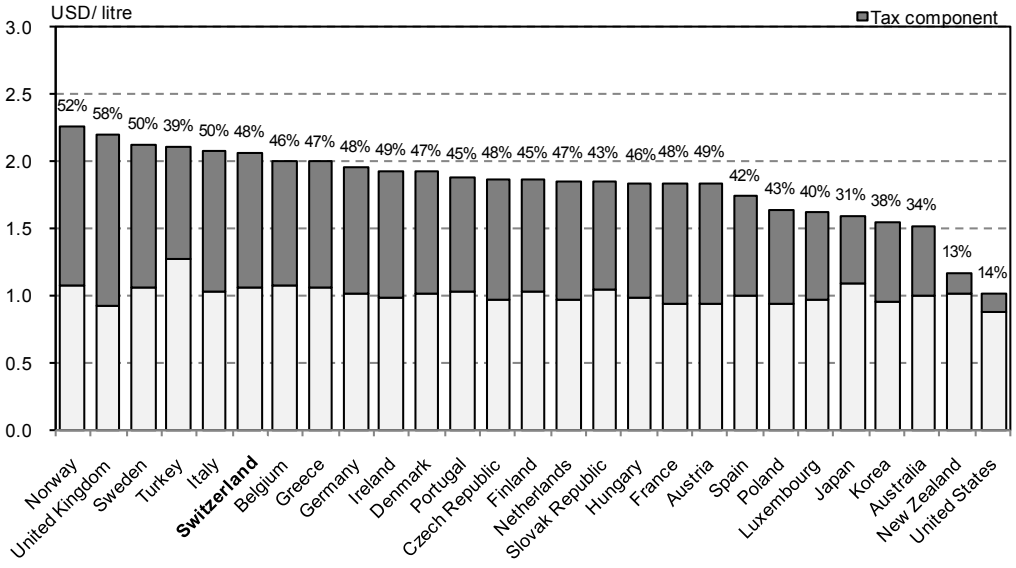
Figure 16. **Unleaded petrol prices and taxes in IEA countries, 4th quarter 2011**



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

Heating oil remains rather inexpensive in Switzerland, although taxes have been increased in the past few years. The CO_2 tax came into force in January 2008 at CHF 12 per tonne of CO_2 and in January 2010 was trebled to CHF 36 per tonne of CO_2, or roughly CHF 0.096 per litre of heating oil, equal to about 10% of the retail price in 2011.

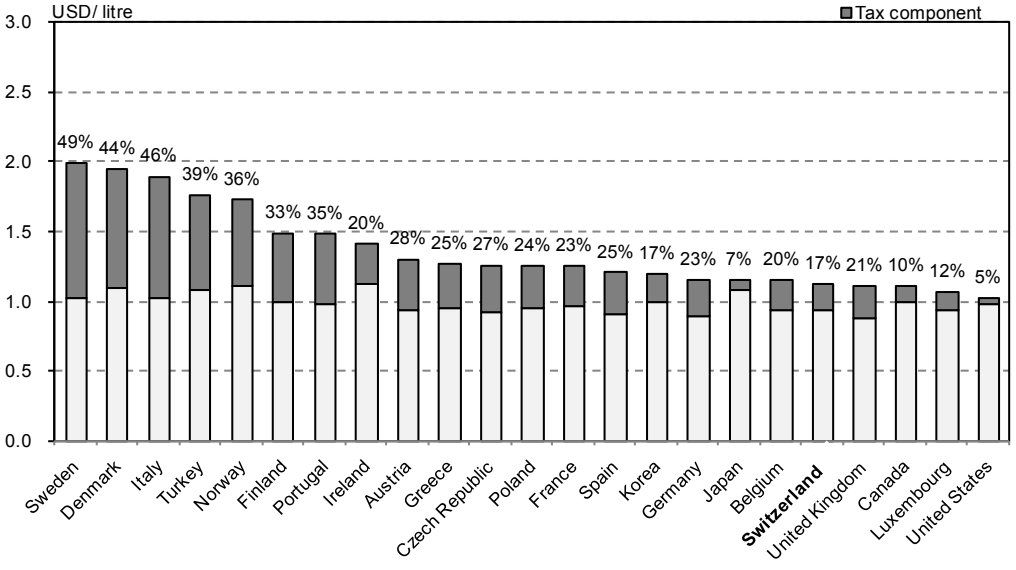
Figure 17. **Automotive diesel prices and taxes in IEA countries, 4th quarter 2011**



Note: Data are not available for Canada.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

Figure 18. **Light fuel oil prices and taxes for households in IEA countries, 4th quarter 2011**



Note: Data are not available for Australia, Hungary, the Netherlands, New Zealand and the Slovak Republic.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2012.

Gasoline prices, too, are lower than in the neighbouring countries (see Figure 16). This is explained by differences in tax rates. In Switzerland, taxes accounted for 50% of the retail price, whereas in Italy and France the share was 57% and in Germany 58%. Low prices in Switzerland lead to fuel tourism from these neighbouring countries. Diesel prices, however, are higher in Switzerland than in the neighbouring countries.

SECURITY OF SUPPLY

STOCKHOLDING REGIME

Switzerland meets its stockholding obligation to the IEA by placing a stockholding obligation on industry. The country does not have public stocks, nor a public stockholding agency.

All oil importers are required to hold a certain amount of stocks of oil products according to their import/sales share. Switzerland does not have a crude oil stockholding obligation. The companies are obliged to hold at least four and a half months of stocks for motor gasoline, diesel and heating oils and three months for jet fuels. Stocks of motor gasoline and heating oil are calculated on the basis of a three-year average of import shares, while stocks of diesel and jet fuel are based on a three-year average of sales shares. These obligatory stocks are usually co-mingled with operating and commercial stocks. Emergency oil stocks are held entirely on the national territory, as Switzerland does not have bilateral agreements to hold stocks on foreign territory.

All oil importers are also required to become a member of a stockholding organisation, CARBURA. It is an industry organisation which co-ordinates importers and other stockholders to implement their obligation. CARBURA is mandated by the government to issue import licences and by its members to manage guarantee funds, pay compensation to stockholders for stockpiling costs and collect statistic data. On behalf of the Administration, CARBURA is asked to verify physical stock levels of each stockholder. The Administration has a legal authority to penalise non-compliant companies.

The importers can delegate up to 50% of their individual obligation to a substitute stockholder. There is one substitute stockholder which is owned by six oil importers as a joint stock company since 2011. As oil importers have some flexibility in the size of their stocks, a Common Stockholder, which is owned by CARBURA, fills the difference between the overall obligation on industry and the sum of stocks held by individual importers and the substitute stockholder. Around 90% of the total compulsory stocks are held by individual importers, while the substitute stockholder and the common stockholder each have 5%.

The National Economic Supply Law (1982) forms the basis for Switzerland's emergency response policy. It provides the government with the statutory power in case of emergency to order demand restraint actions and the release of compulsory stocks, including implementation of IEA collective actions. As for compulsory stocks, the law is complemented by the Ordinance 531.211 of 6 July 1983 on the Main Principles of Stockholding (amended in 2006), the Ordinance 531.215.41 of 6 July 1983 on Establishing Compulsory Stocks on Fuel Oils and Transport Fuels (amended in 2011) and the Ordinance of 8 September 2005 on Releasing Compulsory Stocks of Fuel Oils and Transport Fuels.

DAYS' COVER

Since the previous in-depth review in 2007, Switzerland has consistently met its minimum IEA stockholding obligation, with total stock coverage ranging between 144 and 160 days. Minimum stock levels necessary to cover the 90 days of net imports required by the International Energy Program (one of the founding documents of the IEA) range between 19 mb to 24 mb, depending on the mix of crude and product stocks held. The IEA estimates 28.4 mb was held under Switzerland's stockholding obligation in 2010.

STOCK DRAWDOWN

In case of a supply disruption, the oil companies operating in Switzerland would be affected differently, depending on their supply sources and their supply flexibility. Therefore, compulsory stocks would be released company by company, taking into account their respective supply and delivery obligations. Oil companies would be entitled to make a request for stock release by product. The compulsory stock release would then be calculated according to concrete supply loss of the concerned company.

In case Switzerland participates in an IEA collective action without a factual supply shortage in the domestic market, a voluntary uptake of compulsory stocks would be implemented by importing companies. If Switzerland's international obligations cannot be fulfilled in that voluntary way, the government would try to force the industry to increase liquidity into the market.

Demand restraint is regarded as the secondary emergency response measure to complement the release of compulsory stocks in case of severe oil supply disruptions, which might last longer than six months. With this approach, enough time (six months) would be available to prepare, decide upon and implement demand restraint measures, such as a *pro rata* allocation system for heating oil (Ordinance on Heating Oil Regulation) and a rationing system for transport fuels (Ordinance on Rationing Transport Fuels). According to the severity and anticipated duration of the crisis, light-handed measures like speed limits and Sunday driving bans can be introduced in combination with a stock release.

CRITIQUE

Since the last in-depth review, Switzerland has continued to reduce its dependence on oil. In 2010, oil accounted for 39% of TPES, down from 44% in 2006. This is to be applauded, but more could be done. Oil remains the most important energy source in Switzerland and its share of TPES is still one of the highest among IEA countries. As all oil is imported, further reducing dependence on it would help both to secure energy supplies and to mitigate climate change.

The structure of oil use has changed considerably: heating oil consumption fell by 11% from 2005 to 2010, partly due to the introduction of the CO_2 tax, and that of petrol by 12%, while diesel consumption increased by 35%.

The Climate Cent surcharge (see Chapter 3) is to be replaced by an offset obligation imposed on oil importers starting in 2013. The modalities of this offset are yet to be defined, yet its cost is not to exceed CHF 0.05 per litre of transport fuel. The government expects that most reduction of transport fuel demand and related emissions will stem from the introduction of the European Union's 130 g CO_2 per kilometre average vehicle

fleet regulation. Should the price impact of the offset obligation not be significantly higher than the current Climate Cent surcharge, then external costs of road-based mobility would continue to be inadequately internalised and emissions abatement efforts would remain unevenly spread among sectors. The planned further increases of the CO_2 tax rate on stationary fuels will accentuate the unbalanced burden-sharing among sectors. Concerns about the impact of increasing transport fuel tax levels on tank tourism and hence overall tax revenues have been attenuated by the recent downturn in tank tourism owing to the high exchange rate of the Swiss franc against the euro.

The IEA encourages the government to accelerate the replacement of fuel oil in the existing housing stock through accelerated refurbishment; to further educate landlords as to the benefits of alternative heating options; and, to develop curricula to train refurbishment engineers and craftsmen.

Switzerland is to be commended for its well structured emergency policy and measures, including well-designed allocation and rationing schemes as a complementary measure of stock release. Import structures for both crude oil and oil products are geographically and logistically well diversified, which further enhances security of supply. The government should continue its commendable efforts to maintain and further develop efficient emergency policy, and measures to ensure a smooth implementation of compulsory stock release in case of crisis.

RECOMMENDATIONS

The government of Switzerland should:

- ☐ *Encourage accelerated replacement of oil heating; further educate landlords as to the benefits of alternative heating options; develop curricula to train refurbishment engineers and craftsmen.*
- ☐ *Consider adequately internalising the external costs of transport fuel use.*
- ☐ *Continue commendable efforts to maintain and further develop efficient emergency policy and measures to ensure a smooth implementation of compulsory stock release in case of crisis.*

5. NATURAL GAS

Key data (2010)

Production: none

Share of natural gas: 11% of TPES, 2% of electricity generation

Net imports: 3.0 Mtoe (3.7 bcm) from Germany 68%, France 15%, Netherlands 14%, Italy 3%

Inland consumption: residential 38%, industry 28%, commercial 24%, power generation 8%, transport 1%, others 1%

SUPPLY AND DEMAND

SUPPLY

In 2010, natural gas accounted for 11% of Switzerland's total primary energy supply (TPES) and 2% of electricity generation. Among the IEA member countries, this is the third-lowest share of gas in TPES and the smallest share in electricity generation. Yet natural gas supply has been increasing steadily and, in terms of amount, gas has been the fastest growing energy source over the decade from 2000.

Switzerland imports all of its natural gas. In 2010, imports were 3.0 Mtoe (3.7 billion cubic metres). Imports have increased by 24% since 2000. By country of origin, the Netherlands was the largest supplier, accounting for 26.6% of total imports in 2010. Russia (24%), Norway (23%) and Germany (13%) are other key gas supply sources for Switzerland. By volume, 68% of the total was transported from Germany.

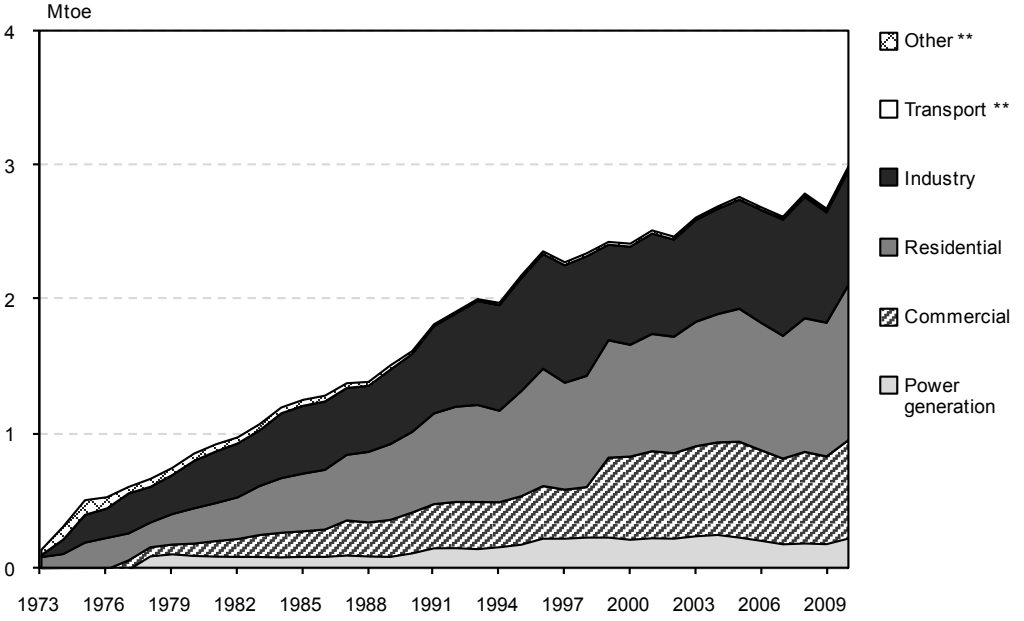
Although Switzerland currently has no natural gas reserves, exploration drilling is underway in Lake Geneva and planned in 2012 at Hermrigen (resources estimated at 15 bcm). The cantons are responsible for issuing oil and gas exploration licences. Although shale gas exploration licences had been granted by the cantons of Vaud and Fribourg, in 2011 both cantons decided to suspend any shale gas operations because of environmental concerns.

DEMAND

Households are the largest natural gas consumer and accounted for 38% (1.2 Mtoe) of the total in 2010. Demand increased by 39% from 2000 and reached a record in 2010 which was a particularly cold year (see figure 19). Industry accounts for 28% of natural gas demand, and increased its demand by 17% over the decade. In the same period, demand in the commercial sector grew by 19% and reached 24% of the total in 2010. Power generation (in decentralised, industrial CHP units) accounts for 8% of gas demand.

Future natural gas demand in Switzerland faces considerable uncertainty, as the government and parliament decided to gradually phase out nuclear power. In one of the electricity supply scenarios, the Energy Strategy 2050 foresees the construction of one combined-cycle gas turbine (CCGT) by 2020 to partially fill the gap between projected electricity supply and demand resulting from the nuclear phase-out. Beyond 2020, up to five more CCGTs may be needed, depending on economic growth and the success and cost-effectiveness of other electricity supply options. In the longer term, possible incremental gas demand by CCGTs of a few bcm is expected to be counterbalanced to some extent by declining residential-commercial gas demand.

Figure 19. **Natural gas supply by sector*, 1973 to 2010**



* Total primary energy supply by consuming sector. *Other* includes other transformation and energy sector consumption. *Industry* includes non-energy use. *Commercial* includes commercial, public services, agriculture, forestry, fishing and other final consumption.

** Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD, Paris, 2011.

LEGAL FRAMEWORK

Switzerland's gas market is open to competition for the largest consumers that are directly connected to the high-pressure grid. Many of the institutions fundamental to a well-functioning market are still to be established and the legal base for market opening is thin. The gas market is partly regulated by the 1963 Pipeline Law.

Article 13 of the 1963 Pipeline Law allows for open third-party access (TPA) to the high-pressure grid, including cross-border transit. Thus, the gas market is open to competition for the largest consumers directly connected to the high-pressure grid. The law entrusts the SFOE with the responsibility for settling disputes over high pressure grid access and tariffs.

Furthermore, the Swiss Gas Association has been self-regulating third-party access to the medium- and low-pressure grids since 2003 through a Gas Industry Agreement, which is binding for all gas operators. However, dissatisfied industry customers filed a case with

SFOE, but later agreed to suspend it, when the Swiss Gas Association offered to negotiate a new agreement with large customers. This new agreement is still being negotiated and should enter into force still in 2012. SFOE will monitor the implementation of the new agreement and has clearly stated that the agreement should not discriminate against small and medium-sized consumers.

Special regulations apply to the construction and operation of the high-pressure gas network. Ensuring that they are duly observed is the responsibility of SFOE, the Federal Pipelines Inspectorate and the Federal Office for the Environment.

At present, gas market regulation has a lower priority than electricity market regulation. SFOE is monitoring development in the gas markets of both Switzerland and abroad. It is working closely together with the Swiss gas industry to evaluate the impacts of the liberalisation of the EU market and gas self-regulation in Switzerland. For the time being, the federal authorities do not intend to introduce new legislation. This option will only be considered under the following circumstances:

- if existing agreements should fail to yield adequate results for the industry;
- if market players (above all, industrial customers) should call for legislation governing network access for third parties; and
- if it should be deemed necessary in view of developments in the European energy sector.

INFRASTRUCTURE

PIPELINES

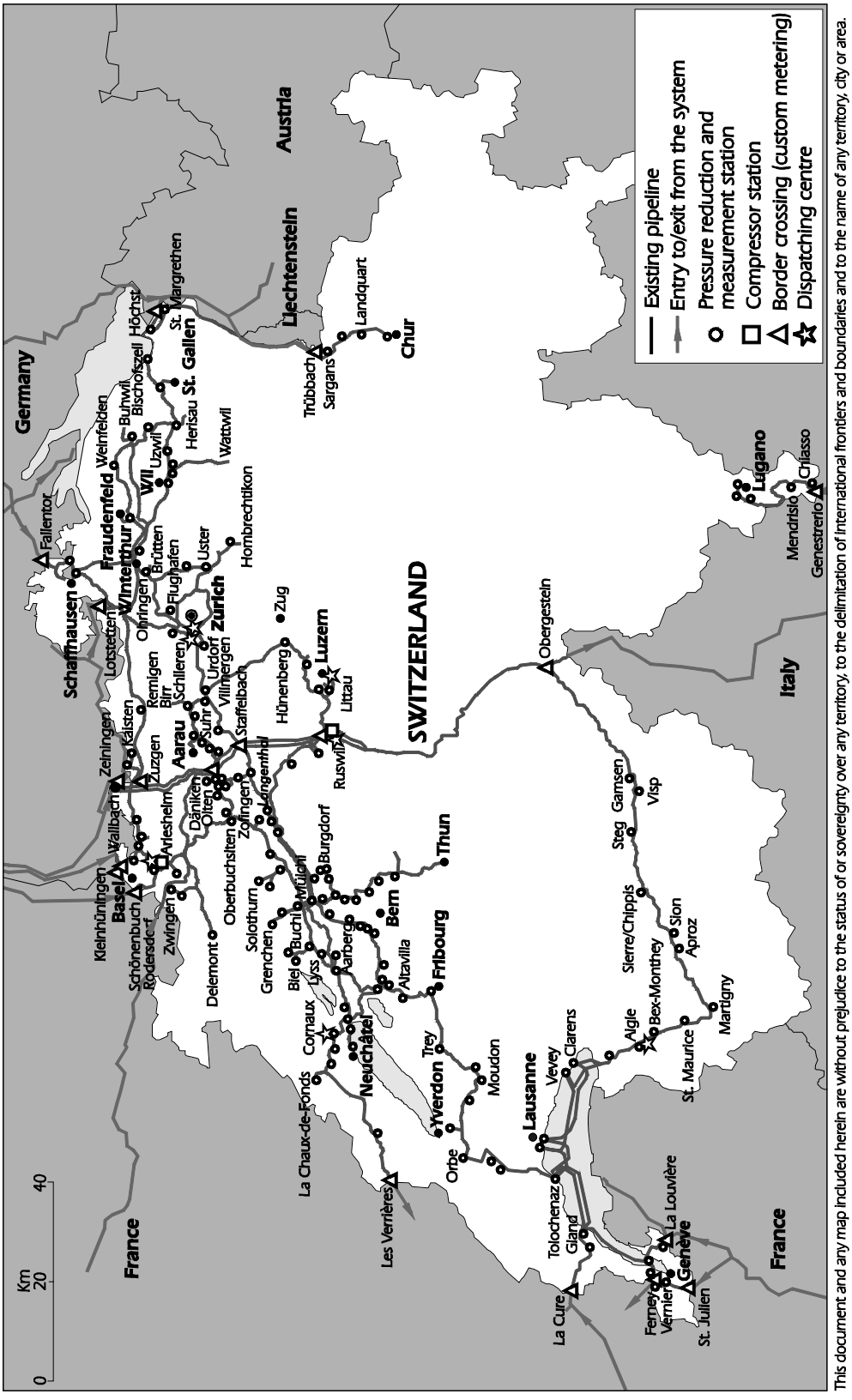
Switzerland has 18 432 km of natural gas pipelines, of which 2 240 km high pressure grid (more than 5 and up to 70 bar), 4 134 km middle-range pressure grids and 12 058 km of less than 1 bar pressure grids. The natural gas network reaches 69% of the Swiss population.

Although Switzerland has 12 cross-border feeding points with the European gas pipeline network, some 70% of Switzerland's gas imports (around 2.6 bcm/y or 7 mcm/d) come through the double entry point of the Transitgas pipeline. The total length of this pipeline is 292 km in Switzerland, from Wallbach (51.5 mcm/d maximum technical capacity) on the German border and Oltingue (19.5 mcm/d) on the French border to Griespass (55.9 mcm/d) on the Italian border. The pipeline is operated by Transitgas AG, which is owned by Swissgas (51% of shares), Fluxys (46%) and E.ON Ruhrgas (3%).

The Transitgas pipeline is used to transport natural gas from the north, primarily from Germany, Norway and the Netherlands, to Switzerland and Italy. While the annual capacity of the pipeline was around 18 bcm in 2010, only 13.5% was used for domestic consumption and the rest transited to Italy. The compressor station in Ruswil has a compression capacity of 60 MW (megawatt) and is the operational centre to maintain and control necessary transporting pressure in Switzerland.

Some expansion to the network is planned or underway. Furthermore, the Transitgas pipeline is being prepared for reverse flow from South (Italy) to North (Germany and France). This will provide a strong degree of resilience in the event of a gas supply disruption north of Switzerland. Reverse flow is scheduled to be operational as from 2015.

Figure 20. **Map of the Swiss high-pressure natural gas network, 2011**



Source: Swissgas.

STORAGE

Switzerland's gas importers are not required to store natural gas, and natural gas storage facilities in the country are mostly in the form of pipelines for daily balancing. However, gas utilities are exploring three projects of potential underground storage sites. A feasibility study for a potential underground storage site in the region of Innertkirchen is under way.

Outside the country, Gaznat SA has a storage capacity in the French underground storage Etrez, which is directly connected to Switzerland's system for the purpose of physical balancing of the Swiss distribution network.

INDUSTRY STRUCTURE

Switzerland has 86 gas utilities, the vast majority of which are akin to the electricity utilities, and are typically local monopolies owned by the cantons and municipalities. They are also often involved in other activities, such as supplying electricity, heat or water. The utilities vary greatly in size. In 2010, the nine biggest, those of the largest cities, sold half of the gas, whereas the 42 smallest utilities accounted for only 10% of total sales.

Vertical integration in gas transmission and distribution is strong. For purchasing gas, the local monopolies together have set up four regional associations: Gasverbund Mittelland AG, Erdgas Ostschweiz AG, Gaznat SA and Erdgas Zentralschweiz AG (EGZ). Each association operates its own high-pressure grid and supplies gas to its owners at cost. The associations, in turn, obtain most of the gas at cost through Swissgas AG, the gas industry's vehicle for imports (see Table 3). Except for EGZ, the regional associations also have direct imports contracts with foreign suppliers.

Table 3. **Shareholders of Swissgas AG, 2012**

Shareholder	Ownership, %
Erdgas Ostschweiz AG, Zurich (EGO)	25.98
Gasverbund Mittelland AG, Arlesheim (GVM)	25.98
Gaznat SA, Lausanne/Vevey	25.98
Swiss Gas Association, Zurich (VSG)	16.45
Erdgas Zentralschweiz AG, Lucerne (EGZ)	5.61

Source: Swissgas.

In 2010, Swissgas AG supplied 53% of total gas imports, followed by Gasverbund Mittelland AG (12%), Erdgas Ostschweiz AG (14%), Gaznat SA (16%) and AIL (3%).

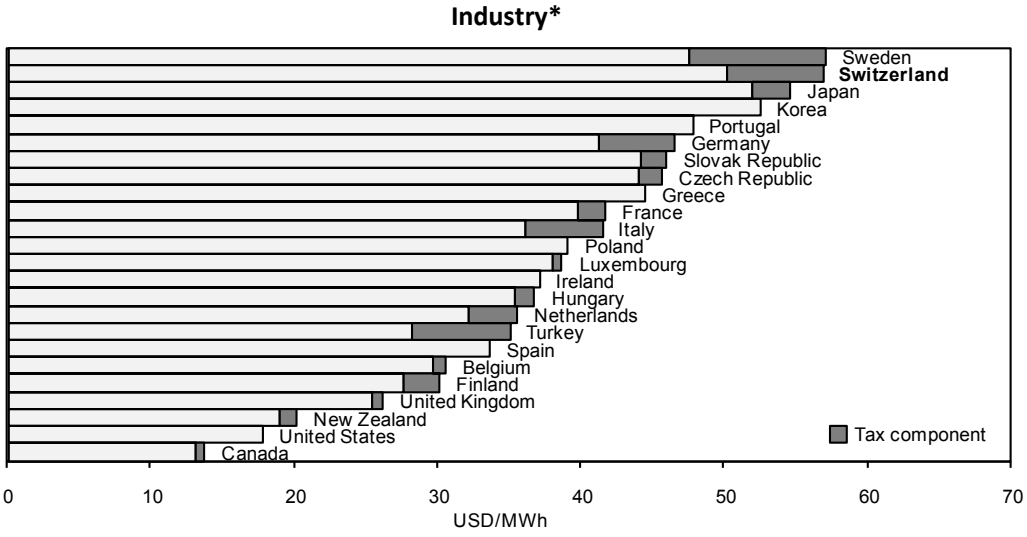
Apart from being the main Swiss gas company, Swissgas is also responsible for handling questions of common interest to the gas industry, such as supply and infrastructure, and represents the Swiss gas industry abroad. Swissgas operates its own high-pressure transmission grid and, through its stake in Transitgas AG, is involved in gas transit.

PRICES AND TAXES

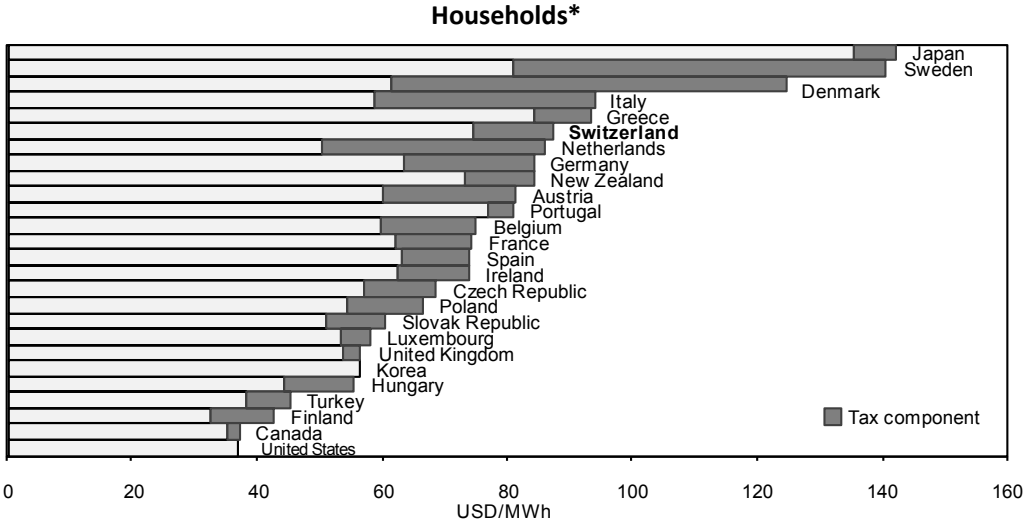
Import prices of natural gas have traditionally been based on long-term contracts and linked to the price of oil. Long-term contracts can potentially cover up to two-thirds of demand. The share of imports bought on the spot markets has been increasing, however, and currently accounts for more than a third of total imports.

Prices paid by all utilities are practically the same, because they obtain the gas through Swissgas and the regional associations at cost. End-use prices, in turn, vary somewhat between utilities. This is largely explained by the local differences in the level of competition from other energy sources.

Figure 21. **Natural gas prices in IEA countries, 2010**



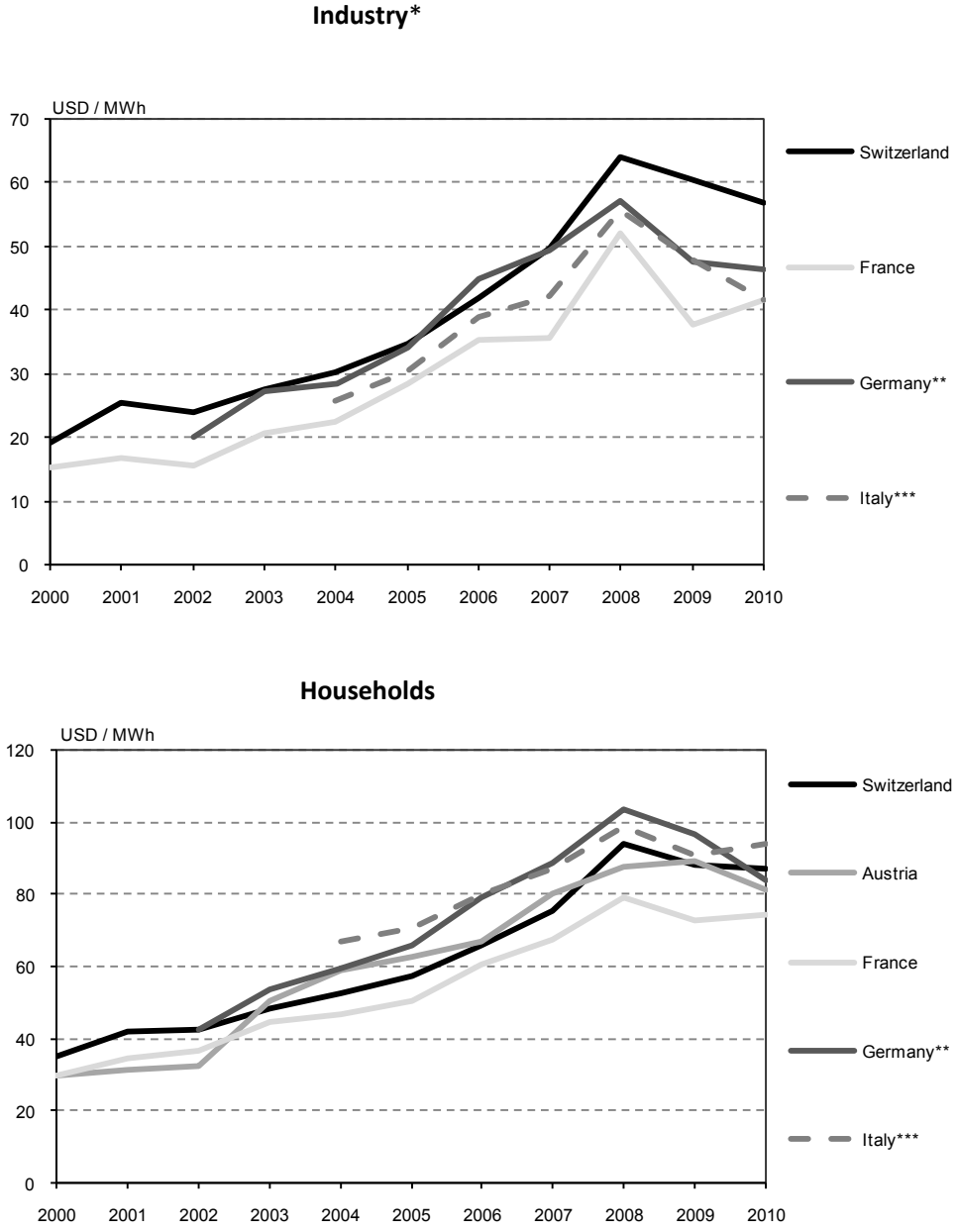
* Tax information is not available for Greece, Ireland, Korea, Poland, Portugal, Spain and the United States. Data are not available for Australia, Austria, Denmark, and Norway.



*Tax information is not available for Korea and United States. Data is not available for Australia and Norway.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2011.

Figure 22. **Natural gas prices in Switzerland and in other selected IEA countries, 1990 to 2010**



* Data are not available for the industry sector in Austria from 2000 to 2010.

** Data are not available for Germany in 2001.

*** Data are not available for Italy from 2000 to 2003.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2011.

In addition to the 8% VAT, which is refundable to businesses, end-users are subject to an excise tax and a special tax used for holding emergency stocks of light fuel oil. Both taxes amount to less than 1% of end-user prices. Natural gas use for heating and as a process

fuel is also subject to the CO_2 tax which came into force in January 2008 at CHF 12 per tonne of CO_2. The CO_2 tax was trebled to CHF 36 per tonne of CO_2 in January 2010, equalling CHF 0.074 per cubic metre, or CHF 6.5 per megawatt-hour.

By international comparison, gas prices in Switzerland are high for industry and slightly more than average for households (see Figures 21 and 22). This is mostly because transport distances from sources are long, distribution companies tend to be small, and large consumers are few. In addition, the gas market is small, implying that the fixed costs of the gas infrastructure, already high in a mountainous country, are spread among fewer customers than in many other countries.

SECURITY OF SUPPLY

EMERGENCY RESPONSE POLICY

The key elements of the Swiss gas security policy are the diversified long-term supply contract portfolio of Swiss gas companies, diversified cross-border intake points with connection to three large natural gas markets (Germany, France, Italy), compulsory stocks of heating oil for fuel switching, an allocation scheme for large consumers and demand restraint measures. The National Economic Supply Law (1982) and the Ordinance 531.215.42 on the stock obligation of natural gas (2003) set the standard of gas supply security for suppliers. All gas importers are requested to fulfil their obligation by taking any one of the following measures:

- holding natural gas stocks;
- holding heating oil stocks;
- delegating the obligation to hold heating oil stocks (instead of gas) to a convenient third party; and
- participating financially in an existing heating oil compulsory stockholding, in proportion to its individual gas stockholding obligation.

As a result, the equivalent of 4.5 months of natural gas consumption is held in the form of heating oil stocks. These heating oil stocks are not categorized as oil emergency stocks. In case of a gas emergency, the Natural Gas Division in the Energy Unit of the Federal Office for National Economic Supply (FONES) has the leading role in co-ordinating the necessary action and maintaining liaison with industry. This division will evaluate an emergency situation and propose necessary response measures to the Delegate for National Energy Supply in co-operation with the concerned authorities and gas industry.

EMERGENCY RESPONSE MEASURES

In the initial stage of a gas emergency, when a shortage of gas supply is anticipated, the first priority is to increase imports from other sources and to switch gas transportation to other unaffected delivery routes. If the gas shortfall cannot be solved with these measures, the government can oblige dual-fuel gas consumers to switch from gas to fuel oil. Switzerland has around 7 000 dual-fuel gas installations, mostly in industry. These dual-fuel units accounted for around 41% of total natural gas consumption in 2010.

The fuel-switching measure may be implemented together with the release of compulsory stocks in the form of heating oil, the fuel most of the dual-fuel gas units in Switzerland can use. The amount of heating oil stocks for gas emergency is around 500 000 m^3 (or about 3.1 mb).

In case fuel switching is not sufficient to compensate for a gas supply shortfall, the government plans to implement an allocation scheme for non-switchable large consumers. However, this measure is currently under preparation. The government plans to clarify the potential saving amount of this allocation scheme.

Regarding small users of gas, such as households, the government, supported by the gas industry, would apply light-handed demand restraint measures, for example appeals to reduce heating temperatures and save warm water.

CRITIQUE

Natural gas has traditionally been used in Switzerland mainly for providing heat for buildings and industry. This is set to change with the nuclear phase-out policy. Increases in gas use are likely, though depending on the number of necessary CCGTs beyond 2020 and demand reductions for space heating. CCGTs can generate reliable baseload power and are relatively energy-efficient. They can also be ramped up and down quickly to complement the output of variable renewable energy which is projected to increase.

Gas market liberalisation remains low on the energy policy agenda. Many of the institutions fundamental to a well-functioning market are still to be established and the legal base for market opening is thin. In view of the close integration of the Swiss gas system into the European supply network, the government should fully explore the benefits of market opening, even though the majority of Swiss consumers appear to be satisfied with current suppliers and prices.

Import sources are well diversified: the government and gas companies are keen to maintain this diversity. According to the Energy Strategy 2050, more gas at affordable prices will be needed in the power sector. Sourcing additional gas will be an important task for Switzerland as Germany, a significant gas transit country for Switzerland, will itself need more gas, following its decision to phase out nuclear power. The government should continue to support preparations for reverse flow of the Transitgas pipeline. The project would enable Switzerland to access pipeline gas from North Africa and possibly the Caspian region and LNG from Italian terminals. It would therefore provide a strong degree of resilience in the event of a gas supply disruption north of Switzerland.

The IEA commends Switzerland for its policy to oblige gas importers to have a heating oil reserve available to be used by dual-fired consumers in times of gas disruptions. The IEA notes, however, that such reserves can only be used by dual-fired consumers, and commends the government's preparation of an allocation scheme for non-switchable large gas consumers. As gas demand increases, Switzerland will have to strengthen its emergency mechanisms. The IEA also encourages the government to regularly review its emergency response measures and strengthen the country's gas storage capacity, if necessary, taking into account the projected increase of natural gas consumption.

RECOMMENDATIONS

The government of Switzerland should:

- *Continue to strengthen emergency response mechanisms in co-operation with the European Union and neighbouring countries, and encourage developments of underground storage in Switzerland and abroad and reverse flow from Italy.*
- *Closely monitor market conditions for non-discriminatory third-party access to gas networks and consider introducing new legislation to encourage more competition.*

6. RENEWABLE ENERGY

Key data (2010)

Share of renewables: 22% of TPES, 58% of electricity generation (IEA averages: 8.0% of TPES, 18.0% of electricity generation)

Hydropower: 11.8% of TPES, 55% of electricity generation

Biofuels[7] and waste: 8.9% of TPES, 3.7% of electricity generation

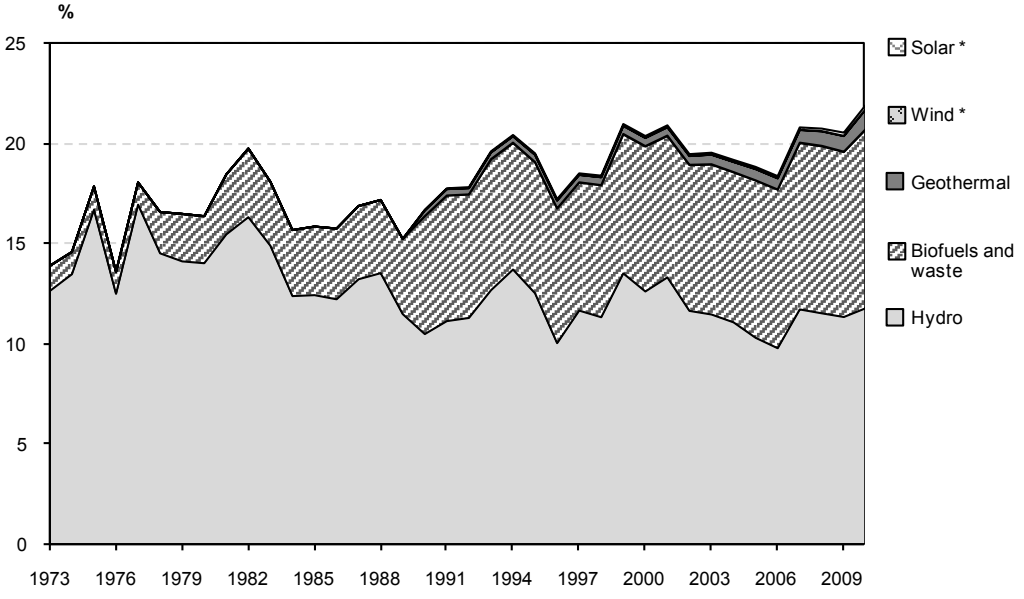
Other renewables: 1.2% of TPES, 0.2% of electricity generation

SUPPLY AND DEMAND

PRIMARY ENERGY SUPPLY

In 2010, renewable energy sources provided 5.8 million tonnes of oil equivalent (Mtoe), 22% of total primary energy supply (TPES) in Switzerland (Figure 23)[8].

Figure 23. **Renewable energy as a percentage of total primary energy supply, 1973 to 2010**



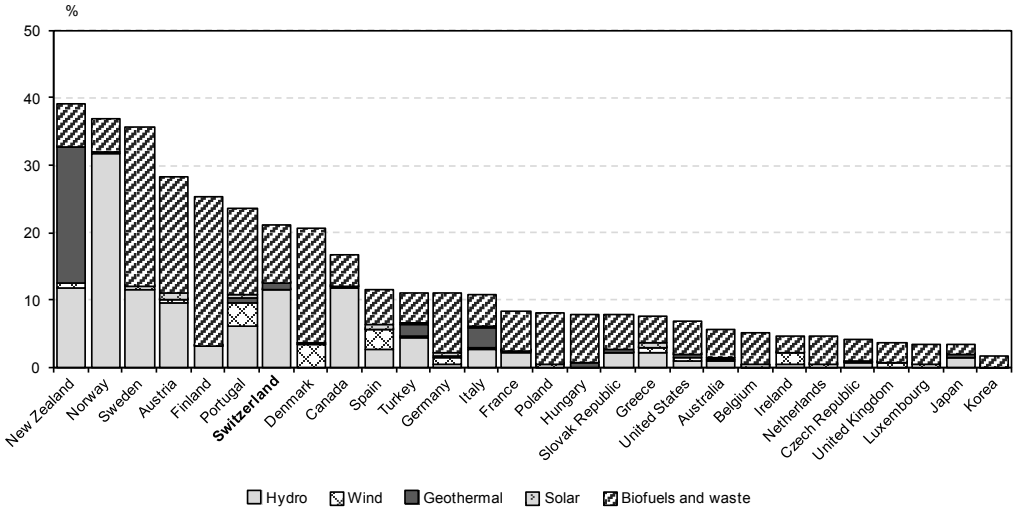
* Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

7. Biofuels and waste = solid and liquid biofuels, biogases, industrial waste and municipal waste.

8. In this report, renewable energy sources include small amounts of industrial waste and non-renewable municipal waste.

Figure 24. **Renewable energy as a percentage of total primary energy supply in IEA countries, 2010**



Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

Hydropower, and biofuels and waste are 95% of the renewables supply. The amount of renewables has increased by 13% since 2000, while the share has remained near 20% of TPES over the decade. Switzerland ranks eighth in the level of renewables in TPES among IEA countries (see Figure 24). Hydropower accounted for 11.8% of TPES, providing more than half of total renewable energy in 2010. The hydro share of TPES slightly decreased from 13% in 2000. Biofuels and waste accounted for 8.9% of TPES (2.3 Mtoe) in 2010, a 30% increase from 1.8 Mtoe in 2000. Geothermal energy (heat pumps) accounted for 1% of TPES in 2010.

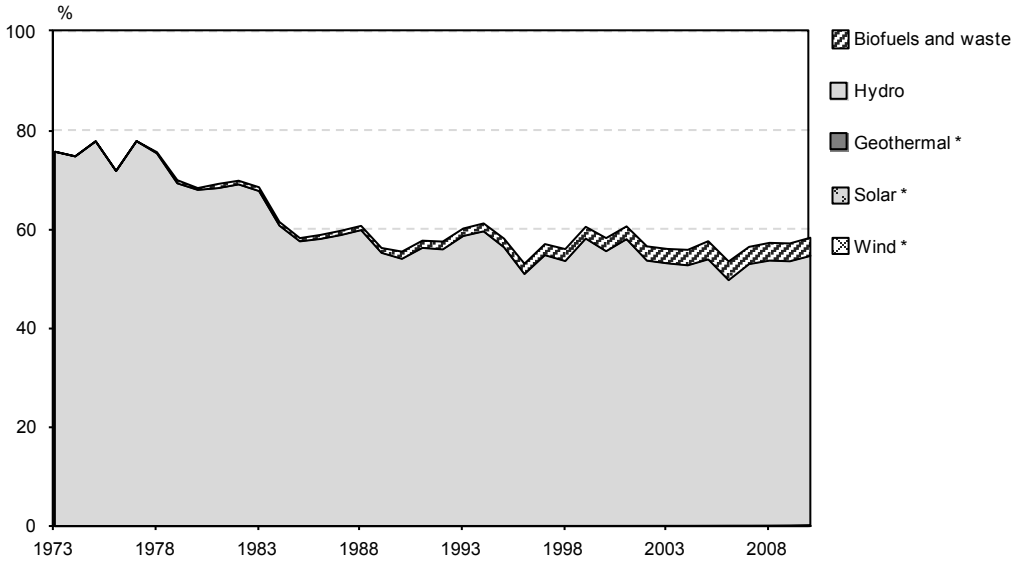
ELECTRICITY, HEAT AND TRANSPORT

Electricity generated from renewable energy sources amounted to 39 TWh, 59% of total power generation in 2010 (Figure 25). Switzerland ranks fifth among IEA countries in power generated from renewable sources (Figure 26).

Hydropower is by far the main contributor at 55% (36 TWh) of total electricity generation in 2010. Hydro accounts for 93% of electricity generation from renewable energy sources. Hydropower generation varies with hydrological conditions, since 2000 between the extremes of 31 TWh in 2005 and 41 TWh in 2001. Biofuels and waste provided 3.7% (2.4 TWh) of total electricity generation in 2010. Generation from wind and solar technologies accounted for 0.2% (0.1 TWh).

Electricity generation from renewable sources increased by about 570 GWh from 2000 to 2010, particularly in the latter years. Generation from large hydro plants has been relatively constant (with variations in the hydrologic cycle) since no new large plants have been built. Over the decade, increased renewables production included municipal solid waste (+300 GWh); biomass (+150 GWh); solar PV (+70 GWh); wind (+30 GWh); biogas from sewage sludge (+20 GWh).

Figure 25. **Electricity generated from renewable sources as a percentage of total generation, 1973 to 2010**

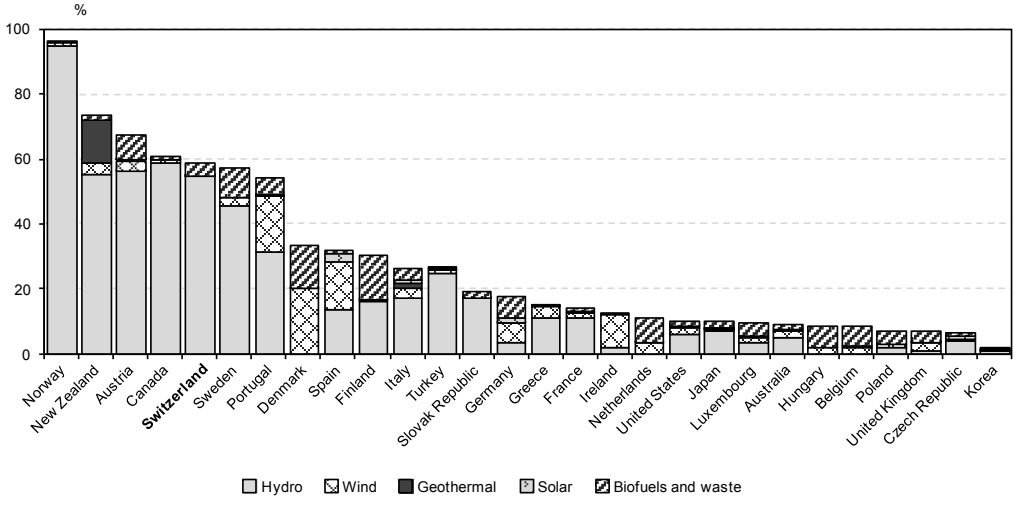


* Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

Switzerland is well endowed with renewable energy resources. The government estimates that hydropower production could feasibly increase by about 8% (3.2 TWh), while a lower estimate of 2 TWh has been suggested by groups concerned about public acceptance. Various studies rate photovoltaic (PV) technical potential at 6 to 17 TWh. Wind resource potential is relatively low (4 TWh) and public acceptance is a concern. Biomass estimates according to the Energy Strategy 2050 are 4.7 TWh (1.9 TWh from biogas (agricultural residues and sewage sludge, 1.1 TWh from wood and 1.7 TWh from municipal waste). Geothermal potential for electricity generation is estimated to be about 4 TWh.

Figure 26. **Electricity generated from renewable sources as a percentage of total generation in IEA countries, 2010**



Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

Box 4. **Geothermal prospects**

Currently, no electricity is produced in Switzerland from geothermal sources, yet there are plans to tap deep aquifers. There is considerable potential for electricity production as well as uncertainties related to feasibility and costs. Experts anticipate that by 2030 a dozen or so power plants will be in operation with a combined output of 800 GWh.

The pioneering Deep Heat Mining project in Basel had an estimated potential of 3 MW_e and 20 MW_{th}. It was abandoned in 2006 after hydro-fracking caused seismic tremors.

Up to CHF 150 million of the grid fees that are collected for the promotion of renewables can be used to cover up to 50% of geothermal exploration risk. First used in September 2011, this mechanism provides CHF 8.3 million as a risk guarantee for the Lavey-les-Bains project. The project has an estimated potential of 3.5 GWh_e/year and 20 GWh_{th}/year. Drilling is to commence in 2012.

Other projects underway or planned include:

- Zurich utility, ewz, drilled a borehole to 2 708 metres in 2010 and found temperatures of 100°C, which is insufficient for electricity production. Initially, the potential had been estimated at 400 MWh/year. A deep heat exchanger was installed in the borehole in 2011.
- The city of St. Gallen is planning a deep geothermal project and has approved financing of CHF 159 million. Seismic investigations revealed a hot aquifer at 4 100 metres. Drilling is to commence in 2012.
- Projects in Thônex, La Côte, Davos and Leukerbad are under consideration.

According to SFOE, heat production from renewable sources reached 13.4 TWh in 2010, an increase of 5 TWh from 2000. Fuel wood accounted for around half of the total and heat pumps for a good fifth. Biomass use (mainly wood) increased by a good 2 TWh, heat pumps by 1.8 TWh, heat from municipal waste by 0.75 TWh and solar by 0.25 TWh. The use of heat from sewage sludge was relatively stable.

According to the IEA, total heat produced from renewable energy sources in combined heat and power (CHP, mainly waste incineration) and heat-only plants (mainly wood) in 2010 was about 5 TWh or 68% of the total renewable heat. This share is very high compared with the IEA average of 16%. Municipal waste was the main renewable energy source for heat production at heat and CHP plants, accounting for 86% of total renewable fuels.

Biofuels accounted for only 0.12% of energy use in transport in 2010.

POLICIES AND MEASURES

TARGETS

The 2008 Electricity Supply Law stipulates that electricity generation from renewable sources should increase by 5.4 TWh by 2030. Switzerland has not set legally binding targets for the volume of other forms of renewable energy, nor does it have targets for the share of renewable energy. However, the Renewable Energy Action Plan of 2007

implies an indicative target of increasing the share of renewable energy in TPES from 16% to 24% by 2020. In the longer term, the Energy Strategy 2050 postulates that a goal to increase electricity generation from renewable sources by 22.6 TWh by 2050 (see Chapters 2 and 7) is feasible.

The SwissEnergy programme, however, included the following goals for the period 2000 to 2010 that were not fixed by law:

- increase heat production from renewable sources by 3%, or 3 TWh;
- increase electricity generation from renewable sources by 1%, or 0.5 TWh; and
- maintain hydropower generation at the 2000 level.

These goals were met. The programme has now been extended to 2020 and its goal is to increase the share of renewable energy in total energy consumption by at least 50% from 2011 to 2020 in agreement with the 2007 Action Plan which aimed at reaching a share of 24% renewable energy in final consumption (calculated by the Swiss statistics method). Also, the increase in electricity demand is to be met through renewable energy as much as possible.

Switzerland and the European Union have been negotiating a bilateral agreement on electricity. The negotiations may also include the EU Renewable Energy Directive and, if concluded, would oblige Switzerland to meet a target for the share of renewable energy in gross final consumption of energy in 2020. According to the methodology used in the directive, the target would approach 35%, while the share today is around 22%.

ELECTRICITY

The 2007 Amendment to the Energy Law contains a package of measures for promoting renewable energy and efficient electricity use. The most significant measure for renewable energy is the cost-reflective feed-in tariff (CRF). It applies to hydropower (up to 10 MW), photovoltaics, wind, geothermal, biomass and waste.

Since January 2009, the feed-in tariffs are banded by technology and specified on the basis of reference facilities for each technology and output category. Remuneration applies for 20 to 25 years, depending on the technology, and is expected to decrease gradually in anticipation of technological progress and more market penetration.

The feed-in tariff is basically the difference between the cost-covering remuneration and the market price. SFOE fixes the market price on which CRF is based (quarterly). Moreover, the feed-in tariffs are adjusted on the basis of SFOE propositions to the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

The feed-in tariff is paid for with a grid levy. The levy has been CHF 0.45 cents per kilowatt-hour generated, bringing the total volume to around CHF 250 million per year. However, the tariff was lowered to CHF 0.35 cents per kilowatt-hour in 2012 since few projects had been brought online. The levy is capped by law at CHF 0.6 cents per kilowatt-hour, rising to CHF 0.9 cents per kilowatt-hour from 2013.

Caps were originally instituted to prevent any single renewable energy technology from draining a disproportionate and economically ineffective share of the total subsidy. Thus, hydropower may not absorb more than 50% of total subsidies; PV could not absorb more than 5% as long as the cost per kilowatt-hour above market price, *i.e.* the feed-in tariff, exceeded CHF 0.50 cents per kilowatt-hour. As the feed-in tariff has decreased,

the share of subsidies to which capped technologies were entitled has increased. Technologies requiring less than CHF 0.30 cents per kilowatt-hour (including PV when its feed-in tariffs fell below that level in 2012) may each capture up to 30% of subsidies.

In 2010, 505 GWh of renewable electricity was generated under the feed-in tariff system. Small hydro amounted to 259 GWh and biomass to 212 GWh. PV generated 21 GWh and wind 13 GWh. The average total remuneration amounts to CHF 20.47 cents per kilowatt-hour, of which CHF 13.61 cents per kilowatt-hour equates to CRF and CHF 6.86 cents per kilowatt-hour equates to the market price. This total funding is CHF 68.8 million.

As of May 2012, waitlisted applications for new renewable electricity facilities amounted to more than 15 000, most of them PV (14 400). Measured in expected power generation, most of the pending projects were wind (1.6 TWh) and hydropower (1.2 TWh). Wind and small hydro projects often clash with laws on nature and landscape protection, and the highest wind energy potential generally lies in environmentally protected areas.

The Energy Strategy 2050 will change the feed-in tariff system. According to the government's proposal in April 2012, the grid levy will be gradually increased from CHF 0.9 cents per kilowatt-hour in 2013 to CHF 1.29 cents per kilowatt-hour in 2020 and CHF 1.82 cents per kilowatt-hour in 2035, assuming that feed-in tariffs will still be necessary. Concurrently, total monies available for feed-in tariffs will rise from CHF 210 million to a maximum of CHF 840 million in 2040. The geothermal risk guarantee is to be increased to CHF 80 million annually for 15 consecutive years. Furthermore, exemption from the grid levy of up to CHF 160 million for energy-intensive industries is pondered.

Furthermore, the cap for feed-in tariffs for all technologies except PV will be lifted. SFOE will consider a special regime for PV. Moreover, for PV installations of less than 10 kW, grants up to 30% of investment cost shall be given instead of feed-in tariffs in order to accelerate their uptake.

In addition to the CRF system, renewable electricity can also be sold directly to consumers who pay a premium for a guarantee of origin. Swissgrid is the accredited issuer of guarantees of origin. This type of sale doubled between 2005 and 2009 to reach 5.7 TWh, most of which is from large hydropower. About 12 GWh was from PV and 8 GWh from wind.

In Switzerland's efforts to increase renewable energy use in electricity and heating, the federal government, cantons, cities and communes are to lead by example. They should meet their own electricity and heating needs through renewable sources of energy and apply the principle of "best practice" in all fields.

HEAT

According to the model building regulations of the cantons (MuKEn[9]), at least 20% of the total heating energy in new buildings should come from renewable sources, *e.g.* heat pumps, wood pellet stoves and solar thermal technologies, or improved energy efficiency.

This standard has stimulated market penetration of renewable energy technologies, particularly for heat pumps in new buildings. They have a market share close to 80% for single family houses. Between 2000 and 2010, the number of heat pumps almost tripled from 67 000 to 177 000 units.

9. *Mustervorschriften der Kantone im Energiebereich* (MuKEn); Model Cantonal Building Prescriptions.

Financial incentives are offered for replacing fossil fuel-based heating systems with heat pumps and other renewable energy technology. Subsidies come from a portion of the CO_2 tax that is earmarked for such purposes at the federal level and funding from the cantons. This funding is delivered according to the harmonised funding model, updated in 2010, which creates a level playing field for the cantons and is supervised by SFOE. In order to participate, a canton needs to have a corresponding legal basis and must supply at least half of the funding. By 2011, all 26 cantons had promulgated the legal basis to participate.

Grants of CHF 147 million for renewables and energy efficiency in buildings were paid in 2010 according to the harmonised funding model, up from CHF 115 million the previous year. Of the funds in 2010, CHF 62 million were allocated for renewable heat, mainly for solar thermal and wood. Out of the CHF 147 million total, grants of CHF 98 million were funded by the cantons and about CHF 48 million co-financed by the earmarked CO_2 levy (maximum CHF 67 million available), plus CHF 1.3 million for indirect measures such as education and information activities from SwissEnergy.

TRANSPORT

The government is using tax policy to promote the use of biofuels in transport. Since 2008, biofuels that fulfil strict environmental criteria are exempt from the excise tax on motor fuels.[10] The administrative hurdles regarding the proof of ecological criteria have been lowered since 2011, *i.e.* by allowing the use of default values. Yet potential changes to the criteria await a report expected in 2012, "Reduction of CO_2 Emissions by Mixing Biofuels and Transportation Fuels".

No other subsidies or incentives apply. Switzerland does not have a biofuels quota. The share of biofuels is very low and there is only minor domestic production. There are no trade barriers for biofuel imports according to Swiss legislation, which is in line with World Trade Organization rules.

CRITIQUE

Switzerland has abundant renewable energy resources and generates more than half of its electricity from hydropower. The decision to gradually phase out nuclear power has triggered a new energy strategy, including accelerated deployment of renewable energy, aiming at a significantly higher share in final energy consumption by 2050. This will have important knock-on effects in terms of power market design, electricity trade, transmission grid development and storage.

Since 2009, electricity generation from renewable sources has been supported by banded feed-in tariffs that are funded from a grid levy which is passed on to all electricity consumers. The absolute amount of support available is capped for each technology. However, only PV deployment has been limited by its cap. In contrast, many wind and small hydro projects, though eligible for feed-in tariff support, have been delayed, often by public opposition and constraints under nature conservation laws.

The government's proposal of April 2012 to gradually triple the levy for funding the feed-in tariffs by 2020 and to remove the caps on funding for individual technologies, to rise the geothermal risk guarantee more than five-fold, as well as to opt for investment

10. Here, biofuels include biogas, bioethanol, biodiesel, vegetable and animal oils.

subsidies for small PV, will multiply the funding potentially available and should accelerate renewable energy deployment. Measures to streamline or simplify consenting processes are also very welcome, as barriers to the use of renewable energy sources are often non-technical.

Switzerland's measures to better integrate variable generation, such as solar and wind, include opening up the provision of ancillary services to market forces so as to reduce the cost of reserves. The integration of the DSOs into an active grid management will need to be stepped up in the next three to five years as distributed production might increase. However, highly decentralised consumption patterns in Switzerland mean that the electricity grid is already well equipped to manage larger amounts of distributed generation relative to more centralised countries. The Energy Systems of the Future thread of the research programme of the Energy Strategy 2050 will be a valuable opportunity to evaluate the trade-offs among different responses to variability on the supply side. Business models for smart grid roll-out need to be better understood and communicated to the owners of the transmission and distribution networks.

In residential heating, fuel oil represents half of all energy use. The 2007 Action Plan, which focused on heat production in particular, encourages the replacement and displacement of fuel oil with heat pumps. These are widely accepted and fitted in some 80% of new houses, but replacement of fuel oil systems in the existing housing stock is slow. The government's moderate renewable heat targets for 2010 (3% more heat, 3 TWh) have been exceeded. Since 2010, the CO_2 tax has also addressed the building sector. Co-ordination of strategy at the national and cantonal levels remains an important factor, as the cantons have the lead on building codes and building refurbishment.

Transport represents 32% of energy consumption and more than half of the fossil fuels in overall energy supply. Renewable energy continues to have an insignificant role in decarbonising the road transport sector in Switzerland, as other measures, such as an enhanced public transportation system and shifting freight from road to rail, are considered more sustainable and cost-effective. The government should continue to monitor the sustainability and cost-effectiveness of transport sector measures and reconsider the role of renewable energy, if merited.

RECOMMENDATIONS

The government of Switzerland should:

- *Ensure that the feed-in tariff rate for renewable energy technologies keeps pace with production cost reductions and that any changes to the established support mechanisms maintain investor confidence.*
- *Assess more precisely the feasibility of exploitation of renewable energy resources, accounting for public acceptance and delays in site planning.*
- *Monitor the need for a more active management of low-voltage distribution grids to enable increasing quantities of distributed generation and efficient use of the networks.*

7. NUCLEAR ENERGY

Key data (2010)

Number of plants in operation: four plants with five reactors

Installed capacity: 3.3 GW

Electricity generation: 26.4 TWh (40% of total generation)

OVERVIEW

Switzerland has five operating nuclear power reactors at four sites. In 2010, they generated 26.4 TWh of electricity, or about 40% of the country's electricity needs (see Table 4). The remaining 60% is almost entirely generated by hydropower plants.

The first nuclear power plant (NPP) in Switzerland (Beznau-1) began commercial operation in 1969, while the latest plant (Leibstadt) was commissioned in 1984 (see Table 4). Owing to increasing opposition to nuclear power since the 1970s, two other nuclear projects, for which sites had already been approved, were abandoned.

Table 4. **Nuclear power plants in operation in Switzerland, 2011**

NPP	Type	Commissioning date	Original net capacity (MW_e)	Latest net capacity (MW_e)	Electricity generation in 2010 (TWh)
Beznau-1	PWR WH – 2 loops	1969	350	365	2.67
Beznau-2	PWR WH – 2 loops	1971	350	365	2.85
Gösgen	PWR 3 Loop	1979	920	985	8.02
Leibstadt	BWR 6	1984	960	1190	8.77
Mühleberg	BWR 4	1972	306	373	3.00

Note: BWR = boiling water reactor; PWR = pressurised water reactor; WH = water heating.

Source: International Atomic Energy Agency (IAEA) Power Reactor Information System.

Over the course of operation, the Swiss nuclear reactor fleet has generated more than 770 TWh of practically CO_2-free baseload electricity. As a combined heat and power plant Beznau also provides 80 MW of heat capacity to industry and homes in 11 towns over a 130 km network. Gösgen NPP supplies process heat (thermal power equivalent of 45 MW) for industrial applications and heat for district heating in the nearby communities.

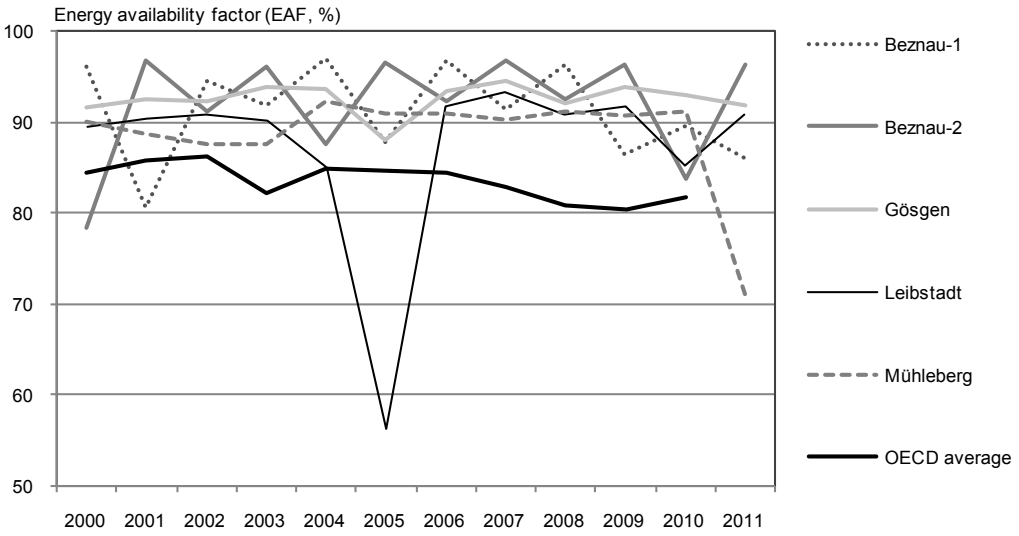
The Swiss nuclear reactor fleet has one of the highest capacity[11] and energy availability[12] factors among OECD countries. Average lifetime capacity factor is more than 85%

11. Capacity factor is the ratio between the electricity supplied and reference power generation.

12. Energy availability factor is the ratio between the electricity that could have been supplied and reference power generation.

(see Figure 27). All Swiss NPPs have had power uprates, in total adding about 500 MW_e gross generating capacity. In the short term, additional uprates are likely to be small and result from applying advanced fuel technologies.

Figure 27. **Energy availability factor of the Swiss nuclear power plants, 2000 to 2011**



Source: International Atomic Energy Agency Power Reactor Information System.

Swiss NPPs are owned by a mix of public and private partners. Beznau and Mühleberg are owned and operated by single public utilities, whereas Gösgen and Leibstadt are owned by multiple electric utilities. Significant stakes are owned by large companies, such as Alpiq, Axpo and BKW (see Table 5).

Table 5. **Ownership of the Swiss nuclear power plants, 2011**

NPP	Ownership
Mühleberg	100% BKW
Beznau-1	100% Axpo
Beznau-2	100% Axpo
Gösgen	40% Alpiq 25% Axpo 15% Energie Wasser Zürich (EWZ) 12.5% Centralschweizerische Kraftwerke (CKW) 7.5% Energie Wasser Bern (EWB)
Leibstadt	27.4% Alpiq 22.8% Axpo 16.3% EGL 13.6% CKW 9.5% BKW FMB Beteiligungen 5.4% AEW Energie 5% Alpiq Suisse

Source: Swiss Federal Office of Energy.

Switzerland has no domestic nuclear fuel-cycle industry and the operators of Swiss NPPs source nuclear fuel and services from the following suppliers of nuclear fuel:

- Mühleberg NPP procures natural uranium and services of separation and production of fuel rods. They are supplied by General Electric and produced at the subsidiary GNF-A in Wilmington, United States.
- Beznau and Gösgen NPPs procure exclusively ready-to-use nuclear fuel, supplied by AREVA and produced at MSZ (Mashinostroitelny Zavod) in Russia.
- Leibstadt NPP procures enriched uranium and services of production of fuel rods. In the past, AREVA was the supplier with production in Lingen, Germany. Today the supplier is again Westinghouse in Västerås, Sweden.

The safe handling and disposal of all radioactive wastes are the responsibility of the waste producers. Spent fuel is either stored in pools at reactor sites, at ZWIBEZ intermediate storage facility (Beznau) or at the centralised interim waste storage facility ZWILAG located in Würenlingen. Before 2006, some used fuel was sent to France and the United Kingdom for reprocessing. Since mid-2006, reprocessing has been halted for a ten-year period following the entry into force of the 2005 Nuclear Energy Law.

LEGAL FRAMEWORK

The Swiss policy on nuclear power has changed several times over the past couple of decades:

- Following a referendum in 1990, a ten-year moratorium on building new nuclear plants and other nuclear facilities was introduced.
- In 2003, two public votes reinstated the use of nuclear as an option for the future (refusal to extend the 1990 moratorium and rebuttal of a nuclear power ban).

After two years of parliamentary debate, a new Nuclear Energy Law (NEL) was adopted in March 2003 and entered into force in February 2005, along with a new Nuclear Energy Ordinance (NEO). The new Act kept the nuclear energy option open, addressed key issues related to radioactive waste management, including a ten-year moratorium on reprocessing spent fuel as of 1 July 2006, and empowered the Federal Department of the Environment, Transport, Energy and Communications (DETEC) to authorise construction, operation and decommissioning of NPPs.

The licensing procedure for new NPPs set out in the NEL was estimated to take about 16 to 18 years between receiving a proposal to build and the end of construction. Three licences would have been required:

- First, the federal government would issue a general licence that determines the site and the main features of a nuclear facility, *i.e.* the reactor system, output category, and main cooling system.
- After this, DETEC issues technical licences for the construction and operation of nuclear facilities.
- The general licence would be voted by parliament. As any parliamentary vote, it would be subject to an optional national referendum. The technical licences would be subject to court appeal.

As from 2007, the three largest Swiss utilities (Axpo, Alpiq and BKW) started projecting new plants to replace the Beznau and Mühleberg NPPs which are expected to be decommissioned around 2020. Before the Fukushima Daiichi accident, public opinion was roughly split 50/50 over new NPPs.

Following the Fukushima Daiichi accident in March 2011, the Swiss government decided not to allow the replacement of decommissioned reactors. The key motivation for this decision was that, according to the Nuclear Energy Law, licenses for new NPPs would have been subject to more than likely referendums. In the wake of the Fukushima Daiichi accident, the public opinion had massively turned against new NPPs, dashing the chances of having nuclear new builds approved by popular vote around 2014 – as foreseen by the pre-Fukushima Daiichi licensing schedule.

By September 2011, both Chambers of Parliament had endorsed the government's decision to gradually phase out nuclear power. However, parliament voted against an outright technology ban and mandated that Switzerland continue research into all energy sources, including nuclear.

LIFETIME OF NUCLEAR POWER PLANTS

Assuming that the phase-out policy is maintained, and that the operational lifespan of NPPs is 50 years, Beznau I could stop operation in 2019, followed by Beznau II and Mühleberg in 2022, Gösgen in 2029 and Leibstadt in 2034. However, a binding "operational lifetime" of NPPs does not exist in Switzerland. The power plants of Beznau, Gösgen and Leibstadt have unlimited operating licences. In the case of Mühleberg, DETEC's 2009 decision to grant it an unlimited operating licence was overruled by the Federal Administrative Court in March 2012, which ordered plant closure in 2013; the ruling of the Federal Administrative Court has been appealed before the Federal Supreme Court by DETEC as well as by the plant operator BKW.

Nuclear plants are allowed to operate as long as they meet the safety criteria defined by the Swiss legal and regulatory framework, supervised by the Swiss Federal Nuclear Safety Inspectorate (ENSI), and as long as the licensee is willing to continue its operation. The nuclear safety stress tests recently conducted showed that the safe operation of Swiss NPPs is currently assured. Thus, nuclear power plants in Switzerland will continue their operation but it is not yet possible to know exactly for how long.

NUCLEAR SAFETY

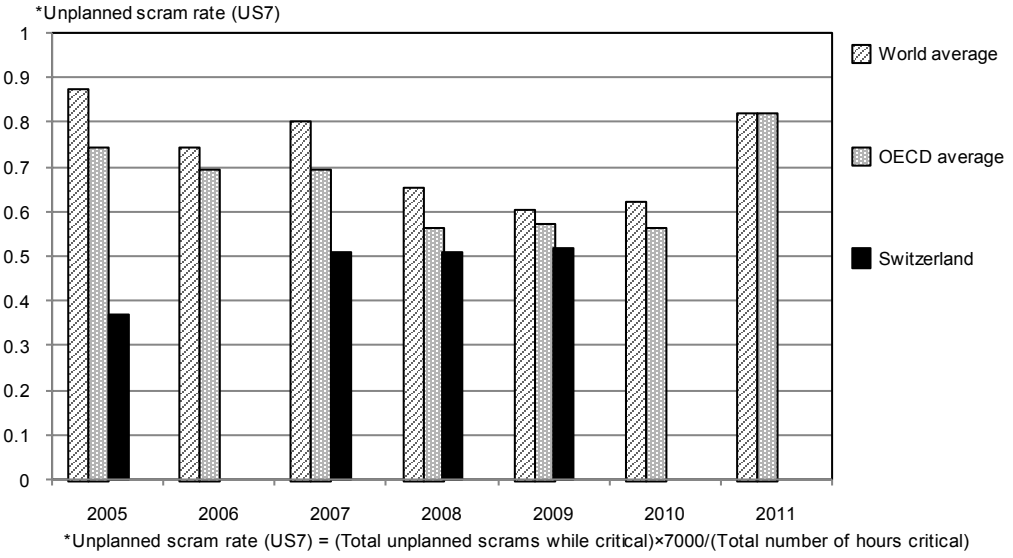
Compliance with the legal requirements on nuclear safety is verified and enforced by an independent nuclear regulator: the Swiss Federal Nuclear Safety Inspectorate (ENSI). After the adoption of the Law on the Federal Nuclear Safety Inspectorate in 2007, the former regulatory agency HSK was turned into an independent agency in 2009, and so complying with the requirements of the 2005 Nuclear Energy Law and the International Convention on Nuclear Safety stipulating that regulators should be independent bodies. ENSI is supervised by an independent board, the ENSI Board, elected by the Federal Council and reporting directly to it.

ENSI is responsible for the supervision of safety and security at all Swiss nuclear facilities, *i.e.* the nuclear power stations, the interim storage facility for radioactive waste and the

nuclear research facilities. It regulates the safety and security aspects of the facilities over their whole lifecycle, including the early planning stages, operation, decommissioning and the radioactive waste disposal. ENSI also supervises the transport of radioactive materials to and from nuclear facilities and is involved in the siting of deep geological repositories for radioactive waste.

In the period covered by this review, ENSI has rated the operation of Swiss nuclear facilities as safe. The number of unplanned reactor shut-downs (scrams) has also been low, and it is significantly lower than the average rates in OECD countries and in the world (Figure 28).

Figure 28. **Unplanned scram rate in Switzerland compared to OECD and world averages, 2005 to 2011**



Note: There were no scrams in Switzerland in 2006, 2010 and 2011.

Source: International Atomic Energy Agency (IAEA) Power Reactor Information System.

After the March 2011 Fukushima Daiichi accident, ENSI took measures to verify the level of safety at Swiss NPPs (see Table 6). The safety reassessments focused on plant design in respect of earthquakes, external flooding and the combination of both events, as well as on the coolant supply for the safety and auxiliary systems and the spent fuel pool cooling.

Some immediate measures were ordered, including setting up an external storage facility for emergency equipment, and plant-specific connections and back-fitting of feed lines for the external supply of the spent fuel pools. The external storage facility is a former bunkered munitions depot of the Swiss Army at Reitnau. The equipment stored at Reitnau is transportable by helicopter to any location in Switzerland.

Also, Swiss operators were ordered by ENSI to take part in the European Union stress test. On the basis of reviews conducted to date, ENSI concluded that Swiss NPPs demonstrate a high level of protection against the impacts of earthquakes, flooding and other natural hazards, as well as against loss of electrical power and ultimate heat sink. However, ENSI and the utilities have identified a number of open points.

Table 6. **Investigations and back-fitting measures for the Swiss NPPs after the Fukushima Daiichi accident**

Date	Type	Subject
18 March 2011	Order	First order by ENSI ordering a design reassessment related to the provisional shut-down criteria with regards to earthquakes and flooding, a reassessments of cooling water supply and spent fuel pools, and the implementation of immediate measures regarding emergency management
31 March 2011	Report	Operators' submission of data on the design of the cooling water supply and of the spent fuel pools
1 April 2011	Order	Second order by ENSI to define the conditions for the design reassessment related to the provisional shut-down criteria
5 May 2011	Order	Third order by ENSI with the review results on the reports submitted by the operators on 31 March 2011 and additional conditions derived therefrom in connection with the improvement measures to be submitted on 31 August 2011, and with the requirement for additional proof for the spent fuel pools
1 June 2011	Implementation	A shared external storage facility for emergency equipment was set up by the operators
1 June 2011	Order	Fourth order by ENSI asking the operators to perform the assessments of the EU stress test
30 June 2011	Proof	Operators' submission of revised proof of safety in case of flooding
15 August 2011	Report	Operators' submission of progress reports on the EU stress test
31 August 2011	Statement	Statement by ENSI regarding the review results on the proof of safety in case of flooding submitted on 30 June 2011
31 August 2011	Report	Operators' submission of improvements to cooling water supply and spent fuel pools
15 September 2011	Statement	Statement by ENSI regarding the EU stress test progress reports submitted on 15 August 2011
31 October 2011	Report	Operators' submission of final reports for the EU stress test (operators' reports)
15 November 2011	Statement	Statement by ENSI with the review results regarding the improvement measures submitted on 31 August 2011
21 November 2011 2 December 2011	Statement	Statement by the International Atomic Energy Agency regarding the Integrated Regulatory Review Service mission to ENSI
30 November 2011	Proof	Operators' submission of documents related to seismic resistance
31 December 2011	Statement	Statement by ENSI with the review results on the EU stress test final reports (operators' reports) submitted on 31 October 2011
31 March 2012	Proof	Operators' submission of revised proof of safety in case of earthquakes and combination of earthquake and earthquake-induced dam failure
30 June 2012	Report	Submission of operators' reports on protection against hydrogen deflagrations and explosions in the area of the spent fuel pool
30 June 2012	Statement	Statement by ENSI with the review results on the proof of seismic safety submitted on 31 March 2012
30 September 2012	Statement	Statement by ENSI with the review results on the reports submitted on 30 June 2012 concerning protection against hydrogen deflagrations and explosions in the area of the spent fuel pools
31 December 2012	Implementation	Back-fitting of connections for mobile external emergency equipment

Source: EU Stress Test – Swiss National Report, amended.

WASTE DISPOSAL AND DECOMMISSIONING

The organisation in charge of nuclear waste disposal is the National Cooperative for the Disposal of Radioactive Waste (NAGRA). It was formed in 1972 by the nuclear power plant operators and the government responsible for the management of radioactive waste from nuclear activities in medicine, industry and research.

The total amount of nuclear waste from different origins in Switzerland is expected to amount to 99 015 m^3, most of which will be low and intermediate-level waste (see Table 7). There is no national policy regarding reprocessing or direct disposal of used fuel. Before 2006, some of the spent nuclear fuel was reprocessed by AREVA at the La Hague plant in France and by BNFL at Sellafield in the United Kingdom. The separated plutonium was used at the Beznau and Gösgen NPPs, and the fission products were vitrified. The 2005 Nuclear Energy Law halted reprocessing for ten years, starting from mid-2006. Used fuel is now retained at the reactors or sent to ZWILAG for interim above-ground storage and managed as high-level waste.

Table 7. **Swiss nuclear waste origin and predicted volumes (assuming a 50-year operational lifetime of NPPs)**

Type and origin	Share
High-level waste (HLW) packaged for disposal (7 325 m^3)	7.4%
NPP operational and reactor wastes (26 000 m^3)	26.3%
NPP decommissioning waste (28 265 m^3)	28.6%
NPP reprocessing waste (1 320 m^3)	1.3%
Waste from spent fuel encapsulation plant (2 220 m^3)	2.2%
Medicine, industry and research (10 090 m^3)	10.2%
Decommissioning waste, mainly research (23 000 m^3)	23.2%
ZWILAG* operational and decommissioning waste (795 m^3)	0.8%

* Intermediate storage facility for the spent nuclear fuel in Switzerland.

Source: NAGRA.

The general policy regarding nuclear waste disposal consists of building a geological repository for the low- and intermediate-level waste (LILW) and high-level waste (HLW). Research on deep geological waste disposal is done at two underground rock laboratories. This research aims to demonstrate the feasibility of safe nuclear waste disposal. The government approved the demonstration of the feasibility for the LILW repository in 1978 and for the HLW repository in 2006.

The process of selecting sites for nuclear waste disposal follows a Sectoral Plan procedure within the framework of legislation on spatial planning. The Sectoral Plan for Deep Geological Repositories came into effect in April 2008. Six areas have since been identified as suitable, and the final decision is expected to be taken at the federal level

approximately in 2022. This decision will be subject to an optional national referendum. Under the current schedule, the repository for LILW is expected to be operational around 2035 and the one for HLW around 2050.

Representatives of the communities and cantons of the six suitable sites are invited to participate in working groups and committees, including specially set up regional conferences foreseen in the siting process. However, the locals cannot veto the decision to site a repository in their area.

In accordance with the polluter-pays principle, waste producers are required to fund the safe disposal of all nuclear waste. This includes the costs of reprocessing until 1 July 2006, NAGRA activities, investigations and interim storage facilities. Two funds, one for waste management and another for decommissioning, are financed by the NPP operators with an average contribution of about CHF 0.01 per kilowatt-hour of nuclear power produced.

The costs of waste management and decommissioning of nuclear facilities are evaluated every five years in order to guarantee an adequate level of funding. According to estimates made by the Swiss Federal Office of Energy (SFOE) in November 2011, the total cost for decommissioning all Swiss NPPs and the ZWILAG intermediate storage facility would be CHF 2.974 billion, 17% more than in the previous estimate in 2006. The decommissioning fund was established in 1984, and at the end of 2010 it held CHF 1.331 billion.

Radioactive waste management costs are projected to be CHF 15.970 billion, about 10% more than in the 2006 estimate. The Swiss waste management fund was created in 2000, and it will eventually cover CHF 8.447 billion of the total costs, the spare amount being covered by ongoing payments. At the end of 2010, it held CHF 2.821 billion.

CRITIQUE

Together with hydropower, nuclear power forms the basis of Switzerland's low-carbon electricity supply. Following the Fukushima Daiichi accident, however, the country has changed its policy regarding the future of nuclear power and will not allow the replacement of the existing reactors at the end of their lifetime.

However, in September 2011 parliament voted against an outright technology ban and mandated that Switzerland continue research into all energy sources, including nuclear. The energy policy implications of this decision are being worked out as part of the work on the Energy Strategy 2050.

Since the last IEA in-depth review in 2007, and before the Fukushima Daiichi accident, some noteworthy steps have been taken in the nuclear arena. Most importantly, the Swiss Federal Nuclear Safety Inspectorate (ENSI) was detached from SFOE and established as a fully independent body in 2009. The process of selecting sites for deep geological repositories of nuclear waste is successfully moving ahead. Six potential areas for high-level waste (HLW) and low- and intermediate-level waste (LILW) have been identified on the basis of safety criteria. Under the current schedule, the repository for LILW is expected to be operational around 2035 and the HLW around 2050. Commendably, the government is paying close attention to ensuring that costs associated with the decommissioning of nuclear power plants and final waste disposal are accurately assessed every five years and that adequate mechanisms exist to fund these costs.

The decision not to allow new builds implies only a gradual and slow phase-out of nuclear energy, because, by law, the operators may continue to use their nuclear power

plants as long as the safety criteria defined by the Swiss legal and regulatory framework, supervised by ENSI, are met. There is no binding operational lifetime in Switzerland, and it is thus not possible to foresee the precise end of the operational lifetime of Swiss NPPs.

However, rapid policy changes bring uncertainty to industry and challenge its ability to maintain and attract a skilled workforce. It will therefore be important to know well in advance the most likely period when nuclear power plants will cease operation in order to ensure the availability of sufficient and timely human and financial resources for the safe operation and decommissioning of the plants, and in order to support the associated research and development.

The government should therefore engage with the industry to ensure a well-planned future implementation of the agreed policies. It should also inform the public and stakeholders on ongoing and intended refurbishment programmes at NPPs, and other activities related to the long-term operation of plants. At a general level, the public should be informed in an objective and transparent manner on benefits and challenges of using nuclear power in Switzerland, in order to enhance confidence in the operation of the existing plants and to support the activities of the regulator.

Nuclear power is controversial in several countries, especially in light of the Fukushima Daiichi accident. However, NPPs in Switzerland are expected to continue their operation for a long time. Building public confidence in nuclear power will require clearer messages and more information on long-term operation of nuclear power plants.

RECOMMENDATIONS

The government of Switzerland should:

- ☐ *Work with the industry to increase confidence in the safe operation of the existing nuclear power plants.*
- ☐ *Promote dissemination of detailed information to stakeholders and the wider public on intended and ongoing refurbishment programmes at NPPs, and other activities related to their long-term operation.*
- ☐ *Continue to show leadership in building nuclear waste repositories and developing mechanisms for further public involvement in the siting process.*
- ☐ *Ensure that sufficient human and financial resources are available for the safe operation and decommissioning of nuclear power plants, and for supporting the associated R&D.*

8. ELECTRICITY

Key data (2010)

Installed capacity: 19.6 GW

Total gross electricity generation: 66.1 TWh

Electricity generation mix: hydro 55%, nuclear 40%, biofuels[13] and waste 4%, natural gas 2%

Peak demand: 10.4 GW

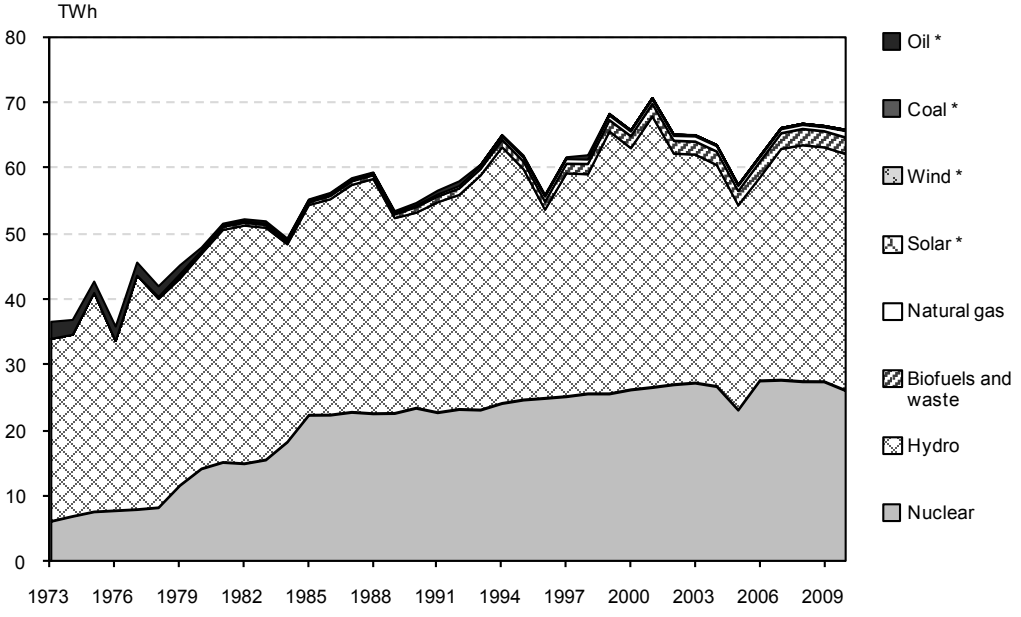
Inland consumption: industry 32%, residential 31%, commercial 30%, transport 5%, other 2%

SUPPLY AND DEMAND

GENERATION

In 2010, total electricity generation was 66.1 TWh, down marginally from 66.6 TWh the previous year (Figure 29).

Figure 29. **Electricity generation by source, 1973 to 2010**



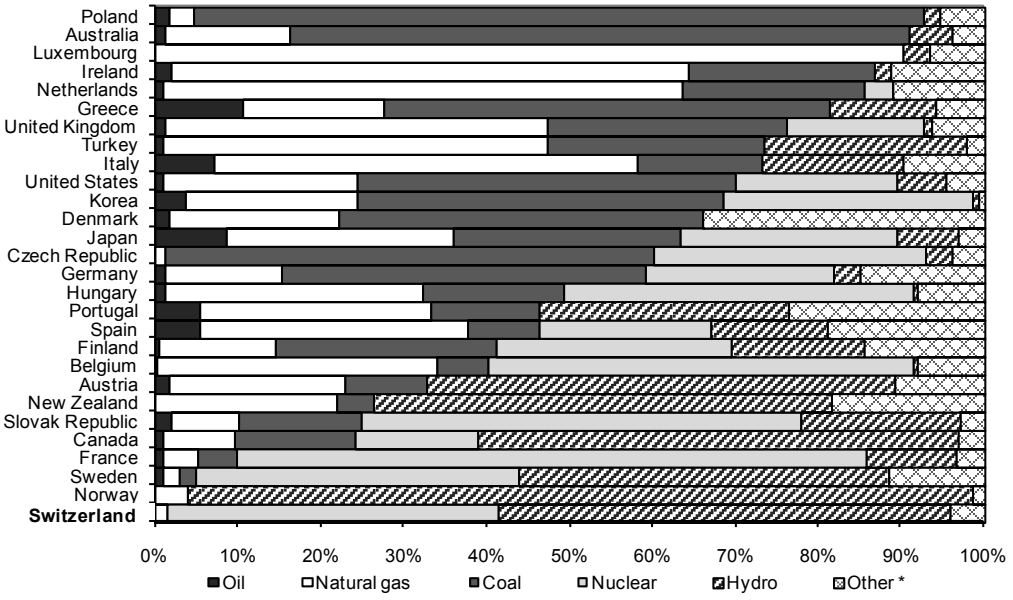
* Negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

13. Biofuels and waste = solid and liquid biofuels, biogases, industrial waste and municipal waste.

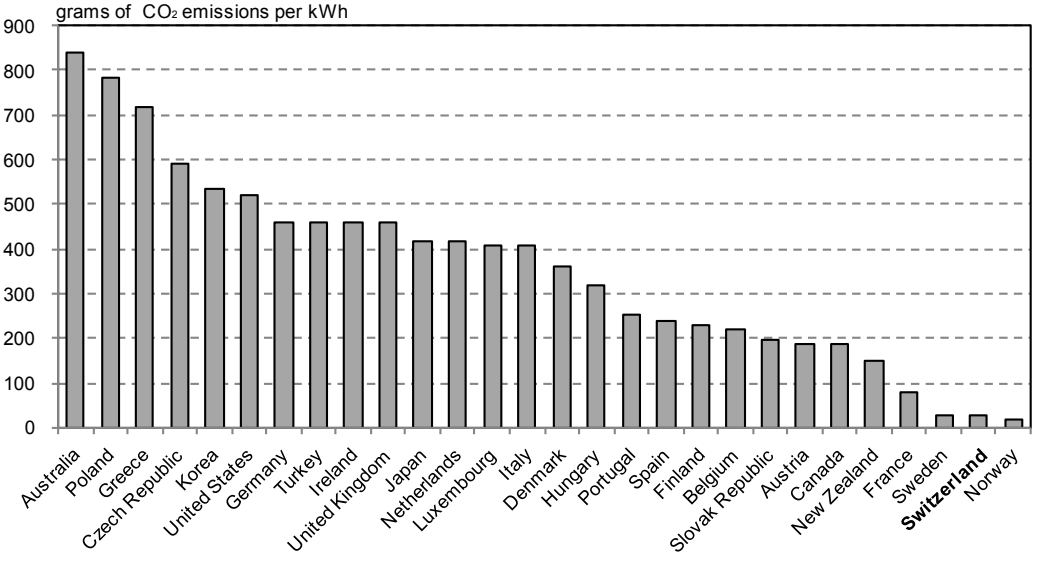
Hydropower is the largest source generating 36 TWh, 55% of total generation. Nuclear power is the second-largest source, providing 26.4 TWh, 40% of total generation. Together hydro and nuclear have continuously provided around 95% of total electricity generation in recent decades. Biomass and waste (4%) and natural gas (2%) accounted for most of the rest in 2010. Switzerland ranks fifth in the share of renewables and has the lowest share of fossil fuels in electricity generation among IEA countries (Figure 30).

Figure 30. **Electricity generation by source in IEA countries, 2010**



* *Other* includes geothermal, solar, wind, and ambient heat production.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2011.

Figure 31. **CO_2 intensity of electricity generation in IEA countries, 2010**



Note: Electricity generated from CHP plants is included.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2011.

Electricity generation varies from year to year, accentuated by changes in hydrological conditions. Over the last decade, total electricity generation has ranged from a high of 71 TWh in 2001 to a low of 57 TWh in 2005, with hydropower contributing 41 TWh in 2001 and 31 TWh in 2005.

Electricity generation in Switzerland produces the second-lowest CO_2 emissions kilowatt-hour in the IEA member countries. Only Norway has a lower carbon-intensity (Figure 31).

CAPACITY

According to the Swiss electricity statistics, at the end of 2009, total installed generating capacity was 19.6 gigawatt (GW), or a 3.4% increase from 2000. Hydropower capacity was 15.3 GW, or 78% of the total, while nuclear capacity was 3.2 GW. Hydropower capacity comprised both run-of river and storage plants and also included 1.8 GW of pumped storage plant capacity. Total hydro storage capacity lies at 8 765 GWh, and storage plants have on average accounted for around 55% of total annual hydro generation over the past ten years.

Typically, run-of-river hydro generation is at its lowest in spring and highest in summer, while hydro storage capacity is used for generation mostly in winter time. Nuclear production is at its lowest during summer months, when NPPs are shut down for annual revision.

The decision to gradually phase out nuclear power will significantly affect Switzerland‘s power generating capacity over the next 20 years. Assuming that the NPPs had a lifetime of 50 years (but this may be more, depending on whether they meet the legal and regulatory safety criteria), Switzerland would have to replace around 2.7 TWh by 2019, another 5.9 TWh by 2022, another 8 TWh by 2029 and another 8.8 TWh by 2034 (assessed on the basis of current generation, see Table 4 in Chapter 6). The options for filling the gap are more domestic generation, imports and energy efficiency.

The 2008 Electricity Supply Law sets a target of 5.4 TWh of additional renewable electricity (including 2 TWh of large hydro) by 2030. The Energy Strategy 2050 banks on an environmentally feasible enhancement of 3.2 TWh of hydropower generation by 2050 (1.5 TWh new large hydro, 1.6 TWh new small hydro, 1.5 TWh uprating existing plants, less 1.4 TWh owing to waterways protection regulation constraints). The strategy also includes gas-fired power, for peak supplies, and about 2 TWh of small combined heat and power (CHP) as winter baseload. Currently, the requirement for full a compensation of CO_2 emissions is holding back investments in CCGTs (see Chapter 3).

IMPORTS, EXPORTS AND TRADE

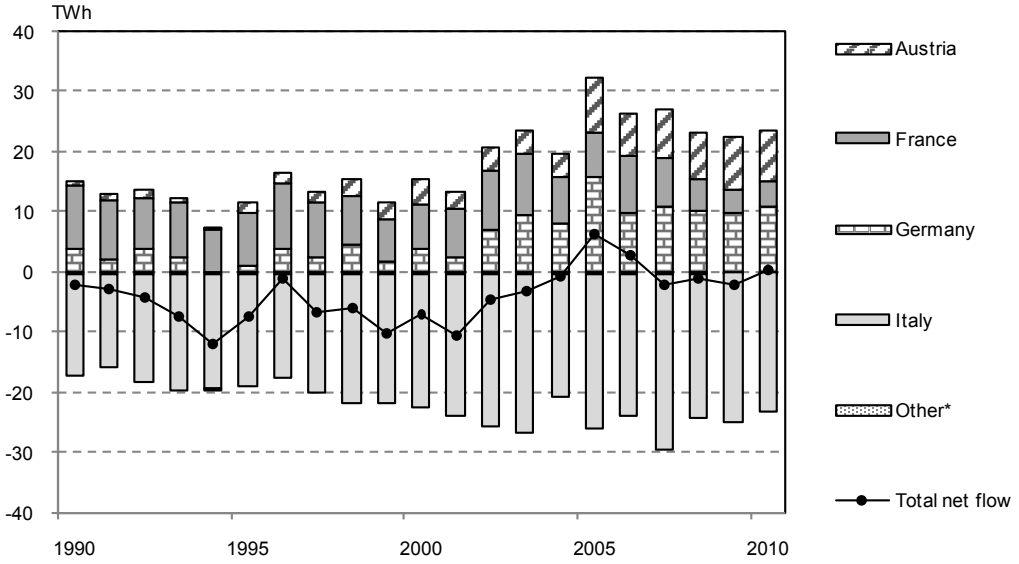
Switzerland is a major player in electricity transit and cross-border trade. It is favourably located in the centre of Europe and has built up an adequate generation mix for trading and efficient network use. Over the past several decades, it has been a net exporter on an annual basis, with the exceptions of 2005, 2006 and 2010. However, the country is a net importer during winter months (October to March) when hydro availability is low. In winter, imports correspond to around 15% of domestic generation, depending on the year.

In 2010, Switzerland was a slight net importer of electricity (see Figure 32), with 33.4 TWh imported from Germany (44% of the total), France (29%) and Austria (24%).

Switzerland exported 32.9 TWh to Italy (72% of the total), France (17%) and Germany (11%). Imports from Switzerland are crucial for Italy, accounting for 8% of the country's total electricity supply and half of imports in 2009.

Switzerland is an important peak electricity producer. The country's water storage capacity, equivalent to 8 765 GWh, provides the operational flexibility to meet demand both at home and abroad during peaking periods. Water is accumulated in the reservoirs during off-peak hours, and then used for power production during peak hours. Already for 2020, about 6 GW of additional hydropower pump and storage capacity, including 4 GW pump capacity are planned, including the 1 GW Linth-Limmern and the 600 MW Nant de Drance which are under construction and the 1 GW Lago Bianco project.

Figure 32. **Swiss net electricity imports and exports by country, 1990 to 2010**



* Negligible. Annual net exports to Liechtenstein from 1990 to 2010 ranged from 0.06 TWh to 0.31 TWh.

Source: *Electricity Information*, IEA/OECD Paris, 2011.

In 2010, Swiss electricity companies exported 66.1 TWh and imported 66.6 TWh, at a total profit of CHF 1.3 billion. On average, the selling price was 36.6% higher than the buying price, according to the 2010 Swiss electricity statistics by SFOE.

Exports are mostly based on short-term and spot contracts. In 2010, long-term contracts (duration of more than two years) accounted for 9% of the total, down from 16% in 2005. In recent years, around half of the imports have been based on long-term drawing rights (duration of more than five years), mainly from the 2 455 MW available at French nuclear power plants.

DEMAND

In 2010, electricity demand was 60 TWh, an increase of 4% from the previous year and up 11% from 2000. Electricity was 24% (5.1 Mtoe) of total final energy consumption in 2010. Electricity demand is historically linked with GDP, but efficiency measures should stabilise demand according to the Energy Strategy 2050.

Over the last decade, all sectors have contributed to the growth in electricity demand. In 2010, the residential, commercial and industry sectors each accounted for about 19 TWh or 32% of electricity demand. About 5% of electricity consumption is in the transport sector.

Consumption is highest in winter and peaks in the morning and in the evening at around 10 to 11 GW. On top of this peak consumption, Switzerland is exporting at a capacity of around 2 to 3 GW during the day and importing at a capacity of 2 GW at night, mainly for pumping and domestic demand (saving peak capacity).

LEGAL FRAMEWORK

2008 ELECTRICITY SUPPLY LAW

The 2008 Electricity Supply Law (ESL) is the main law in the electricity sector. It is a major step in reforming Switzerland's electricity market. It established an independent regulator and an independent transmission system operator (TSO). It stipulates open and non-discriminated access to the grid and requires the utilities to separate the accounting of the distribution activities from their other activities. To accommodate concerns over security of supply, it also includes provisions for customer protection and public services obligations. The ESL is largely based on the relevant EU legislation.

The ESL opens the Swiss electricity market for competition in two phases. End-users with an annual consumption of more than 100 MWh have been free to choose their supplier since October 2008. The first phase of market opening covers roughly 50% of electricity consumption. Proceeding to the second phase, all end-users will be free from 2015, unless they wish to remain with their incumbent supplier. However, the second phase is subject to a facultative referendum. Consumers may in general choose between a regulated or a market price.

The ESL established a regulator, the Electricity Commission (ElCom). ElCom is responsible for ensuring compliance with the law and, in particular, monitors grid access and conditions for grid use. ElCom also controls *ex post* all grid tariffs and the energy tariffs in the regulated scheme. ElCom also monitors the cross-border congestion management of the TSO and the use of revenues from cross-border capacity auctions (see Box 5).

The ESL also established a TSO for operating and supervising the national high-voltage transmission grid (220/380 kV). Swiss utilities, owning the high-voltage network, were obliged to legally unbundle the grid from their other activities by 1 January 2009 and must hand over their grid assets to the TSO by the end of 2012. Transmission system operation must be transparent and access to the network non-discriminatory. The TSO publishes tariffs and other conditions of network access and use.

The ESL is planned to be revised to address shortcomings, kindle market opening and accommodate the outcome of the ongoing negotiation over an electricity agreement between Switzerland and the European Union.

OTHER FEDERAL LAWS RELEVANT TO ELECTRICITY

In addition to the ESL, other federal laws relevant to the electricity sector are the 1902 Law on Electricity, the 1916 Law on the Use of Hydropower Resources, the 2005 Nuclear Energy Law and the 2007 amendment to the Energy Law (see Chapters 5 and 6).

The 1902 Law on Electricity regulates the construction, operation and maintenance of networks and power plants. The focus of the 1916 Law on the Use of Hydropower Resources is clear from the title. The law includes regulations on the royalty tax on water use, which is levied by the cantons.

The Energy Law was revised in spring 2007 to increase feed-in tariffs for generation from new installations. Feed-in tariffs have since been revised. Most recently, in April 2012, the government, when presenting the Energy Strategy 2050, decided to increase total levies available for feed-in tariffs in the years to come as a response to the looming electricity supply challenge following the nuclear phase-out decision (see Chapter 5).

The 1995 Cartel Law is also highly relevant to the electricity sector. It stipulates that a dominant position may exist, if an enterprise has a position of strength on the market relative to its competitors, especially if the other enterprises are dependent on it for structural reasons. Compliance with the Cartel Law is monitored by the Competition Commission.

SUB-FEDERAL REGULATION

Cantons and municipalities have their own regulations on market entry, end-user prices and quality and conditions of service. Traditionally, cantonal legislation has focused on energy efficiency, promoting renewable energy sources and technical and safety issues. Competition has not been a priority. Cantons issue licences for power plant use. The exceptions are hydropower plants on the Swiss border and nuclear power plants, which require licences from the federal government. Cantons also issue licences for water use at hydropower plants. Furthermore, cantons and municipalities decide how to organise electricity distribution in their territory. Typically, distribution has been entrusted to a monopoly utility, often owned by the canton or municipality itself.

Box 5. **ElCom**

When the Electricity Supply Law entered into force on 1 January 2008, the Federal Electricity Commission (ElCom) was formally entrusted with the task of supervising the liberalisation of Switzerland's electricity market. As an independent regulatory authority at the federal level, ElCom is responsible for supervising the smooth transition from a monopoly situation in the electricity supply sector to an electricity market based on the principles set out in the ESL. ElCom has to ensure that the liberalisation of the market does not result in unauthorized tariff increases. ElCom also has to supervise that security of supply is guaranteed by monitoring the network infrastructure planning and use.

ElCom has been entrusted with judicial powers so that it can effectively perform its various duties. It monitors compliance with the provisions of the Electricity Supply Law and the Energy Law, and can pronounce legally binding decisions and rulings as necessary.

ElCom has the following specific duties:

- To verify the electricity tariffs of customers who are in the regulated scheme. It is authorised to prohibit unjustified increases in electricity prices, or may order the reduction of excessively high tariffs. It may take action on the basis of complaints or in its official capacity.

Box 5. **ElCom** (continued)

- To mediate and pronounce rulings on disputes relating to access to the electricity network. With effect from 1 January 2009, large-scale consumers can freely choose their electricity supplier. Small-scale consumers will only have access to the free market from 2015, assuming that no referendum should be called opposing the full liberalisation of the electricity market.
- To rule on disputes relating to feed-in tariffs to be paid to producers of electricity from renewable energy sources with effect from 2009.
- To monitor the situation in electricity networks with respect to security and efficient use of the network.
- In the case of congestion on cross-border transmission networks, to regulate the allocation of network capacities and co-ordinate its activities with the European electricity market regulators.
- To ensure that the high-voltage network is handed over to the national Transmission System Operator (Swissgrid) according to schedule (separation process).

Elcom has been an observer to the Council of European Energy Regulators (CEER) since January 2012. This is important, because although integration of cross-border electricity markets in Europe and Switzerland is advancing, ElCom is not a member of ACER (the EU Agency for the Co-operation of Energy Regulators).

ELECTRICITY AGREEMENT WITH THE EUROPEAN UNION

Switzerland and the European Union have been negotiating an electricity agreement since 2007. The original aim was to regulate cross-border electricity transmission, mutual market access and the recognition of declarations of origin for electricity from renewable energy sources. With the introduction of the European Union's third liberalisation package and the EU Renewables Directive 2009/28/EC, the scope of the negotiations was expanded. Consequently, Switzerland adapted its negotiation mandate in autumn 2010 to include renewables and to provide for the possibility of negotiating other relevant energy matters at a later stage, such as gas security, energy infrastructure and energy efficiency. Negotiations are currently ongoing and complexity has increased. Their outcome is uncertain, since they are overshadowed by the broader issue of how bilateral agreements between Switzerland and the European Union are to be structured in future (institutional and horizontal issues). Negotiations so far have focused on issues relating to electricity market, mainly on:

- market opening in Switzerland (partial until now, full subject to referendum in 2015);
- exemption of long-term contracts with France from auctioning at the Swiss-French border;
- participation of Swissgrid in the European Network of Transmission System Operators for Electricity (ENTSO-E) and of ElCom in the Agency for the Cooperation of Energy Regulators (ACER);
- compatibility of Swissgrid's foreseen legal status with any of the three models provided for in the third package (ownership unbundling, independent system operator, independent transmission operator);

- unbundling of distribution system operators (DSOs);
- merchant lines between Switzerland and neighbouring countries;
- exploratory talks on renewable energy.

INDUSTRY STRUCTURE

Switzerland has about 850 utilities. In annual sales volume, they range from 100 MWh to more than 10 TWh. Most of them, some 800, are small local distributors and suppliers, operating at the municipal level as a local monopoly.

Three large vertically integrated groups: Axpo14, Alpiq and BKW account for more than 50 TWh, or roughly 80%, of generation in Switzerland and are the main suppliers for the distribution companies. They are the largest owners of the Swiss high-voltage transmission grid and are also major distributors. They also jointly own many of the largest power plants. They all operate at the supra-cantonal level and are very active in international electricity trading.

Most Swiss electricity companies are partly or wholly owned by the public sector. According to SFOE's annual electricity statistics, in 2010, the electricity sector companies were 85% publicly owned (56% by the cantons, 29% by municipalities). Private Swiss ownership was 7.7%, while foreign owners held 7.2% of the total, among them EDF, E.ON and EnBW. Of the three largest companies, Axpo is 100% public sector-owned and the other two (Alpiq and BKW) are in mixed ownership.

The number of Swiss electricity companies has decreased from some 1 200 in the mid-1990s to some 850 in 2010. Consolidation has affected also the largest groups, as one of the big three, Alpiq, was created at the beginning of 2009 in the merger of Atel (Aare-Tessin AG für Elektrizität) and EOS (Energie Ouest Suisse).

TRANSMISSION AND DISTRIBUTION

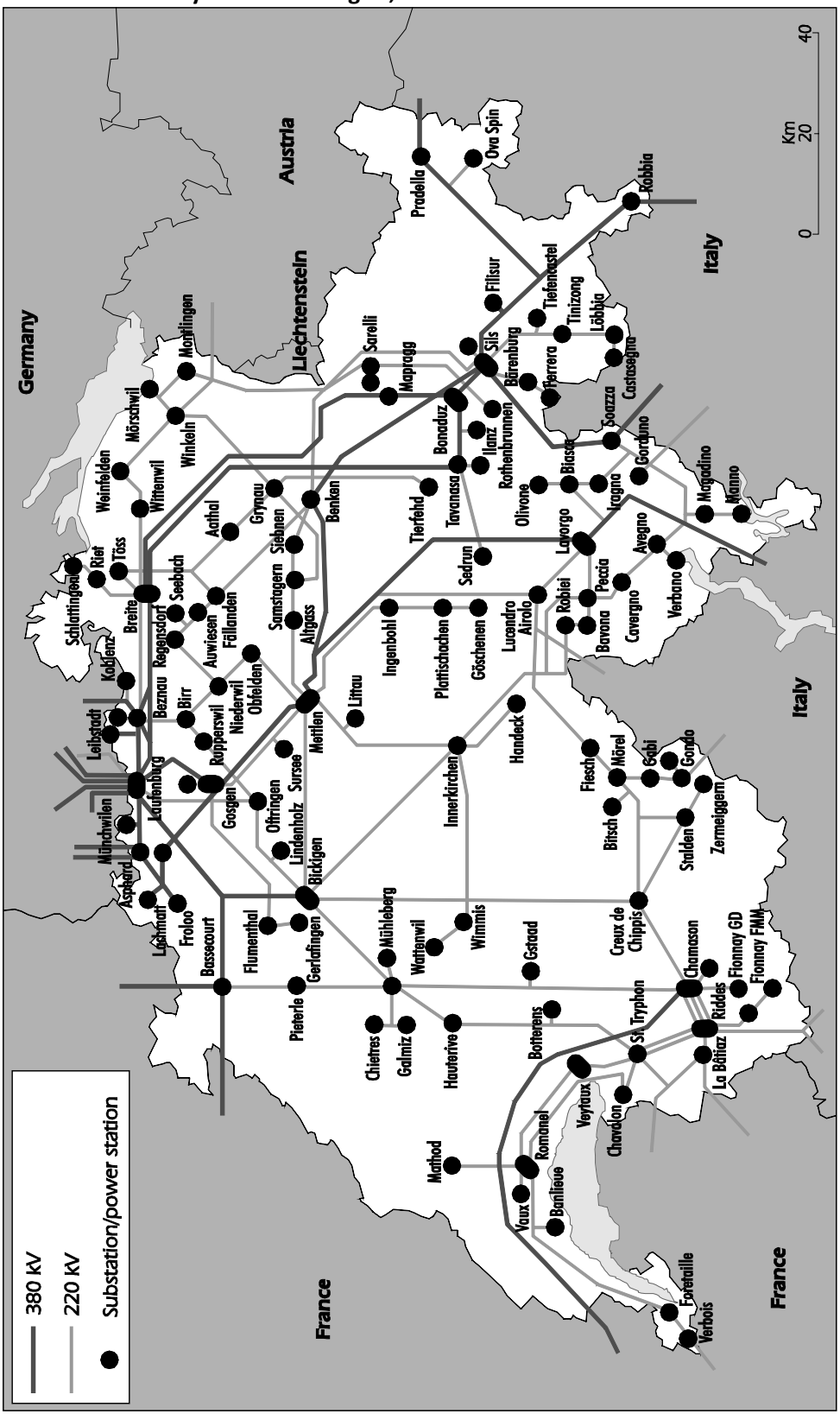
TRANSMISSION NETWORK OPERATION

Switzerland has some 6 700 km of high-voltage (220/380 kV) transmission lines. These are owned by the largest electricity companies. Through ownership in these companies, the cantons and municipalities control about 75% of the grid. The Swiss Federal Railways own and operate a separate 132 kV transmission grid running on 16 2/3 Hz. Switzerland also has significant cross-border transmission capacity (see Table 8).

Since December 2006, Switzerland's transmission system is operated by Swissgrid, a company set up in 2004 by the grid-owning utilities. Swissgrid was preceded by Etrans, a system co-ordinator formed in 2000. After the major blackouts in 2003, the utilities decided to replace Etrans with a legally separate company, as it had become evident that Etrans lacked the formal powers needed for effective grid management and a strong interface with other system operators in Europe. Swissgrid is a member of ENTSO-E (European Network of Transmission System Operators for Electricity).

14. Axpo is the holding company for Axpo AG, Elektrizitäts-Gesellschaft Laufenburg (EGL) and Centralschweizerische Kraftwerke (CKW).

Figure 33. **Map of the Swiss electricity transmission grid, 2011**



Source: Swissrid.

The legal base for an independent Swiss transmission system operator (TSO) is the 2008 Electricity Supply Law. From 1 January 2008, Swissgrid has assumed overall responsibility for operating the Swiss high-voltage grid and has gradually gained independence from the grid-owning utilities. By 1 January 2009, the utilities legally unbundled transmission grid operation from their other activities and by 1 January 2013, they must hand over their grid assets to the TSO.

By law, the TSO must be an independent company based in Switzerland and majority-owned by cantons and municipalities. It shall not be active in energy production or distribution, nor have ownership in companies in the sector. The majority of the board members (including the chairman) must be independent of the utilities.

Swissgrid is today owned by the three big electricity groups Axpo (41.7% of shares), Alpiq (32.6%), BKW (11.2%) as well as by Elektrizitätswerk der Stadt Zürich (ewz, 12.6%) and Repower AG (1.9%). The companies are directly or indirectly majority-owned by the cantons and municipalities.

Anticipating the Electricity Supply Law, Swissgrid introduced the schedule balance group (SBG) system in late 2005 to provide a framework for electricity exchange within Switzerland and, in particular, for international transits and cross-border electricity exchange. In 2008, it set up the balance management system, which comprises schedule management (based on the SBG system), meter data management and balance settlement management.

In the control area of Switzerland, around 900 MW of generating capacity is reserved for balancing the consumption and generation. Swissgrid procures this reserve capacity on the basis of calls for tenders. In March 2012, Swissgrid joined the international Grid Control Cooperation (GCC) for secondary control ancillary service, thereby increasing cost efficiency and system security.

TRANSMISSION NETWORK PLANNING AND INVESTMENT

SFOE and the Swiss Federal Office for Spatial Planning are jointly responsible for overseeing the development of the transmission grid. For this purpose, they maintain a Transmission Lines Plan *(Sachplan Übertragungsleitungen)*, which includes all planned projects for capacity expansion. The plan is part of the formal licensing process and is binding to all parties. The plan seeks to determine the most suitable corridor for construction projects of transmission lines and optimise Switzerland's existing transmission network, before any detailed planning takes place. The current plan is valid until 2015 and updated regularly.

Swissgrid analysed in 2011 the impact of the electricity supply scenarios of the Energy Strategy 2050 for the transmission network (see Box 6).[15] One of the conclusions is that the network needs to be further developed without delay regardless of the future electricity supply option and that the permitting process for network projects should be considerably shortened.

About 60% of the transmission network assets are now over forty years old, and the grid is on its limit to meet the present-day requirements. According to Swissgrid, around 80 TWh was transported by the Swiss transmission network in 2010. Projections by Swissgrid indicate that almost 1 000 km of high-voltage network will have to be added or

15. *Neue Energiepolitik. Erneuerungen und Ausbauten des Übertragungsnetzes*, Swissgrid, 2012.

replaced by 2020. According to SFOE estimations, between CHF 2.3 and 2.7 billion will need to be invested for the expansion of the transmission grid up to 2050 and about CHF 4 billion are needed for the renovation of the existing grid by 2030.

In 2011, the working group Transmission Lines and Supply Security, led by DETEC and comprising representatives from the cantons, the utilities, large consumers and environmental organisations proposed several measures to accelerate transmission network development. For example, to prioritise network expansion, to improve communication to the general public and to revise legislation in order to shorten the administrative processes from the current 9 to 12 years to around five years.

DISTRIBUTION

Switzerland's electricity distribution network (400 V to 160 kV) covers roughly 69 000 km. It is mostly owned by the cantonal and municipal utilities, which traditionally had a monopoly status in their supply area. The ESL has opened distribution networks to non-discriminatory TPA and imposed unbundling, at the accounting level, of distribution activities from all other activities of the utilities. ElCom monitors distribution operations, including cost accounting and the level of profit, and decides over any possible disputes. In the event of congestion, priority must be given to deliveries to consumers in the regulated scheme and to production facilities from renewable sources.

Box 6. **Swissgrid's two post-nuclear phase-out scenarios**

In June 2011, Swissgrid published a study examining the impact of the nuclear phase-out decision on the electricity network. They focused on two scenarios to substitute the expected supply gap: first, to increase other domestic electricity generation, and second, to increase electricity trading. The outcome of the study will also be considered for the future development of the network.

For the first option, the future energy mix would be secured through hydropower plants, gas cogeneration plants and decentralised production from renewable energy sources. Swissgrid anticipates that around 60% of electricity production is likely to come from decentralised energy sources. This would primarily have an impact on the 50 kV and 132 kV distribution network. A consequence could be an upgrade to a 220 kV transmission network. Since the energy sources in question are more volatile, this would result in greater challenges in terms of network regulation. Energy storage facilities and additional lines between the main centers of consumption in the north of Switzerland and these storage facilities would be needed.

In this first option, the pumped storage capacities in the Alps would no longer merely be utilised as a battery for Europe, but would also – first and foremost – fulfill this function for domestic consumers. In the implementation of the strategic network, the focus has to be on securing Switzerland's electricity supply. The battery function for the planned wind farms and solar plants in the north and the south of Europe can only be applied to a limited extent. In Swissgrid's view this would result in an increase in electricity prices in Switzerland and restrict the economic value of Switzerland's power plants. According to Swissgrid, a high-capacity transmission network forms the basis for investments in new pump storage power plants such as Nant de Drance or Linth-Limmern.

Box 6. **Swissgrid's two post-nuclear phase-out scenarios** (continued)

The second option envisages compensating for the loss of production from nuclear energy through changes in international electricity trading. In this scenario, it would be necessary to increase the cross-border transmission capacities. The expansion would be co-ordinated by the European Network of Transmission System Operators for Electricity (ENTSO-E). As the operator of the Swiss transmission network, Swissgrid is a member of this body. The master plan involving all operators is updated every two years.

In its June 2011 report, Swissgrid also pointed out that increasing net imports in order to secure Switzerland's domestic electricity demand would have major economic consequences. In 2010, Switzerland's revenue from electricity trading amounted to around CHF 1.3 billion. If its exports had to be cut and Switzerland had to import additional quantities of electricity, then this added value would be significantly reduced.

CROSS-BORDER CAPACITY

In the former Union for the Coordination of Transmission of Electricity (UCTE) area (now the regional group Continental Europe), Switzerland has around 20% of the cross-border capacity, though it only accounts for some 3% of electricity consumption. Rapid growth of cross-border trade in electricity in recent years is a challenge to Switzerland's transmission grid. Transalpine lines are particularly congested and the interconnection between Switzerland and Italy is a major bottleneck.

There is also a considerable congestion at the northern borders of Switzerland, the so called "Norddach" (northern roof). This bottleneck is evidenced particularly in winter, when Switzerland needs to import electricity from the North.

The Electricity Supply Law entrusts the TSO with the responsibility for cross-border congestion management. It states that available transmission capacity can be allocated through market procedures, such as auctions. Priority for capacity use is given to domestic customers in the regulated scheme and to deliveries under international contracts that were concluded before 31 October 2002 (*i.e.* when the Florence Forum of EU regulators introduced market-based congestion management). ElCom monitors the efficient use of cross-border capacity and the distribution of auction revenues.

Today, cross-border capacity is allocated at explicit auctions (yearly, monthly and daily). Auctions for the capacity with Germany and Austria began in 2006 and with Italy in 2008. Capacity with France is mostly reserved for incumbents with long-term contracts, but excess capacity has been auctioned since the beginning of 2012. Intra-day capacity is available on first-come first-serve basis on the border with France and from mid-2012 on the border to Italy.

Since January 2012, uniform regulations apply to all explicit auctions of cross-border capacity in the Central West Europe and Central South Europe electricity market regions, including Switzerland. However, despite this harmonisation, the separation of electricity and transmission capacity markets in explicit auctions nonetheless gives rise to inefficiencies (*e.g.* unused capacities, even if electricity prices on the two sides of the interconnector differed). Cross-border transmission capacities are utilised more efficiently through implicit auctions, and these also enable holding shorter-term auctions. Swissgrid is an observer in the market coupling in the Central-West Europe (CWE) region, with the ultimate aim of becoming integrated into the CWE market coupling.

Table 8. **Net transfer capacities between Switzerland and its neighbours, winter 2010/11 and summer 2011 (three-month average)**

Country	To Switzerland, MW		From Switzerland, MW	
	Winter 2010/11	Summer 2011	Winter 2010/11	Summer 2011
Austria	295	307	1 200	1 200
France	3 200	3 000	1 100	1 100
Germany	1 070	1 143	4 000	4 000
Italy	1 856	1 537	3 576	2 552
Total	6 421	5 987	9 876	8 852

Source: SFOE.

PRICES AND TAXES

WHOLESALE PRICES

Around 90% of wholesale electricity in Switzerland is traded over-the-counter (OTC) and is largely subject to public service obligations – and therefore likely to be below the referenced market prices. Exchange-traded volume accounts for merely some 10% of the Swiss market.

OTC price indications for Switzerland are available through the Swiss Electricity Price Index (SWEP). SWEP is the volume-weighted average for deliveries at the 380 kV Laufenburg hub between 11:00 and 12:00 the following day. SWEP was initiated by ATEL and EGL, and launched in March 1998.

Exchange-traded wholesale price index is offered by the Swiss Electricity Index (Swissix), which is the average price at the European Energy Exchange (EEX) in Leipzig for next-day deliveries within the Swissgrid control area. Swissix has indices for both base and peak loads. It was launched in December 2006.

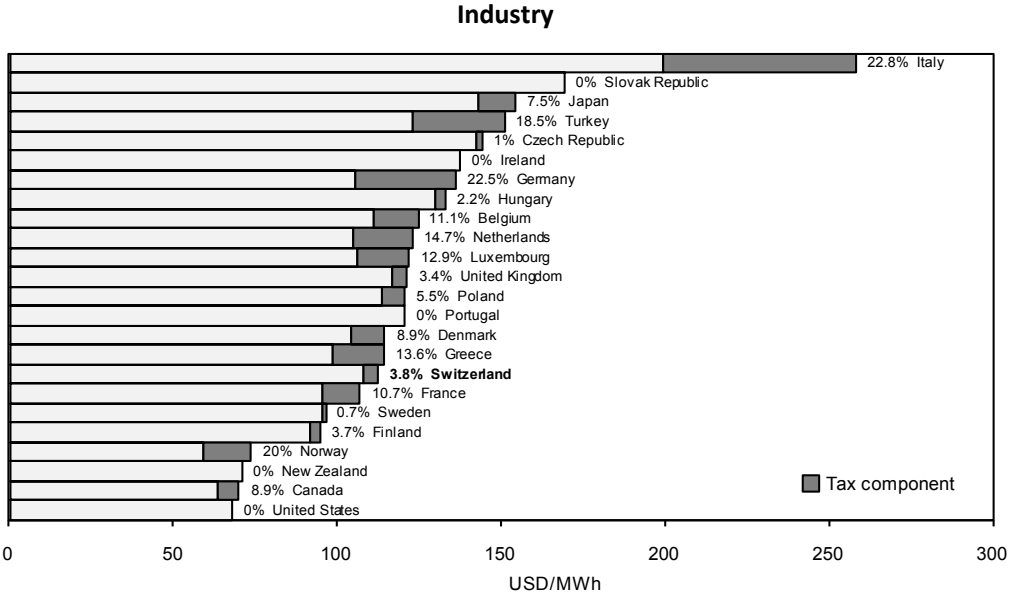
RETAIL PRICES

Retail prices for electricity have been increasing for the past several years. They vary strongly according to supply area. For households, average prices between cantons vary by more than 50%. Within individual cantons, price differences can be even wider, mainly because some mountain municipalities benefit from local low-cost hydropower. For industry, price differences are smaller, but still represent tens of percentage points. Detailed information on retail electricity prices across Switzerland is available on ElCom's website at www.strompreis.elcom.admin.ch.

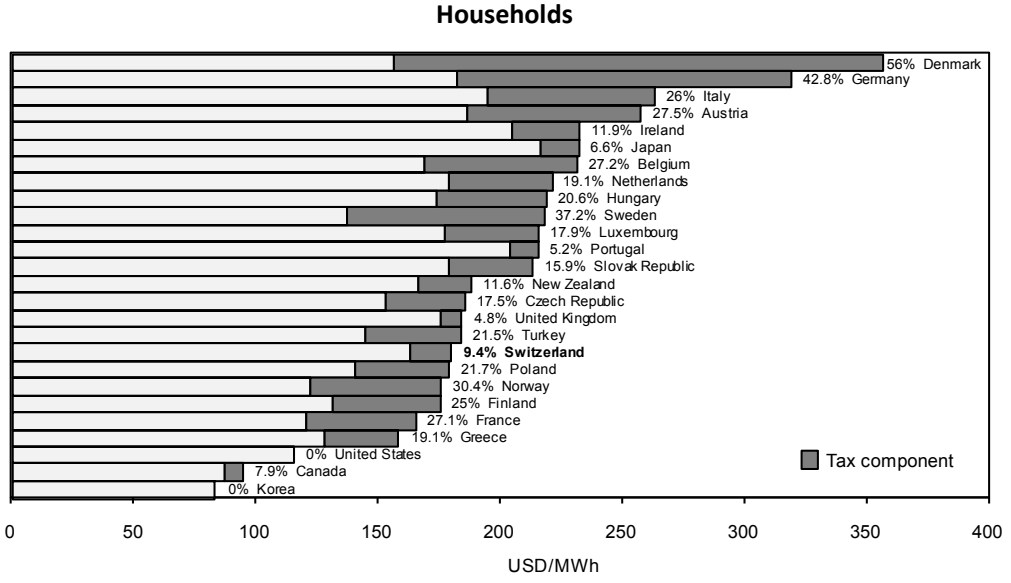
The total end-user price is primarily influenced by prices for the network and energy of around CHF 8 to 10 cents per kilowatt-hour each, whereas local fees and payments and the grid levy to finance feed-in tariffs for less than 10% together (CHF 0.9 and 0.45 cents per kilowatt-hour on average).

By international comparison, the Swiss end-users currently pay below-average prices. Yet, prices are higher than in countries with a similar low-carbon generation profile. This is especially true for industry (see Figures 34 and 35).

Figure 34. **Electricity prices in IEA countries, 2010**



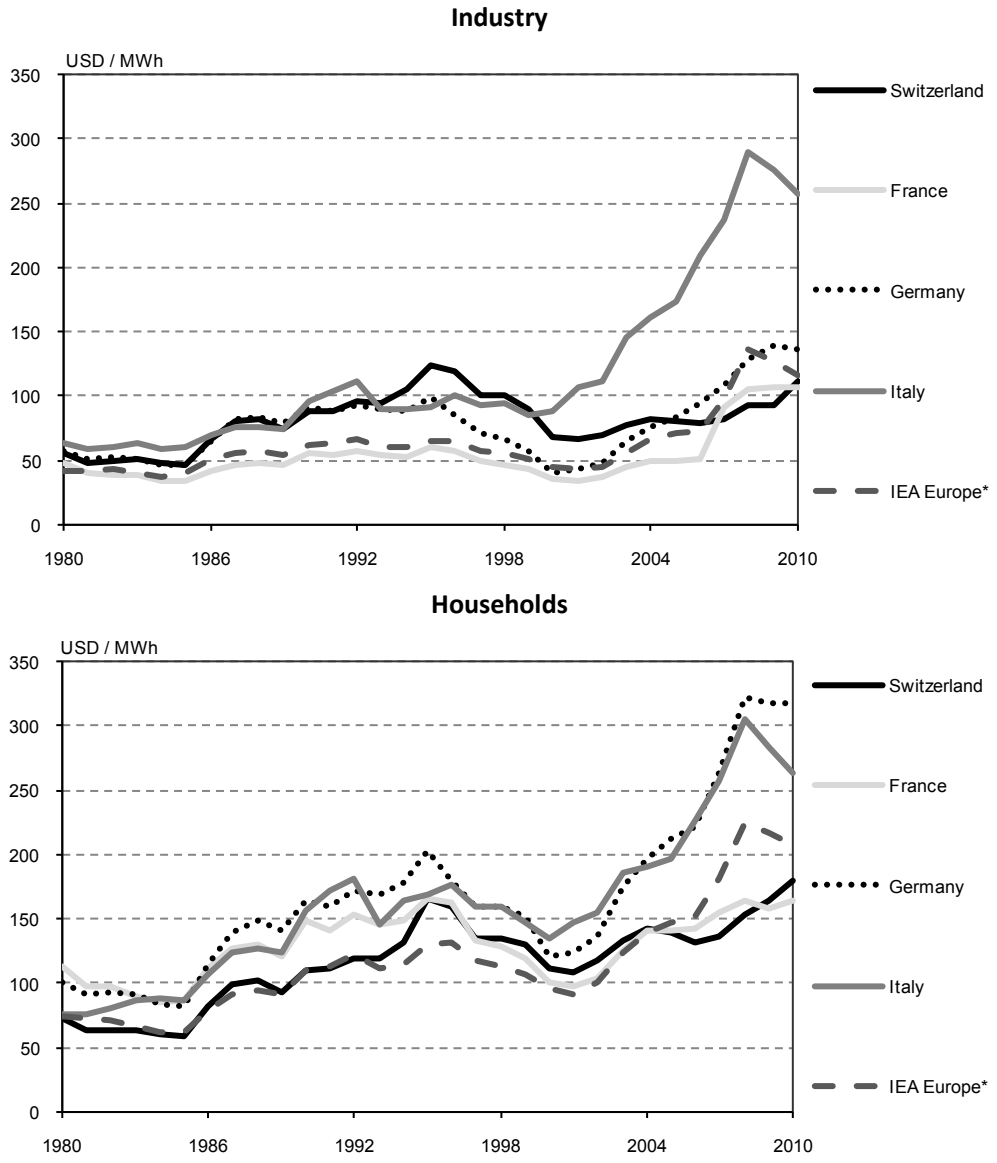
Note: Tax information not available for Ireland, New Zealand, Portugal, the Slovak Republic and the United States. Data are not available for Australia, Austria, Korea and Spain.



Note: Tax information not available for Korea and the United States. Data are not available for Australia and Spain.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2011.

Figure 35. **Electricity prices in Switzerland and in other selected IEA countries, 1980 to 2010**



* IEA Europe includes Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2011.

TAXES

At the federal level, the only tax on electricity is the 8% VAT, which is refundable to industry. However, the cantons and municipalities can levy taxes on generation, transmission and distribution. The level of these taxes varies, but the most important ones are the royalty taxes and concession fees on water use for hydropower production. The maximum annual royalty rate has been increased from CHF 80 per kilowatt of net capacity in 2010

to CHF 100 in 2011-14 and will be further increased to CHF 110 for the years 2015-20. In 2011-14, this is expected to amount to CHF 500 million per year, equalling around CHF 14 per megawatt-hour of hydropower.

SUPPLIER SWITCHING

Switching rates have remained low, around 4%. Regulated prices are typically more attractive than prices based on the free market. The regulated price is calculated on the minimum generating cost (efficient total cost). Most of the power plants in Switzerland, where hydro and nuclear power dominate, are between 20 and 50 years old and produce at lower cost. The prices in the free market are dominated by the prices of the European Electricity Exchange, which are currently higher for most of the time.

CRITIQUE

Since the 2007 IEA energy policy review, Switzerland has made clear progress in electricity market reform. The Electricity Supply Law adopted in 2007 started the first stage of electricity market liberalisation. The main provisions of this law have been or are being implemented, as recommended by the last in-depth review. End-users with an annual consumption of more than 100 MWh have access to the market. A full market opening by 2015 would be a positive step.

Switzerland has commendably created an independent regulator (ElCom), with sufficient authority and resources. Non-discriminatory access to the grid is now ensured, and grid tariffs are regulated. The ownership of transmission grid assets will be transferred to Swissgrid, the transmission system operator, by the end of 2012. Moreover, market transparency regarding final prices has been improved since Elcom (the regulator) publishes very detailed price information by canton and municipality.

Switzerland's electricity supply is dominated by hydro and nuclear power: it is almost carbon-free. Huge hydropower capacity, including large storage, is a valuable flexible tool to balance the system. Moreover, the central position of the country in Europe, and ample interconnection capacity, represents a considerable opportunity to optimise production scheduling and to sell flexibility to neighbouring countries.

On a yearly basis, domestic supply meets demand by a margin of several TWh, but seasonality complicates the picture, as the winter peak demand coincides with lower run-of-river hydro production. This situation leads to excess capacity in summer and scarcity in winter. Security of supply is not at stake, thanks to imports and hydropower reservoirs. However, these structural seasonal imbalances will have to be carefully monitored, considering decreasing nuclear generation and an increase in variable non-hydro renewable generation. Switzerland's energy storage capacity may be used more and more to satisfy domestic demand.

The nuclear phase-out decision is the major question that the electricity sector now has to deal with. Several scenarios, with varying amounts of new capacity or imports, are being analysed as options to replace nuclear power. Whatever the choice, large investments in new generating and network capacity will be needed.

As the electricity industry is capital-intensive, investors need security over the long term. This implies a need for stable political decisions and legislation. Moreover, as far as possible, the procedures for permitting new generating capacity, including storage, and for new power lines, should be simplified and shortened.

Investments in new hydropower capacity are being made on free market terms and the government has also increased support for other renewable power technologies. However, investments in baseload plants need stronger incentives. Operators seem reluctant to invest in CCGT capacity in Switzerland under the current regulatory framework. CO_2 emissions from gas-fired power plants should be treated as much as possible as in the neighbouring countries where the power sector is within the EU Emissions Trading Scheme, ensuring no overall increase in European CO_2 emissions. The current domestic compensation obligation deters investments and therefore reduces the options for replacing nuclear power in a timely manner, which in turn potentially weakens security of electricity supply.

Large investments will also be needed in transmission and distribution grids, even without the nuclear phase-out, because of ageing infrastructure and increasing load from new hydro facilities. Any plans for incentive-based regulation should include strategic projects (reducing congestion, increasing interconnection capacity, enabling the integration of more renewable power, and placing transmission lines underground, where feasible). In this regard, the definition of a fair rate of return for these investments will be crucial.

To encourage more investments in generating capacity, the regulatory framework of the retail market and the wholesale market should be reconsidered. As end-user prices are regulated close to generating cost and below spot market prices for most of the time, consumption is subsidised and incentives for investing in generating capacity are reduced. It is no wonder that very few customers have switched from regulated tariffs to market contracts.

Beyond the question of retail price regulation, the wholesale market price should be able to drive investment decisions. To play this role, the wholesale market must be sufficiently transparent and liquid. Further integration in the European electricity market, on the basis of efficient cross-border capacity management and market coupling, should be ensured. Transparency should be improved, with the publication of comprehensive generation data related to capacity availability and utilisation.

Switzerland should continue to take an increasingly European approach to developing its electricity infrastructure, to its own benefit and to that of its neighbours. The efforts to join the Central-West Europe market coupling are very welcome, as that would allow for the optimisation of the allocation process for cross-border capacity and closer market integration in Europe. Switzerland is already involved in the harmonisation of interconnection capacity auction rules and other operational management of the electricity system. In general, an even closer co-operation with neighbouring countries' TSOs and regulators is recommended.

For an electricity hub such as Switzerland, electricity market coupling with neighbours would be an important step and should have priority. OTC trades with explicit auctions for capacities can secure imports to cover deficits in domestic production; but, trading in an effective coupled market could offer better opportunities to Swiss market players and generators with fast response hydropower, considering the planned increase in hydropower reservoir and pumped storage facilities.

RECOMMENDATIONS

The government of Switzerland should:

- *Provide a predictable policy and legal framework to attract investments in the power sector.*
- *Simplify and shorten, as far as possible, the permitting procedures for approving network and generation projects, and strengthen the communication to the general public so as to increase the level of acceptance of such projects.*
- *Give sufficient investment incentives to network operators, with a particular attention to investments of high strategic importance.*
- *Improve generation transparency by providing open access to comprehensive data on the availability and utilisation of generating capacity.*
- *Consider fully liberalising retail electricity prices, so that decisions on generation investment and demand-side management could be driven by clear price signals in line with the fair value of electricity and give stronger incentives than under the current cost-based end-user tariff system.*
- *Maintain drive towards market coupling and harmonisation of system operations with EU neighbours for greater wholesale market liquidity, and maximise value of hydro storage and flexible generation.*

PART III
ENERGY TECHNOLOGY

9. ENERGY TECHNOLOGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

Key data (2011 estimates)

Government energy RD&D spending: CHF 226 million

Government energy RD&D spending per GDP: USD 0.4 per 1 000 units of GDP (same as IEA median)

Government energy RD&D spending per capita: USD PPP 18.9 (IEA median: USD PPP 16.5)

OVERVIEW

Switzerland ranks the highest among OECD countries in terms of patents and trademarks per capita (all areas of R&D, including energy), and is positioned in third place in terms of energy research, development, demonstration and deployment (RDD&D) expenditures per unit of GDP. International co-operation and the efficient implementation of public research findings are high priorities of the Swiss government.

The Swiss public RD&D landscape is transparent, well-funded and agreed among all stakeholders. A high priority is attached to international co-operation and the implementation of research findings.

Energy research is an important pillar of energy policy in Switzerland. The objectives are to create a secure and sustainable energy supply, strengthen Switzerland's position as a marketplace for energy technology and maintain the high quality of publicly funded energy research.

INSTITUTIONAL FRAMEWORK

The energy research carried out in the public sector is based on the Master Plan for energy research of the federal government, which is updated every four years by the Swiss Federal Energy Research Commission (CORE). The Swiss Federal Office of Energy (SFOE) is responsible for the implementation of the Master Plan.

FEDERAL ENERGY RESEARCH COMMISSION

The Federal Energy Research Commission (CORE) acts as a consultative body for the government and the Department of the Environment, Transport, Energy and Communications (DETEC).

It defines the federal energy research Master Plan, reviews and supports Swiss energy research programmes, comments on other energy research activities by the federal government and provides information concerning findings and developments in the area of energy research.

Priorities are defined to reflect the vision of a 2 000-W, 1-tonne of CO_2 per capita and year society, a target that will help secure a sustainable energy supply as called for in the Swiss Federal Constitution. This vision rests on the premise that 2 000 W and 1 tonne of CO_2 per capita are the average energy and emissions "footprints", which the planet can sustain.

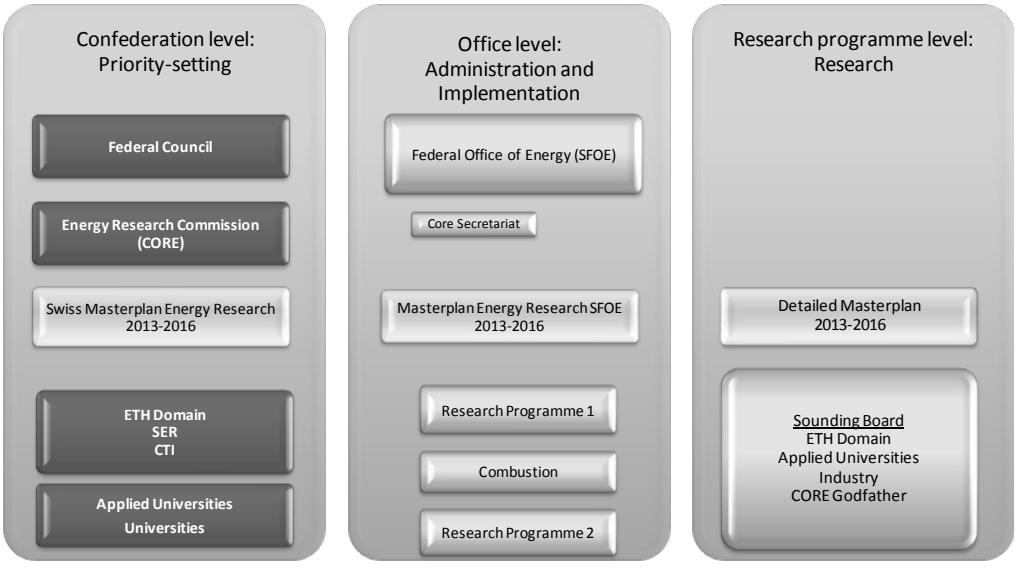
The CORE comprises 15 members from the industrial sector, the energy industry (large corporations, SMEs and start-ups), federal institutes of technology, universities, universities of applied sciences, the cantons, the Swiss National Science Foundation; the Commission for Technology and Innovation (CTI) and other promotional bodies are observers.

SWISS FEDERAL OFFICE OF ENERGY

In collaboration with CORE, the Swiss Federal Office of Energy (SFOE) is responsible for energy RD&D policy and for elaborating and implementing the Master Plans. SFOE maintains an overview on national and international research activities, participates in different national and international forums (networking), seeks to strengthen the network of the Swiss research community and maintains statistics on Swiss energy research.

At the operational level, SFOE guides projects, including the organisation of conferences and knowledge and technology transfer. It also administers inter-ministerial working groups and writes position papers and responses to the general public. It also serves as the CORE Secretariat.

Figure 36. **Swiss public energy research framework**



Source: Swiss Federal Office of Energy.

SFOE has strong links to all federal public institutions relevant for energy research, like the State Secretariat for Education and Research (SER) or the CTI and the private sector, the European Union and the IEA.

Universities such as the Swiss Federal Institutes of Technology (ETH) are not linked to the priorities of the Master Plan (this stems from the principle of freedom of research).

Through its programme managers, SFOE has an ongoing exchange with the universities, often resulting in common research projects. Besides this, SFOE has regular steering group meetings with the ETH Domain.

In addition to SFOE, other institutions promote energy research, organised into three pillars: basic research; applied basic research and product-related applied R&D; and product-related applied research, pilot and demonstration plants. Each of these institutions places specific demands on the projects they support, and they also have their own financing modalities.

A large proportion of the research projects are conducted by public scientific institutions. The main federal institutions are the Swiss Federal Institutes of Technology in Zurich (ETHZ) and Lausanne (EPFL), the Paul Scherrer Institute (PSI) and the Swiss Federal Laboratories for Materials Testing and Research (EMPA). Universities (basic research) and universities of applied sciences (applied research) also carry out R&D.

POLICIES AND PROGRAMMES

The federal energy research is an integral part of research at the federal level. Research concepts have been defined for 12 policy areas, and they also regulate the cross-relations between the various areas.

ENERGY RESEARCH CONCEPT

The federal energy research concept is the strategic planning tool for the relevant federal decision-making authorities – *e.g.* the State Secretariat for Education and Research (SER), the Swiss Federal Office of Energy (SFOE), and the Commission for Technology and Innovation (CTI). It is also intended as an orientation aid for cantonal and municipal authorities responsible for the implementation of the energy policy objectives.

Furthermore, it serves to inform the involved research institutions about areas in which new activities are planned, thereby assuming the character of a public call for tenders for new research projects.

Finally, the concept documents how, and with what means, the public authorities deploy energy research in order to achieve their energy policy objectives.

ENERGY RESEARCH MASTER PLAN

The federal energy research concept is detailed through Federal Energy Research Master Plans. These include the objectives, means, focus areas and budget allocations for publicly funded energy research in Switzerland. They take into account the entire chain of value adding from research to innovation to market and focus on various levels. From this overarching goal, targets in three sub-priority areas are set: technical and scientific, economic, and social science.

The draft federal Master Plan is reviewed at the National Energy Research Conference, held every four years and attended by the Swiss energy research community. On the basis of the conference feedback, CORE and SFOE finalise the Master Plan and submit it to the federal government and parliament for approval.

For 2008-11, the focus of public energy RD&D maintained the same priorities as the previous plan, notably: rational use of energy, renewables, nuclear energy, and energy policies and economics. The 2008-11 Master Plan set the following targets for 2050: phasing out fossil fuels in space heating, halving energy use in buildings, tripling the use of biomass for energy and reducing average fuel consumption of the passenger car fleet to 3 litres per 100 km. This was supported by developing 23 technology streams that:

- have the highest possible system effectiveness and lowest possible emissions in transport, buildings and electricity generation;
- use ambient and solar heat as well as biomass;
- use in the shorter term hydro and geothermal power; and
- reduce in the longer term dependence on fossil fuels (using photovoltaics, hydrogen and other sources, instead).

The draft Master Plan 2013-16 was presented at the Energy Research Conference in November 2011. It is based on a holistic approach to Swiss energy research with a view to achieving sustainable development. In a departure from previous plans structured according to technologies chosen by SFOE, the Master Plan 2013-16 bundles energy research into four application fields:

- buildings and workplace;
- mobility;
- energy systems; and
- industrial processes.

Each application field will integrate research in engineering, natural sciences and social sciences, will integrate basic and applied research, and will include short-tem (until 2016) and long-term (2020-50) goals for each area of action.

Extensive public consultations will be carried out, both “top-down” (global and national energy and climate policies) and “bottom-up” (target definition in co-operation with the Swiss research community, and better strategic focus and ease of communication). The final plan is expected to be released in mid-2012.

The Master Plan 2013-16 shows that the gradual phasing-out of nuclear energy is technically feasible and economically viable by reshaping the energy system through, among other measures, supporting targeted research at the national and international levels, technology transfer between universities and industry and the establishment of new, innovative businesses.

CLEANTECH MASTERPLAN

In September 2011, after thorough stocktaking and broad public consultations, the government adopted the Cleantech Masterplan, a strategy to promote resource efficiency and renewable energies. It aims at strengthening cleantech businesses through greater coordination of science, business, government and policymaking so as to achieve a strong position in the global growth market for resource-efficient technologies, products and services by 2020. It identifies five areas of action: research, knowledge and technology transfer; regulation and market-based promotion programmes; international markets and export promotion; policy to encourage innovation; skills and training.

Box 7. **The Electricity Networks Research Centre**

Switzerland has understood the important role it plays and will play in the future as a regional electricity hub and has created programmes to address this. In March 2010 the Electricity Networks Research Centre was created at the Federal Institute of Technology in Zurich (ETHZ) by public and private stakeholders. The goal is to provide independent information and responses to pressing issues concerning electricity networks. The work programme includes:

- support, co-ordination and evaluation of applications for projects;
- financial support for projects;
- support for an active research network, *i.e.* for networking activities at the national and international levels; and
- representation of national research interests in the area of networks within regional and international initiatives.

The programme includes studies to assess the impacts of the changing technological, economic and legislative environment of network operation and reliability of supply. Furthermore, efforts are being made to define concepts for new forms of network infrastructure (from the regional to the transnational level), taking into account the aspects of increasingly independent production and energy storage systems.

PROGRAMME EVALUATION

In 2009, the Federal Audit Office of the Ministry of Finance carried out the first audit (evaluation) of the effectiveness of Swiss research programmes. Though the basis for the audit was financial, one recommendation called for aligning research priorities according to Swiss academic and economic capacities. Further improvements were suggested as follows:

- increasingly focus priorities on those areas most important to the country in terms of its energy policy requirements, taking into account the fabric of the economy and the academic capacities;
- clearly state which areas are not considered a priority;
- distinguish between the financial commitment expected from SFOE and other sources of public financing;
- systematically apply the principle of competition when allocating research mandates; and
- adopt a consistent approach to evaluating and selecting applications for all its research programmes.

These suggestions, if implemented, would align energy policies and priorities with programmes, improve transparency and accountability. Evaluating the outcomes of individual RD&D programmes would be an important next step to improving national research efforts.

In addition, in early 2011 SFOE began an extensive self-evaluation of the publicly funded programmes under their responsibility. Though the findings and recommendations had not been made public by April 2012, preliminary results show a clear rationalisation of resources on the basis of priorities rather than institutionalised programmes, processes or mechanisms. The expected outcome is an overall increase in research capacities.

FUNDING MECHANISMS AND LEVELS

MECHANISMS

Most energy RD&D in Switzerland is funded by industry. According to SFOE estimates, in 2009, the private sector accounted for 80% of the country's total energy RD&D spending of CHF 1 053 million (see Table 9). Four-fifths of the private-sector funding went into pilot and demonstration projects and product development.

In public RD&D, research on efficiency, renewables and nuclear energy accounts for comparable amounts of funding while private funding goes predominantly into pilot and demonstration projects for efficiency.

Table 9. **Energy research funding by sector, 2009 (million CHF)**

	Research and development			Pilot and demonstration			Total
	Public	Private	Total	Public	Private	Total	
Efficiency	73	90	163	5	440	445	608
Renewables	60	60	120	7	170	177	297
Nuclear	54	5	59	0	45	45	104
Socio-economic	14	5	19	0	25	25	44
Total	**201**	**160**	**361**	**12**	**680**	**692**	**1 053**
Share of total research funding	19%	15%	34%	1%	65%	66%	

Source: Swiss Federal Office of Energy.

Public funding for energy RD&D comes through various channels, with individual projects often receiving funds from several sources. In 2009, 54% of the public-sector funding for energy RD&D came from the Board of the Swiss Federal Institutes of Technology (ETH Board). The latter finances basic research within its sphere, namely the Paul Scherrer Institute (PSI), the Federal Institutes of Technology at Zurich (EHTZ) and Lausanne (ETHL) and the Materials Science and Technology Institute (EMPA).

SFOE and the Federal Nuclear Safety Inspectorate (ENSI), the nuclear safety authority, accounted for 16% of total public funding for energy RD&D in 2009. SFOE has a key role as co-ordinator in public funding. It contributes to the funding of most public RD&D projects and is involved in additional projects through its membership in advisory boards.

Cantons and municipalities (9%) supported applied research at universities of applied sciences, as well as pilot and demonstration projects.

The European Union's Framework Programme for Research and Technological Development (11%), in which Switzerland participates through the 1987 Swiss-EU Agreement on Scientific-Technological Cooperation, funded Swiss participants in European RD&D projects on efficiency, nuclear fusion and renewable energy.

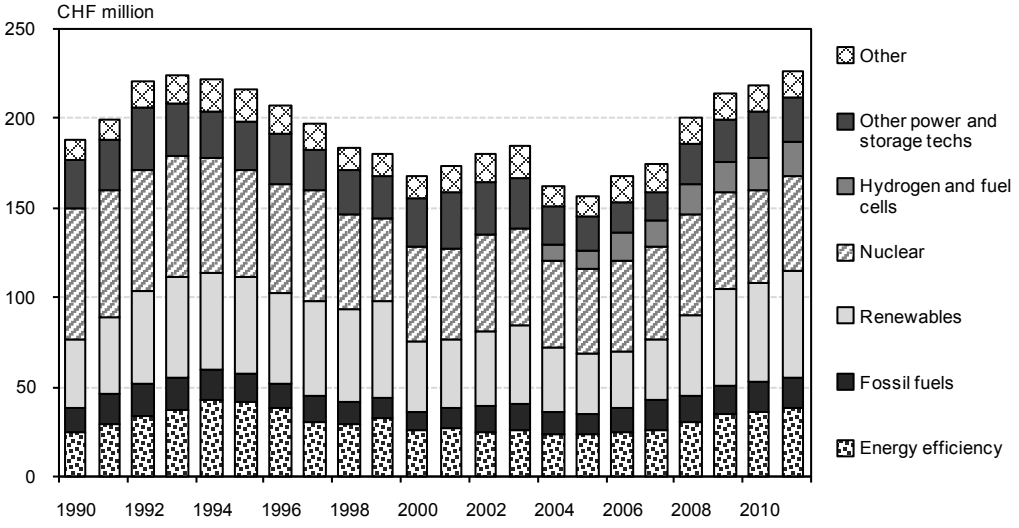
The Swiss Innovation Promotion Agency (5%) funded universities in public-private joint projects aiming to commercialise innovations. In each project, funding by the Commission for Technology and Innovation (CTI) had to be matched by industry.

The Swiss National Science Foundation (2%) supported basic research at universities and provided grants to junior scientists. Other public-sector funding (3%) comprised federal offices other than SFOE with energy-related research activities (agriculture, environment, spatial development).

FUNDING LEVELS

Public RD&D funding has increased steadily from 2005 (see Figure 37), reaching CHF 226 million in 2011, 45% more than in 2005. 2011. Renewable energy projects have received the largest percentage of government RD&D funding since 2009. It was CHF 60 million, 26.4% of total funding in 2011, an increase of 80% from 2007. Nuclear ranks second in government RD&D funding with CHF 52 million. Nuclear's share declined from 32% in 2000 to 23% in 2011. RD&D funding for energy efficiency accounted for 17% of the total in 2011, a 46% increase from 2000. Hydrogen and fuel cells accounted for 8.5% of RD&D funding in 2011 and fossil fuels for 7.5%. Other RD&D areas accounted for 18% of RD&D expenditures in 2011.

Figure 37. **Government RD&D spending on energy, 1990 to 2011***

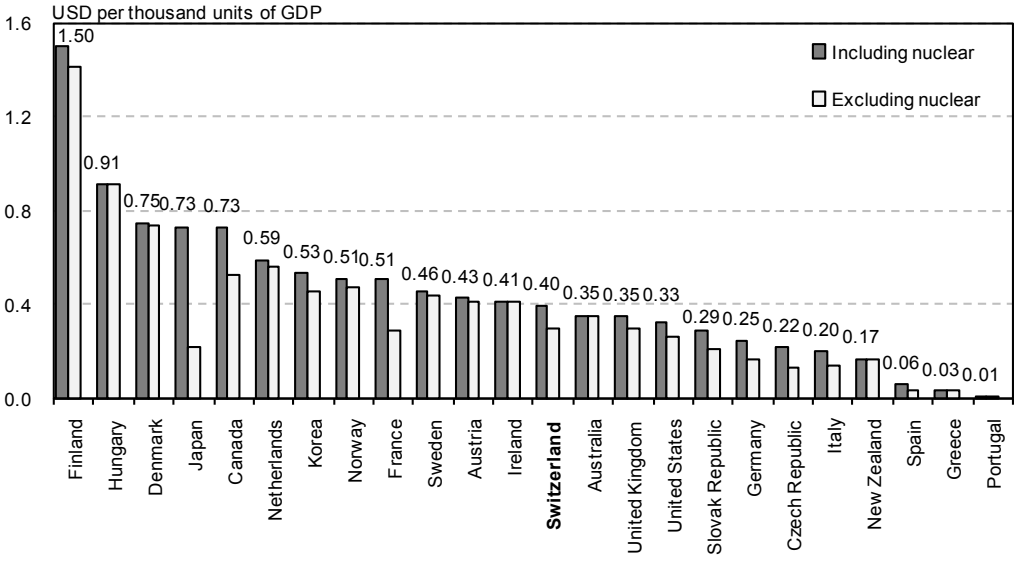


* Estimates for 2011.

Source: Swiss Federal Office of Energy.

Switzerland ranked close to the IEA average in relative energy RD&D spending in 2010; 13th in terms of public spending on energy RD&D per GDP (see Figure 38) and 8th in terms of spending per capita.

Figure 38. **Government spending on energy RD&D per GDP in IEA countries, 2010**



Note: Data for Belgium, Luxembourg, Poland, and Turkey are not available.

Sources: *OECD Economic Outlook*, OECD Paris, 2011 and country submissions.

PUBLIC-PRIVATE PARTNERSHIPS

There is a clear separation between the research portfolios of the public sector, centred on very research-intensive universities, and the private sector, centred on the large research units of multinational companies.

The government has practically no influence on private research strategies, except through securing favourable localisation conditions to the research activities of multinational companies or through public-private partnerships. The involvement of the private sector occurs most directly through the following three initiatives.

The Swiss **Cleantech Masterplan** was created by the government to encourage innovation specifically among Swiss companies that foster eco-innovation and sustainable development in their products, services and processes ("cleantech"). It is an association of businesses fostering innovation in cleantech, making recommendations to policy makers and participating in public debates.

As the government's Innovation Promotion Agency, the **Commission for Technology and Innovation** (CTI) lends support to RD&D projects, to entrepreneurs as well as to the development of start-up companies. CTI helps to optimise knowledge and technology transfer through the use of thematic and regional networks and platforms. Its annual budget is around CHF 10 million.

Swisselectric Research is the research initiative led by the large Swiss electricity companies. It is committed to developing innovative solutions for a sufficient, secure, affordable and environment-friendly electricity supply. Its annual budget is around CHF 10 million. SFOE is a full member of the steering board.

In addition, public bodies often grant financial aid to industry, to engineering consultancies and to private individuals. Such projects are operated, when possible, in partnership with public research centres. SFOE also provides funds for private-sector projects with no obligation to feed the results into the national public knowledge base.

There are also frequent, informal consultations between public and private experts working in the same area, which avoids most gaps and overlaps. In addition, researchers in the major cutting-edge energy industries in Switzerland were invited for the first time to take part in the consultation and priority-setting process. There are also many joint projects between universities and the private sector, for example through funding of innovative start-up companies and particular projects.

INTERNATIONAL COLLABORATION

Switzerland takes advantage of the multiplying factor of international collaboration. SFOE is the primary organisation that represents Switzerland in IEA Standing Committees, including as a Chair to the IEA Committee on Energy Research and Technology (CERT). Switzerland participates in 22 of the 42 IEA multilateral technology initiatives, or Implementing Agreements, in areas in line with the overall energy priorities:

- **cross-cutting**: energy technology research database, energy technology systems modeling;
- **end-use buildings**: buildings and community systems, efficient electrical end-use equipment, heat pumps;
- **end-use electricity**: demand-side management, high-temperature superconductors, smart grids;
- **end-use industry**: combustion, industrial technologies and systems;
- **end-use transport**: advanced fuel cells, advanced motor fuels, hybrid and electric vehicles;
- **fossil fuels**: greenhouse gas reduction;
- **fusion**: fusion materials; and
- **renewables**: bioenergy, geothermal, hydrogen photovoltaics, solar heating and cooling, solar chemical, wind.

Switzerland (the Federal Institutes of Technology and other universities, industry, etc.) also participates in many of the European Union's Seventh RD&D Framework Programme activities and the EU's Strategic Energy Technology Plan (SET Plan) work on biomass and smart grids.

CRITIQUE

Switzerland ranks the highest among OECD countries in terms of patents and trademarks per capita (all areas of RD&D, including energy), and is positioned in third place in terms of energy research, development, demonstration and deployment (RDD&D) expenditures per unit of GDP. International co-operation and the efficient implementation of public research findings are high priorities of the government.

The Energy Strategy 2050 implies changes also for energy RD&D. Encouragingly, the work to align energy RD&D with the new long-term strategy has already begun. The research portfolios of the major energy technologies will be reviewed and co-ordination will be strengthened among universities and universities of applied sciences, business and centres

of technological expertise. The Energy Strategy 2050 also calls for a "Co-ordinated Energy Research Switzerland" action plan or research concept mandated to the Swiss Energy Research Commission (CORE) to review Swiss energy research in light of the new long-term strategy, and in co-operation with industry, academia and public administration.

The Master Plan 2013-16 involves consultations with the Swiss public and private research stakeholders at all levels and on all aspects of RD&D. It will focus on four cross-cutting fields of implementation (buildings and workplace; mobility; energy systems; and industrial processes) with specific examples for technologies where the Federal Energy Research Commission (CORE) sees the greatest advantage and possibilities for success stories.

The Master Plan 2013-16 shows that the gradual phasing-out of nuclear energy is technically feasible and economically viable by reshaping the energy system through, among other measures, supporting targeted research at the national and international levels, technology transfer between universities and industry and the establishment of new, innovative businesses.

Another important instrument for strengthening public engagement in energy technology development and demonstration is the Cleantech Masterplan. One notable outcome was the 2010 creation of a research centre on electricity grids (*Forschungsstelle Energienetze*) involving public and private stakeholders to serve as a neutral platform to discuss pressing issues in the field.

Public RD&D increased steadily from 2005 to 2009, by 37% in total. This increase in public funding is to be applauded. Further increases are in sight, as the Energy Strategy 2050 includes a doubling of public funding for RD&D, with a focus on development and demonstration programmes. While funding is a key supply-side measure, the right regulatory frameworks will be crucial to facilitate a market pull of technologies by consumers (*e.g.* renewable energy) as well as industry (investments in efficiency), electricity generators (new sources) and grid operators (investments in technology advancements and network refurbishments).

There is frequent, informal consultation between public and private experts working in the same area, which avoids most gaps and overlaps. In addition, researchers in the major cutting-edge energy industries were invited for the first time to take part in the consultation and priority-setting process. Positively, there are also many joint projects between universities and the private sector, for example through funding of innovative start-up companies and particular projects.

To complement the various existing priority-setting processes, in 2009 the first audit (evaluation) of the effectiveness of Swiss research programmes was carried out by the Federal Audit Office of the Ministry of Finance. Though the basis for the evaluation was financial, one recommendation called for aligning research priorities according to Swiss academic and economic capacities. Stakeholders would benefit from further evaluations based on other criteria, or indicators of success with a view to further build the capacity of Swiss research programmes and stakeholders.

This first research audit and master plan consultation processes have had positive knock-on effects. For example, master plans are now being created at cantonal or municipal level. In addition, SFOE has recently begun an extensive self-evaluation of its responsibilities for the various publicly-funded programmes. Preliminary analysis shows a rationalisation of responsibilities resulting in increases in research capacity. This best practice would be a great benefit to the other organisations with responsibilities for Swiss public RD&D.

Switzerland takes advantage of the multiplying factor of international collaboration and, in a positive development, the country has increased its participation in international RD&D programmes in recent years, for example in the areas of electricity grids and biomass.

In summary, the Swiss public RD&D landscape is transparent, well-funded, agreed among all actors, and takes advantage of international expertise. However, given the goal to gradually phase out nuclear energy, the government will need to strengthen and increase current RD&D efforts. The Energy Strategy 2050 calls for strengthening and rationalising energy research nationwide, but specific policies are yet to be detailed. Setting in place regular evaluations as well as mechanisms to benefit from results from publicly funded RD&D projects carried out in the private sector would serve to build national research capacities, improve programme efficiency and increase accountability.

RECOMMENDATIONS

The government of Switzerland should:

- ☐ *Ensure a policy framework conducive to market pull and uptake of new technologies.*
- ☐ *Maintain plans to double public funding of energy research, development and demonstration, and emphasise development and demonstration.*
- ☐ *Implement regular evaluations at all levels of public research.*

PART IV
ANNEXES

ANNEX A: ORGANISATION OF THE REVIEW

REVIEW CRITERIA

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

REVIEW TEAM AND PREPARATION OF THE REPORT

The in-depth review team visited Switzerland from 21 to 25 November 2011. The team met with government officials, energy suppliers, interest groups and various other organisations. This report was drafted on the basis of these meetings, the team's preliminary assessment of Switzerland's energy policy, the government response to the IEA energy policy questionnaire and other information.

The members of the team were:

IEA member countries

Mr. Lars Georg JENSEN, Denmark (team leader)

Mr. Minoru AIHARA, Japan

Mr. Silvano DOMERGUE, France

Mr. Milosz KARPINSKI, Poland

IEA non-member country

Mr. Xiang DONG, China (special observer)

OECD Nuclear Energy Agency

Dr. Alexey LOKHOV

International Energy Agency

Mr. Hugo CHANDLER

Mr. Shinji FUJINO

Ms. Carrie POTTINGER

Mr. Miika TOMMILA (desk officer)

The team is grateful for the co-operation and assistance of the many people it met during the visit, the kind hospitality and the willingness to discuss the challenges and opportunities that Switzerland is currently facing. The team wishes to express its sincere appreciation to Dr. Walter Steinmann, Director, and his staff at the Swiss Federal Office

of Energy for their hospitality and personal engagement in briefing the team on energy policy issues. In particular, the team wishes to thank Mr. Jean-Christophe Füeg and Dr. Lukas Gutzwiller for their unfailing helpfulness in preparing for and guiding both the visit and the entire review process.

Miika Tommila managed the review and drafted Chapters 1 to 5 and 8 of the report. Other chapters were drafted by Debra Justus (Chapter 6 and the sections on energy efficiency in Chapter 3), Alexey Lokhov (Chapter 7) and Carrie Pottinger (Chapter 9). Chapters 4 and 5 benefited from the IEA 2012 Emergency Response Review of Switzerland, drafted by Yuichiro Nishida. Georg Bussmann and Yuichiro Tanaka drafted statistics-related sections for most chapters. Helpful comments were provided by the review team members and many IEA colleagues, including André Aasrud, Manuel Baritaud, Ulrich Benterbusch, Sara Bryan Pasquier, Doug Cooke, Anne-Sophie Corbeau, Shinji Fujino, Rebecca Gaghen and Christina Hood.

Georg Bussmann, Yuichiro Tanaka and Bertrand Sadin prepared the figures. Karen Treanton and Raphael Vial provided support on statistics. Muriel Custodio, Astrid Dumond and Angela Gosmann managed the production process. Debra Justus, Viviane Consoli and Cheryl Haines provided editorial assistance. Marilyn Ferris helped in the final stages of preparation.

ORGANISATIONS VISITED

During its visit in Switzerland, the review team met with the following organisations:

Association for Energy-intensive Industries

Association for Environmentally Sound Energy (VUE)

Association of Swiss Distribution System Operators (DSV)

Avenir Suisse

Canton of Aargau

Canton of Basle (City)

Canton of Valais

Cleantech Association

Competition Commission

EconomieSuisse

ElCom

Energieforum

Energy Agency of the Economy (EnAW)

Federal Energy Research Commission (CORE)

Federal Finance Administration (EFV)

Federal Office for Spatial Planning

Federal Office for the Environment

Federal Office of Education and Technlology

GEB (large electricity users' group)

IWB (Basle utility)

Minergie

Nuclear Repository Site Investigation Agency (NAGRA)

Oil Industry Union (EV)

State Secretariat of the Economy (SECO)

Swisselectric

Swissgrid

Swisspower

Swiss Agency for Efficient Energy Use (SAFE)

Swiss Agency for Electric Appliances (EAE)

Swiss Association of Electricity Companies (VSE)

Swiss Association of Engineers and Architects (SIA)

Swiss Energy Foundation (SES)

Swiss Federal Office of Energy (SFOE)

Swiss Gas Association (VSG)

WWF Switzerland

ANNEX B:
ENERGY BALANCES
AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	1980	1990	2000	2008	2009	2010
TOTAL PRODUCTION		**4.28**	**7.03**	**10.25**	**12.03**	**12.81**	**12.79**	**12.64**
Coal		-	-	-	-	-	-	-
Peat		-	-	-	-	-	-	-
Oil		-	-	-	-	-	-	-
Natural Gas		-	-	0.00	-	-	-	-
Biofuels & Waste[1]		0.24	0.47	1.43	1.81	2.23	2.21	2.33
Nuclear		1.64	3.74	6.18	6.92	7.25	7.25	6.90
Hydro		2.40	2.82	2.56	3.17	3.10	3.07	3.10
Wind		-	-	-	-	0.00	0.00	0.00
Geothermal		-	-	0.07	0.10	0.19	0.21	0.26
Solar/Other[2]		-	-	0.01	0.02	0.04	0.04	0.05
TOTAL NET IMPORTS[3]		**14.41**	**13.40**	**13.95**	**12.57**	**14.03**	**14.29**	**13.53**
Coal	Exports	0.02	-	0.01	-	-	-	-
	Imports	0.24	0.51	0.35	0.19	0.16	0.17	0.13
	Net Imports	0.22	0.51	0.34	0.19	0.16	0.17	0.13
Oil	Exports	0.23	0.05	0.16	0.64	0.63	0.50	0.40
	Imports	15.24	13.45	13.35	12.74	13.19	13.45	12.14
	Int'l Marine and Aviation Bunkers	-0.67	-0.68	-1.03	-1.55	-1.41	-1.35	-1.41
	Net Imports	14.34	12.72	12.16	10.56	11.16	11.60	10.33
Natural Gas	Exports	-	-	-	-	-	-	-
	Imports	0.15	0.87	1.63	2.43	2.81	2.69	3.01
	Net Imports	0.15	0.87	1.63	2.43	2.81	2.69	3.01
Electricity	Exports	0.90	1.43	1.97	2.70	2.82	2.88	2.83
	Imports	0.60	0.73	1.79	2.09	2.72	2.70	2.87
	Net Imports	-0.30	-0.70	-0.18	-0.61	-0.10	-0.19	0.04
TOTAL STOCK CHANGES		**0.22**	**-0.39**	**0.11**	**0.42**	**-0.06**	**-0.10**	**0.04**
TOTAL SUPPLY (TPES)[4]		**18.91**	**20.04**	**24.32**	**25.01**	**26.78**	**26.97**	**26.21**
Coal		0.33	0.33	0.36	0.14	0.16	0.15	0.15
Peat		-	-	-	-	-	-	-
Oil		14.45	12.51	12.26	11.03	11.09	11.51	10.35
Natural Gas		0.15	0.87	1.63	2.43	2.81	2.69	3.01
Biofuels & Waste[1]		0.24	0.47	1.44	1.81	2.24	2.23	2.34
Nuclear		1.64	3.74	6.18	6.92	7.25	7.25	6.90
Hydro		2.40	2.82	2.56	3.17	3.10	3.07	3.10
Wind		-	-	-	-	0.00	0.00	0.00
Geothermal		-	-	0.07	0.10	0.19	0.21	0.26
Solar/Other[2]		-	-	0.01	0.02	0.04	0.04	0.05
Electricity Trade[5]		-0.30	-0.70	-0.18	-0.61	-0.10	-0.19	0.05
Shares (%)								
Coal		*1.7*	*1.6*	*1.5*	*0.6*	*0.6*	*0.6*	*0.6*
Peat		-	-	-	-	-	-	-
Oil		*76.4*	*62.4*	*50.4*	*44.1*	*41.4*	*42.7*	*39.5*
Natural Gas		*0.8*	*4.3*	*6.7*	*9.7*	*10.5*	*10.0*	*11.5*
Biofuels & Waste		*1.3*	*2.4*	*5.9*	*7.2*	*8.4*	*8.2*	*8.9*
Nuclear		*8.7*	*18.7*	*25.4*	*27.7*	*27.1*	*26.9*	*26.3*
Hydro		*12.7*	*14.1*	*10.5*	*12.7*	*11.6*	*11.4*	*11.8*
Wind		-	-	-	-	-	-	-
Geothermal		-	-	*0.3*	*0.4*	*0.7*	*0.8*	*1.0*
Solar/Other		-	-	-	*0.1*	*0.1*	*0.2*	*0.2*
Electricity Trade		*-1.6*	*-3.5*	*-0.7*	*-2.4*	*-0.4*	*-0.7*	*0.2*

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

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1980**	**1990**	**2000**	**2008**	**2009**	**2010**
TFC	**16.67**	**16.62**	**18.66**	**19.58**	**20.64**	**20.17**	**21.05**
Coal	0.42	0.33	0.35	0.14	0.16	0.15	0.15
Peat	-	-	-	-	-	-	-
Oil	13.41	12.04	11.60	11.32	11.10	10.77	11.01
Natural Gas	0.11	0.71	1.49	2.19	2.59	2.49	2.76
Biofuels & Waste[1]	0.24	0.32	0.86	0.99	1.13	1.19	1.27
Geothermal	-	-	0.07	0.10	0.19	0.21	0.26
Solar/Other	-	-	0.01	0.02	0.03	0.04	0.04
Electricity	2.50	3.03	4.04	4.50	5.05	4.94	5.14
Heat	-	0.19	0.25	0.32	0.39	0.38	0.41
Shares (%)							
Coal	*2.5*	*2.0*	*1.9*	*0.7*	*0.8*	*0.7*	*0.7*
Peat	-	-	-	-	-	-	-
Oil	*80.4*	*72.5*	*62.2*	*57.8*	*53.8*	*53.4*	*52.3*
Natural Gas	*0.7*	*4.3*	*8.0*	*11.2*	*12.6*	*12.3*	*13.1*
Biofuels & Waste	*1.4*	*1.9*	*4.6*	*5.1*	*5.5*	*5.9*	*6.0*
Geothermal	-	-	*0.4*	*0.5*	*0.9*	*1.0*	*1.2*
Solar/Other	-	-	-	*0.1*	*0.1*	*0.2*	*0.2*
Electricity	*15.0*	*18.2*	*21.6*	*23.0*	*24.5*	*24.5*	*24.4*
Heat	-	*1.1*	*1.3*	*1.6*	*1.9*	*1.9*	*2.0*
TOTAL INDUSTRY[6]	**4.74**	**4.50**	**3.89**	**4.45**	**4.63**	**4.30**	**4.48**
Coal	0.11	0.23	0.31	0.11	0.15	0.14	0.14
Peat	-	-	-	-	-	-	-
Oil	3.67	2.75	1.31	1.46	1.31	1.20	1.22
Natural Gas	0.01	0.35	0.58	0.73	0.90	0.82	0.85
Biofuels & Waste[1]	-	0.12	0.16	0.44	0.43	0.40	0.44
Geothermal	-	-	0.01	0.01	0.01	0.02	0.02
Solar/Other	-	-	-	-	0.00	0.00	0.00
Electricity	0.95	1.02	1.48	1.56	1.66	1.57	1.66
Heat	-	0.03	0.05	0.14	0.16	0.15	0.15
Shares (%)							
Coal	*2.4*	*5.0*	*8.0*	*2.5*	*3.3*	*3.3*	*3.2*
Peat	-	-	-	-	-	-	-
Oil	*77.3*	*61.1*	*33.6*	*32.9*	*28.3*	*28.0*	*27.3*
Natural Gas	*0.3*	*7.8*	*15.0*	*16.5*	*19.5*	*19.1*	*19.0*
Biofuels & Waste	-	*2.7*	*4.0*	*9.9*	*9.4*	*9.2*	*9.7*
Geothermal	-	-	*0.1*	*0.2*	*0.3*	*0.3*	*0.4*
Solar/Other	-	-	-	-	-	-	-
Electricity	*20.0*	*22.7*	*38.1*	*35.0*	*35.8*	*36.4*	*37.0*
Heat	-	*0.6*	*1.2*	*3.1*	*3.5*	*3.6*	*3.3*
TRANSPORT[4]	**3.54**	**3.70**	**5.15**	**5.83**	**6.12**	**6.04**	**6.03**
OTHER[7]	**8.39**	**8.42**	**9.63**	**9.30**	**9.89**	**9.83**	**10.54**
Coal	0.30	0.10	0.04	0.03	0.01	0.01	0.01
Peat	-	-	-	-	-	-	-
Oil	6.38	5.77	5.37	4.25	3.96	3.81	4.06
Natural Gas	0.10	0.36	0.91	1.45	1.68	1.65	1.89
Biofuels & Waste[1]	0.24	0.20	0.71	0.55	0.68	0.78	0.83
Geothermal	-	-	0.06	0.10	0.18	0.20	0.24
Solar/Other	-	-	0.01	0.02	0.03	0.04	0.04
Electricity	1.37	1.83	2.34	2.72	3.12	3.11	3.21
Heat	-	0.16	0.20	0.18	0.23	0.23	0.26
Shares (%)							
Coal	*3.6*	*1.2*	*0.4*	*0.3*	*0.1*	*0.1*	*0.1*
Peat	-	-	-	-	-	-	-
Oil	*76.0*	*68.6*	*55.8*	*45.7*	*40.0*	*38.7*	*38.5*
Natural Gas	*1.1*	*4.2*	*9.4*	*15.6*	*17.0*	*16.8*	*17.9*
Biofuels & Waste	*2.9*	*2.3*	*7.3*	*5.9*	*6.9*	*7.9*	*7.8*
Geothermal	-	-	*0.7*	*1.0*	*1.8*	*2.0*	*2.3*
Solar/Other	-	-	*0.1*	*0.2*	*0.3*	*0.4*	*0.4*
Electricity	*16.3*	*21.7*	*24.2*	*29.3*	*31.6*	*31.7*	*30.5*
Heat	-	*1.9*	*2.1*	*1.9*	*2.3*	*2.3*	*2.5*

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1980**	**1990**	**2000**	**2008**	**2009**	**2010**
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**4.48**	**6.95**	**9.58**	**11.17**	**11.68**	**11.57**	**11.32**
OUTPUT (Mtoe)	**3.17**	**4.14**	**4.73**	**5.69**	**5.77**	**5.73**	**5.68**
(TWh gross)	36.82	48.18	54.99	66.12	67.04	66.67	66.06
Output Shares (%)							
Coal	-	*0.1*	*0.1*	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	*7.1*	*1.0*	*0.7*	*0.3*	*0.2*	*0.2*	*0.1*
Natural Gas	-	*0.6*	*0.6*	*1.3*	*1.1*	*1.1*	*1.6*
Biofuels & Waste	-	*0.4*	*1.5*	*2.6*	*3.6*	*3.6*	*3.7*
Nuclear	*17.1*	*29.8*	*43.0*	*40.0*	*41.3*	*41.5*	*39.9*
Hydro	*75.8*	*68.1*	*54.2*	*55.7*	*53.8*	*53.6*	*54.6*
Wind	-	-	-	-	-	-	*0.1*
Geothermal	-	-	-	-	-	-	-
Solar/Other	-	-	-	-	*0.1*	*0.1*	*0.1*
TOTAL LOSSES	**2.26**	**3.42**	**5.33**	**6.06**	**6.56**	**6.48**	**6.22**
of which:							
Electricity and Heat Generation[9]	1.31	2.60	4.58	5.14	5.51	5.43	5.20
Other Transformation	0.22	0.11	0.06	0.05	0.04	0.05	0.04
Own Use and Losses[10]	0.73	0.71	0.69	0.86	1.01	0.99	0.98
Statistical Differences	**-0.02**	**-**	**0.32**	**-0.63**	**-0.43**	**0.33**	**-1.06**
INDICATORS	**1973**	**1980**	**1990**	**2000**	**2008**	**2009**	**2010**
GDP (billion 2005 USD)	246.43	252.01	313.93	349.05	408.45	400.78	411.66
Population (millions)	6.44	6.39	6.80	7.21	7.71	7.80	7.79
TPES/GDP[11]	0.08	0.08	0.08	0.07	0.07	0.07	0.06
Energy Production/TPES	0.23	0.35	0.42	0.48	0.48	0.47	0.48
Per Capita TPES[12]	2.94	3.14	3.58	3.47	3.47	3.46	3.37
Oil Supply/GDP[11]	0.06	0.05	0.04	0.03	0.03	0.03	0.03
TFC/GDP[11]	0.07	0.07	0.06	0.06	0.05	0.05	0.05
Per Capita TFC[12]	2.59	2.60	2.75	2.72	2.68	2.59	2.70
Energy-related CO_2 Emissions (Mt CO_2)[13]	43.0	39.2	41.4	42.5	43.8	42.4	43.8
CO_2 Emissions from Bunkers (Mt CO_2)	2.0	2.0	3.1	4.6	4.2	4.0	4.2
GROWTH RATES (% per year)	**73-80**	**80-90**	**90-00**	**00-08**	**08-09**	**09-10**	**73-10**
TPES	0.8	2.0	0.3	0.9	0.7	-2.8	0.9
Coal	-0.0	0.9	-9.1	1.9	-6.8	2.0	-2.0
Peat	-	-	-	-	-	-	-
Oil	-2.0	-0.2	-1.1	0.1	3.8	-10.1	-0.9
Natural Gas	28.7	6.5	4.1	1.8	-4.0	11.7	8.5
Biofuels & Waste	10.1	11.8	2.4	2.7	-0.5	5.3	6.3
Nuclear	12.5	5.1	1.1	0.6	-0.1	-4.8	4.0
Hydro	2.3	-1.0	2.1	-0.3	-0.9	0.9	0.7
Wind	-	-	-	-	-	50.0	-
Geothermal	-	-	4.1	8.2	8.2	23.3	-
Solar/Other	-	-	11.1	5.4	25.7	20.5	-
TFC	-0.0	1.2	0.5	0.7	-2.3	4.4	0.6
Electricity Consumption	2.8	2.9	1.1	1.4	-2.1	4.0	2.0
Energy Production	7.3	3.8	1.6	0.8	-0.1	-1.2	3.0
Net Oil Imports	-1.7	-0.4	-1.4	0.7	4.0	-11.0	-0.9
GDP	0.3	2.2	1.1	2.0	-1.9	2.7	1.4
Growth in the TPES/GDP Ratio	0.5	-0.4	-0.7	-1.1	1.5	-4.5	-0.5
Growth in the TFC/GDP Ratio	-0.4	-1.1	-0.5	-1.2	-2.0	2.0	-0.8

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

Footnotes to Energy Balances and Key Statistical Data

1. Biofuels and waste comprises solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
2. "Other" includes ambient heat used in heat pumps.
3. In addition to coal, oil, natural gas and electricity, total net imports also include biofuels.
4. Excludes international marine bunkers and international aviation bunkers.
5. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
6. Industry includes non-energy use.
7. Other includes residential, commercial, public services, agriculture, forestry, fishing and other non-specified.
8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and 100% for hydro, wind and photovoltaic.
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 1 000 US dollars at 2005 prices and exchange rates.
12. Toe per person.
13. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach from the Revised 1996 IPCC Guidelines. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to 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, member countries 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 are 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 respect the Polluter Pays Principle where practicable.

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 member countries wish to retain and improve the nuclear 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 encourages 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 the meeting of 4 June 1993 Paris, France.)

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

ANNEX D: GLOSSARY AND LIST OF ABBREVIATIONS

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

b/d	barrels per day
bcm	billion cubic metres
CCGT	combined-cycle gas turbine
Cent	Refers to Swiss cent, CHF 0.01
CHP	combined production of heat and power
CH_4	methane
CO_2	carbon dioxide
CORE	Federal Energy Research Commission
CRF	cost-reflective feed-in tariff
CTI	Commission for Technology and Innovation
DETEC	Department (Ministry) of the Environment, Transport, Energy and Communications
DSO	distribution system operator
EAEc	Energy Agency for the Economy
ElCom	Electricity Commission
ESL	Electricity Supply Law
EU	European Union
EU-ETS	EU Emissions Trading Scheme
FOEN	Federal Office for the Environment
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt, or 1 watt × 10^9
GWh	gigawatt-hour, 1 gigawatt × 1 hour
ktoe	thousand tonnes of oil equivalent
kW	kilowatt, or 1 watt × 10^3
kWh	kilowatt-hour, or 1 kilowatt × 1 hour
LNG	liquefied natural gas
LPG	liquefied petroleum gas

mcm	million cubic metres
Mt	million tonnes
Mt CO_2.eq	million tonnes of CO_2 equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt, or 1 watt x 10^6
MWh	megawatt-hour, or 1 megawatt x one hour
NAGRA	National Cooperative for the Disposal of Radioactive Waste
NPP	nuclear power plant
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, *i.e.* PPP estimates the differences in price levels between countries
PV	photovoltaics
RD&D	research, development and demonstration
SAFE	Swiss Agency for Efficient Energy Use
SFOE	Swiss Federal Office of Energy
SWEP	Swiss Electricity Price Index
TFC	total final consumption of energy
TJ	terajoule
toe	tonne of oil equivalent, defined as 10^7 kcal
TPA	third-party access
TPES	total primary energy supply
TSO	transmission system operator
TW	terawatt, or 1 watt × 10^{12}
TWh	terawatt-hour, or 1 terawatt × 1 hour
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax
W	watt

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