

SWISS NUCLEAR PHASEOUT: ENERGY SUPPLY CHALLENGES

The decision to phase out nuclear energy is of strategic importance for Switzerland. Providing a clean, economic, and climate-friendly supply of energy is a major political and societal challenge. A number of ongoing developments in Europe pose further obstacles to a transformation of Switzerland's energy supply. If the Federal Council's "Energy Strategy 2050" is to be implemented successfully, a consensus on burden-sharing must be reached.



Leibstadt nuclear power plant, 9 July 2012.

Reuters/Arnd Wiegmann

The nuclear disaster of Fukushima marked a turning point in Swiss energy policy. Soon after three reactor blocks had been destroyed by the earthquake and subsequent tsunami wave in Japan in mid-March 2011, Federal Councillor Doris Leuthard suspended the application procedure for general licences for replacing nuclear power plants in Switzerland. In May 2011, the Federal Council approved a complete nuclear phaseout. Under this arrangement, existing nuclear plants are to continue operating, but will not be replaced after their operational lifetime expires as specified by safety guidelines.

In spring and autumn of 2011, both chambers of parliament approved the basic decision to enter into a nuclear phaseout. Some critics attributed the abrupt change of course of some political parties mainly to electioneering tactics. For their part, these parties explained their about-face by arguing, among other points, that in the aftermath of Fukushima the already contentious question of building new nuclear

plants was no longer likely to enjoy the support of a majority of the Swiss population. In Switzerland's direct democratic political system, this would effectively mark the end of Switzerland's nuclear age.

Since the parliament's decision to phase out nuclear energy, the Federal Council has rapidly advanced plans for ensuring Switzerland's power supply without nuclear energy. Based on a scenario analysis, the measures needed for a nuclear-free Switzerland were identified and specified in the framework of working groups on an "Energy Strategy 2050". On the basis of this document, the Federal Council in April 2012 commissioned the Federal Department of the Environment, Transport, Energy, and Communications (DETEC) to elaborate the necessary changes to the constitution and laws. The respective consultation process with stakeholders (*Vernehmlassung*) is expected to take place in autumn of 2012.

The measures proposed by the Federal Council make it clear that the nuclear pha-

seout is a decision of strategic importance for Switzerland. So far, nuclear energy supplied 40 per cent of the country's electricity needs. In order to be able to compensate for the loss of nuclear energy, the Federal Council's Energy Strategy anticipates not only an expansion of renewable energy, but also wants to spur Switzerland's transformation into a "2,000 Watt society". This implies significant savings in electricity as well as in overall energy consumption. Such a strategy will not only come at a cost in economic terms, but also presupposes a transformation of society as a whole. This cannot be brought about with administrative measures alone, but requires a consensus on the concrete arrangements for burden-sharing.

Against this background, further fundamental political debates on the merits of a nuclear phaseout and the policies of the proposed energy transformation are to be expected. Parliament, too, will have to deal with this complex matter repeatedly. In the following, the issue of the nuclear phaseout will first be contextualised within the current state of energy supply in Switzerland and the core international developments in energy policy. Building upon this, the Federal Council's new Energy Strategy will be critically examined, taking into account the criteria of security of supply, economic viability, and climate protection.

Comfortable status quo

Switzerland has hitherto been in a comparatively comfortable position when it came to energy supply. Its electricity supply in particular is marked today by very good statistics on climate protection, but also

good marks in terms of security of supply and economic efficiency. Among the industrialised countries, Switzerland has by far the least CO₂-intensive GDP, due also to its economic structure. While emissions per capita are not quite as impressive with respect to the high level of wealth, they are still among the lowest among industrialised nations and are just over half of the per-capita emissions of citizens in Germany. However, the substantial emissions included in imports of economic goods are not included in this figure.

The excellent performance of Switzerland's electricity production is due to the usage of hydropower and nuclear energy, both of which supply baseload power while emitting almost no CO₂. Furthermore, the country's geographic situation and its infrastructure links to the EU allow it to import affordable nuclear electricity from France. This means that almost no fossil fuels are needed to generate electricity, which also enhances the security of supply. While Switzerland is currently forced to import fuel rods, these can easily be stockpiled for long periods, if necessary, while the uranium needed to produce fuel rods is not expected to become scarce in the foreseeable future.

The main current challenges for the electric power industry concern the power transmission network, which is in urgent need of being expanded and overhauled in order to ensure security of supply. Switzerland's integration in the EU power market does enhance its security of supply, but also brings growing burdens. Within the European transmission network, the Swiss-Italian border features the greatest flows of electrical currents.

When it comes to crude oil products, which are used mainly to power individual transport and heating, Switzerland's statistics are considerably worse than those for electricity supply. First of all, at 39 per

cent of primary energy consumption, Switzerland's oil consumption is comparatively high by comparison among OECD countries, which factors largely in Switzerland's carbon footprint. Secondly, the security of supply in this area is only average. While there are large depots for crude oil products that can cover more than four months of consumption in an emergency, Switzerland generally depends on the flawless functioning of the international oil market, which is subject to geopolitical risks. Third, the price of crude oil is highly volatile and has a long-term upward trend.

A positive factor in the overall balance sheet is that at 12 per cent, natural gas only accounts for a small part of Switzerland's primary energy consumption. On the one hand, natural gas has a negative effect on the climate; on the other, securing supply is difficult for Switzerland when it comes to natural gas: It is a transit country for deliveries to Italy, but has only one main import pipeline, the Transgas pipeline, and no facilities for storage. Also, the options for diversifying suppliers are limited, further increasing exposure to geopolitical risks. So far, any problems have been alleviated by the possibility of substituting oil for gas with about 40 per cent of consumers and through consultations with suppliers abroad. However, such agreements may prove null and void in times of crisis, since national regulations of EU states and the EU crisis reaction mechanism prioritise the supply of home markets.

Changing external conditions

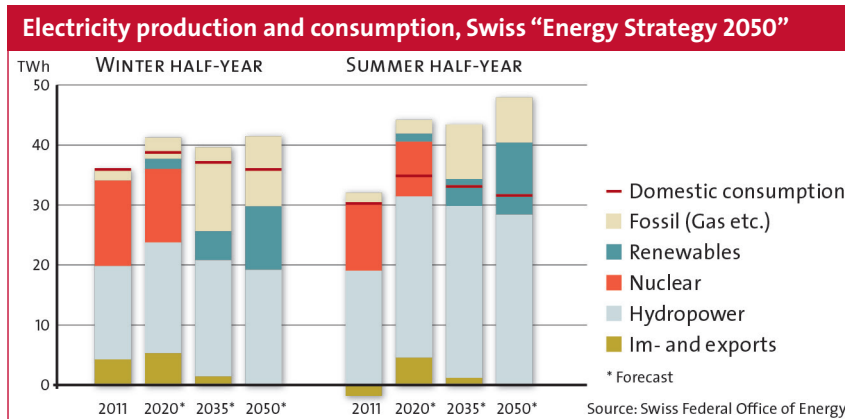
Switzerland's options in energy policy after a nuclear phaseout and the possible repercussions of such a step for the security, the economic efficiency, and the carbon footprint of Switzerland's energy supply depend to a considerable extent on the international environment in which the country's energy policy is formulated. In this respect, three developments are worth examining in particular:

First, at the international level, there are no signs of convergence regarding either energy policies or energy prices for end-users. This constitutes a great challenge in terms of competitiveness. In the US, both energy prices and CO₂ emissions are falling from their high levels due to the availability of cheap domestic natural gas and the reduced dependence on coal. In the EU, the picture is more disparate. The national energy policies diverge significantly and variously prioritise climate protection, a nuclear phaseout, or economic efficiency. A number of European countries did change their economic policies after Fukushima: Germany turned towards "King Coal" after an abrupt decision to abandon nuclear energy, while gas-dependent Italy decided to reverse an earlier decision to re-adopt nuclear power. The latter decision had been taken because of a strong increase in fuel costs. Much like Switzerland, Belgium decided not to build any new reactors. Other countries such as Finland, Bulgaria, the UK, Lithuania, Poland, or the Czech Republic, however, are holding fast to their plans to expand nuclear energy. Finland is currently constructing a new nuclear power station and plans to start building another in 2015.

Against this background, it comes as no surprise that the end-user prices differ strongly across Europe: The Scandinavian countries benefit from their affordable mix of hydropower, nuclear power, and biomass, while Germany and Italy are mainly investing in expensive solar and wind power and have undertaken financial guarantees to support these for decades to come. Since these costs are apportioned nationwide by way of network costs and special premiums, the end-users' cost structures are highly diverse in an international comparison, despite convergence in prices on the wholesale electricity markets. No unified international trend of increasing electricity prices is to be expected for the foreseeable future.

Second, these national divergences have a distorting effect on the EU electricity market, despite the fact that this market is becoming increasingly integrated. Differences in national electricity mixes have always caused price differences at the electricity exchanges: In Germany, coal ensures affordable prices for baseload power, as does nuclear energy in France, while Italy must accept high costs due to its dependency on gas-powered plants. However, in Europe today, increasing mar-

Terminology
Baseload electricity: Minimum level of electricity demand during a day
Peak demand: Electricity demand that occurs during peak time and fluctuates quickly
Operating reserve: Spare electricity generation capacity that can be made available in case of fluctuations of demand or supply, and in case of breakdown of a power plant
Primary energy demand: Overall demand for energy sources before conversion or transformation into usable energy
CCS: Carbon capture and storage: CO ₂ is separated and pressed in underground storage. Increases energy demand by about 10%
GW: Gigawatt, 1 Million kW, unit of electric power
TWh: Terawatt hour, 1 Billion kWh, unit of electric work



ket liberalisation has brought about not only increasing regulation of business relations, but, paradoxically, also more direct interventions by nation-states. These interventions affect the prices paid on energy exchanges as well as the stability of the European transmission network, with which Switzerland is inextricably integrated. National feed-in tariffs as subsidies for renewable capabilities are causing relative declines of wholesale prices at the energy exchanges today, as significant overcapacities are being created. This devalues existing power plants and has the greatest impact on power plants generating energy for peak demand, which can no longer be operated profitably in many places. This, in turn, reduces the reliability of energy supply especially during peak demand periods in the winter. Italy has already been forced to subsidise fossil power plants as a result, while Germany is considering introducing such a subsidy in the form of "capacity markets".

Third, natural gas is becoming increasingly important for the security of supply within the European power grid. EU states such as Germany and Austria anticipate an increase of electricity generation in gas-powered plants. This trend lays the groundwork for a new cascade of risks, since problems with gas supplies can immediately affect the stability of the electricity grid, as illustrated in February 2012. Then, Russia failed to meet its delivery commitments, resulting in disruptions to supplies in several southern German power plants. Since most of these were not designed for alternative petroleum-based operations, the supply of electricity to southern Germany was on the brink of collapse. Once more, the geopolitical risks of natural gas imports became evident. In this sector, Europe is still too dependent on a few suppliers. The EU continues to struggle with building up new relations with suppliers

from geopolitically fragile regions, as evidenced by the so far fruitless efforts to secure natural gas from Central Asia.

Phaseout opportunity costs

The nuclear phaseout will remove one of the pillars of Switzerland's carbon-friendly energy supply. Also, the options for purchasing French nuclear electricity expire beginning in 2017 and can probably not be renewed under the current conditions. Therefore, up to 45 per cent of baseload generation will have to be incrementally replaced or saved.

In order to master these challenges, the Federal Council's Energy Strategy 2050 relies on several pillars: First, energy efficiency is to be enhanced in order to reduce consumption; second, the use of hydropower and new renewable energy sources is to be expanded; and third, if necessary, fossil-powered electricity generation will have to be introduced by using combined cycle natural gas power plants (CCGT). Measures have already been outlined to achieve the first milestone by 2020. Two further packages of measures are to follow in 2020 and 2035 in order to achieve the targets by 2050. The measures can be expected to escalate with time from lower to higher levels of intervention. Already the first package of measures will give rise to intensive discussions, however.

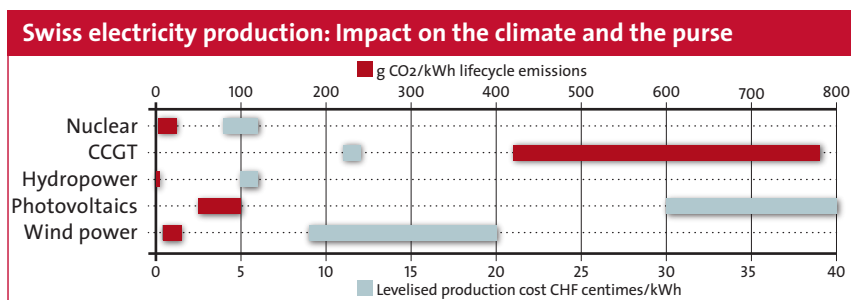
The suggestions in the area of energy efficiency, for instance, are extremely ambitious. By 2050, the current annual consumption of electricity of around 65 TWh is to remain approximately constant – despite forecasts of continued demographic increase, more economic growth, and enhanced consumption of 6 TWh by pumped storage plants. Also, it is anticipated that in the interests of greater efficiency, electricity will increasingly be used to generate heat in buildings and for powering mobil-

ity, replacing oil products in these areas. As part of the Energy Strategy, it is anticipated that the population will reduce its use mainly of fossil fuels, for which purpose high taxes on fuel are already being discussed. The share of electricity in final consumption is to continue to increase, while overall energy consumption will have to decrease. According to calculations by the ETH Board, the current annual rate of energy productivity growth would have to quadruple in order for this target to be reached.

The main share of energy economies of 18.5 TWh is to be contributed by the corporate sector. However, the first bundle of measures will only suffice to reach 39 per cent of that target at most, which is why further-reaching measures will be required later on. According to business sources, the corporate sector can save 7 TWh at most. Therefore, a core component of the expected savings will be electricity prices, which under the Energy Strategy are to increase by 250 per cent due to a steering tax, the fostering of renewables, and contributions to network financing. Due to the divergent price levels for electricity in Europe and globally, exemptions will probably have to be granted to particularly energy-intensive companies.

The most important change in the spectrum of electricity supply will be the expansion of renewables, which are being subsidised through feed-in tariffs. The latter does not affect the prices for electricity on energy exchanges, but is passed on directly to Swiss consumers. Due to its (limited) suitability for supplying baseloads and its low lifetime CO2 emissions, hydropower is a desirable candidate for expansion, but the potential for further expansion here is limited at only 4 TWh. Also, local populations and environmental groups can be expected to offer resistance against large-scale projects in this area.

Solar power, on the other hand, is to play a major role. Photovoltaic power is to be expanded to a peak capacity of around 9.5 GW (equivalent to the output of more than seven nuclear plants of the Leibstadt type) by 2050. Since solar panels only produce electricity for a few hours a day, this capacity can only achieve an annual output of around 10 TWh. Wind energy is expected to contribute another 4 TWh a year, to be generated by 800 turbines. PV panels are quite cost- and energy-intensive in production, resulting in relatively high electricity



costs. Also, their lifetime CO₂ emissions are twice as high as those of nuclear energy. But security of supply is perhaps the biggest problem due to the intermittent nature of wind and solar power. In order to achieve the steady flow of electricity that is necessary to match demand and guarantee network stability, storage technology is required, which adds further storage and network costs.

It is true that Switzerland with its capacities in the areas of reservoirs and pumped storage is considerably better prepared than other countries for stabilising the intermittent supply of weather- and daylight-dependent renewables. However, in Switzerland, too, the options for seasonal storage are limited. For instance, solar power can be stored during daylight hours, when more energy is produced than consumed, and can be used for electricity generation during the night. Also, fluctuations in production can easily be balanced out by the baseload-generating hydropower stations. However, due to limitations in size of reservoirs, it is hardly possible to shift large volumes of stored solar power from summer to winter months. Also, solar energy and hydropower are positively linked, since less insolation during the winter means less solar energy and also less hydropower. Therefore, while Switzerland tends to experience overproduction of electricity during the summer – as do Germany and Italy – renewables cannot supply sufficient power during the winter. To remedy this state of affairs, some experts and energy actors have urged increased imports of wind power from Germany. This, however, would require a massive expansion of transmission networks in Germany and Switzerland. Also, Germany would have to invest in direct-current networks in order to reduce transmission losses.

In phasing out nuclear energy, Switzerland will thus hardly be able to avoid ushering in a new phase of using fossil fuels for power production for providing both baseloads and operating reserve. The Federal Coun-

cil's energy scenarios anticipate that up to seven combined cycle power plants (CCGT) may be necessary. This proposed integration of electricity and natural gas for power supply brings new risks for supply due to the increased relevance of natural gas for power supply. In addition to enhanced geopolitical risks through increasing demand for gas, traditional risks of technical disruptions to supply must also be taken into consideration. Supply to power plants must be ensured at all times.

Two means of alleviating that problem are conceivable: Power plants equipped with oil burners for substitution, or gas storage capacities. The former would indubitably be the easier option, but would increase capital and operating costs somewhat and require space for petroleum storage tanks. The gas storage option, on the other hand, would require a natural gas storage facility to be built in Switzerland, which would be very expensive. Alternatively, an agreement with the EU on natural gas storage and emergency supply is possible. While access to EU gas storage facilities is already technically feasible, Switzerland cannot reserve any permanent storage capacities for itself as the gas markets have been liberalised. A possible option would be to adopt EU regulations in the gas sector. That would oblige Switzerland, however, to be able to secure its own supply even if imports from Germany should cease. To this end, Switzerland would, for instance, have to enable the Transgas pipeline for reverse flow.

Also, natural gas plants are problematic when it comes to economic considerations. Fuel costs in Europe continue to be too high for profitable operation of gas-powered plants. In Switzerland, too, a subsidisation scheme would possibly be required as incentive for investment. Gas-powered plants also constitute a problem for Swiss emission targets due to their high CO₂ emissions. These emissions are currently only being discussed in terms of cost, with integration with the (dysfunctional) Euro-

pean emissions trading system being suggested as a possible remedy. In any case, Switzerland's very good performance in terms of CO₂ emissions will be tarnished. Avoiding emissions is still better than purchasing certificates, which can hardly reflect the real cost of CO₂. The problem could potentially be sidestepped by investing in Carbon Capture and Storage (CCS) technology. However, this technology is still at the trial stage and accordingly expensive. It also struggles to overcome resistance from the general public.

By phasing out nuclear energy, Switzerland is eliminating a risk at the local level that has a very low probability of occurrence, but potentially catastrophic consequences for society as a whole. The long-term risks of nuclear energy arising from radioactive waste are reduced, but not eliminated. There is ultimately no consensus on assessing the risks associated with nuclear energy, and the matter is one of societal value judgments. However, the decision to phase out nuclear energy is likely to bring high costs of opportunity. It is quite possible that a nuclear-energy-free Switzerland will have to lower its sights when it comes to security of supply, but also concerning competitiveness and the climate protection scores of its energy mix. Also, given the very ambitious energy efficiency targets of the Federal Council, there is a considerable risk that they will not be met. This increases the likelihood that additional electricity generation from fossil sources will be needed. This caveat pertains also to the overall targets for oil and natural gas consumption. As the "energy turnaround" is envisaged to become a project encompassing societal transformation, its success presupposes a stable consensus. Such a consensus, in turn, can only be reached if the consequences of a phaseout are being specified and openly discussed.

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