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Facts for the energy decisions of tomorrow

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ENERGIE-SPIEGEL

FACTS FOR THE ENERGY DECISIONS OF TOMORROW

Outlook for CO_2-free electricity in Switzerland

New renewable energy sources

In spite of all appeals for voluntary savings, the electricity demand in Switzerland has grown steadily since 1990. When the first nuclear plants disappear from the grid around 2020, there will be a gap in the electricity supply that must be filled. New renewable energy sources are heavily discussed options when considering how this demand can be filled in the most cost-effective and CO_2 free way.

Thanks to hydropower, 60% of the Swiss electricity production is already sustainable. But the potential for new, large hydro power plants has been exhausted. At the same time, the use of fossil fuels for power production should also be avoided as much as possible to reduce resource depletion, limit price swings and satisfy binding political climate protection targets. The remaining resources, besides conservation, are new renewable resources (small hydro, wind, biomass, solar energy and geothermal) and advanced nuclear systems.

These two options are fundamentally different, but play important roles in the politics of climate protection. How much each can contribute to Swiss electricity production in the next 30 to 40 years and at what price has been recently investigated in work done for the Swiss Federal Office for Energy (BFE)[1].

This Energie-Spiegel shows the results of the first part of the PSI study. New renewables could increase their contribution to our electricity supply from 3% today to 10% of our current demand by 2035, if their promotion is significantly strengthened. Their significant potential must be qualified, because only some of them become cost-competitive in the medium term, in spite of expected technological advances. And some of the new renewables encounter resistance on the basis of nature and landscape protection.

The import of renewable electricity (e.g. wind power) appears interesting at first glance, but there exist large uncertainties with regard to availability and transmission capacity. When electricity in Europe grows scarce, each country will look out for itself first.

[1] Neue Erneuerbare Energien und Neue Nuklearanlagen: Potenziale und Kosten Beitrag zu den Energieperspektiven 2035/2050 des Bundesamtes für Energie www.energie-schweiz.ch; http://gabe.web.psi.ch/projects/bfe/index.html

Content

Small but beautiful.

The new renewables are coming.

The technologies investigated here for renewable electricity production differ strongly from each other in their levels of development. Small hydro and wood-fired cogeneration are mature technologies; wind energy is technologically established, but can still be improved. New technologies based on biomass, photovoltaic solar and geothermal energy are emerging, but still have a great potential for improvement.

Small Hydro

No one wants to flood more alpine valleys. But the building of small, environmentally sustainable hydro plants is still possible, if the necessary, accompanying ecological measures are implemented. This potential should be used. The current total generation of all hydro plants with a capacity of less than 10 MW could be increased from 3400 GWh/year to 5600 GWh/year, including about 200 GWh/year from small installations of less than 1 MW. If need be, another 150 GWh/year from drinking water and wastewater treatment plants installations with capacities of 300 kW and less are also possible. Electricity costs depend in each case upon the location of the power plants, and lie mostly above the current market price, but this power can be readily marketed with an ecopower premium.

Wind

A total of 96 wind parks are possible in Switzerland, each park averaging 7 wind turbines of 1.25 MW size, primarily in the Jura, peri-alpine regions and the Alps. The generating potential lies in the range of 1150 GWh/year – more than the sum delivered by all new renewables today (with the exception of small hydropower). Single turbine installations could bring a further 2850 GWh/year, but their construction is less realistic. An increase to 600 GWh/year appears possible by the year 2035, and full construction to 1150 GWh/year by the year 2050. Cost should not be an unbeatable hindrance for the development of wind power in Switzerland, but significant opposition on the basis of landscape and nature protection can be expected.

Biomass

Biomass is not available in unlimited quantities, but can be used in many ways. The ecologically usable potential can be significantly raised on one hand by the increased use of different types of biomass, and on the other hand by a two to three fold increase in the generation efficiency. Future costs depend on future trends in forestry and agriculture, as well as on disposal fees. The reduction of these future biomass transformation costs also depends at least by half upon the future use of fossil resources, e.g. whether fuel cell technology can replace fossil fuels in the electricity generation market or in cogeneration applications. In general, an overall strategy is needed to coordinate the more profitable use of biomass for creating electricity, heat and transportation fuels.

> Best Chances of Realization: Small Hydro and Biomass

Photovoltaics

If only the most suitable roofs in Switzerland were covered with photovoltaic installations, this would contribute a total energy production of 9.4 to 13.7 TWh/year – comparable to the production of a nuclear power plant about the size of Leibstadt, or about 20% of Swiss demand. But even if the costs drop strongly according to expectations, photovoltaics remain very expensive. Therefore, only a linear growth up to about 100 GWh/year is expected by the year 2035. Anything further would require extremely ambitious and targeted promotion. Large installations would be more advantageous in alpine locations. The solar radiation is greater there and the winter production would be about twice that in the Swiss midlands, but one can also rely on massive opposition on the basis of landscape protection.

Geothermal

There is a very high technical potential for geothermal energy in Switzerland. However the uncertainties related to the cost of generating this energy are almost as large. The most critical factors are the geological data and capital costs (especially drilling costs). Geothermal generation of electricity becomes more economic when the waste heat can also be used. Therefore the availability of a municipal heat distribution network or a large commercial heat user can become a decisive factor. A more exact judgment will be assisted by the demonstration plant in Basel when it begins operation.

Table: Overview of Electricity Potential and Costs for Renewable Energy in Switzerland.

	Energy System	Advantages	Disadvantages/Limits	Production [GWh/year]	Potential [GWh/year]		Cost [Rp./kWh]	
				2004	2035	Long term	Today	2035
Baseload	Small hydro <10MW / <1MW	Mature technology; high acceptance	Changes local water usage	3500 / 850	5800 / 1100	5800 / 1200	5–25	4–20
Baseload	Biomass	Multiple resources	Competing possible uses for resources (fuels); emissions reduction technologies necessary	900	2000–3000	9000 (With 100% use for electricity production)	20–40	10–30
Baseload	Geothermal	Very high potential	No commercial plants in operation; most waste heat has limited commercial use, prognosis very uncertain	0	1000–2000	Very high, speculative	No reference plants currently exist.	7–15
Weather dependent	Wind energy (Swiss plants; imports possible, but very uncertain)	Mature technology; Potential for cost reduction still possible	Limited number of appropriate locations; conflicts with landscape and nature protection; reserve energy necessary.	5,4	600	4000 (Wind parks 1150, single turbines 2850)	12–25	12–15
Weather dependent	Photovoltaics (roof or building integrated installations)	High acceptance; Integration in existing buildings possible	Costs currently very high; reserve energy necessary	16.7	100–2700 (Strongly dependent upon promotion)	16 700 Roofs 13 700, Facades 3000	50–90	22–42

Potential 2035: The realization of this potential is seen as realistic under the conditions of a targeted, public promotion effort.

Long-term technical potential; no consideration of costs and acceptance problems.

Possible, but not for free.

Current policies are aimed at providing up to 10% of Switzerland's current energy demand with renewable energy by the year 2035, about 5500 GWh/year. In the long run the usable, renewable energy resources are much larger. And the technical potential, determined by technological and technical process criteria, also exists. Whether the goal can be reached depends chiefly upon the economic performance of the technologies – i.e. whether the total costs are acceptable.

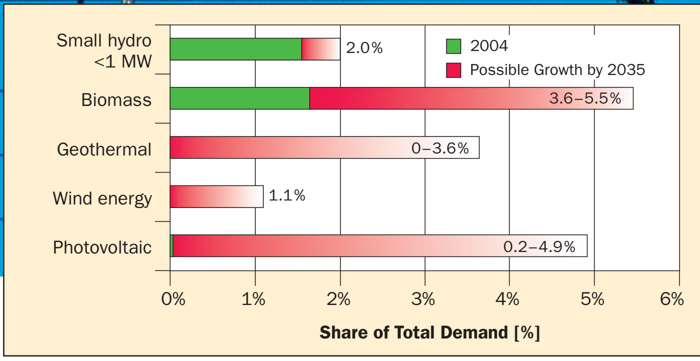

Figure 2: Current share of the new renewables, as well as possible growth with targeted promotion by 2035, compared to electricity use in 2004. The realizable potential for geothermal is speculative. A growth of photovoltaic energy that strongly exceeds the lower bound of the given interval is rather improbable.

Domestic Production

The goal of generating 10% of today's level of electricity demand from renewable resources by the year 2035 is technically possible (Fig. 1). This 10% includes a great part of the realistic potential for wind and small hydro (<1 MW), substantial contributions from biomass and geothermal, as well as a relatively small contribution from photovoltaics. Since geothermal is today just being developed, its share must be seen to a certain extent as speculative.

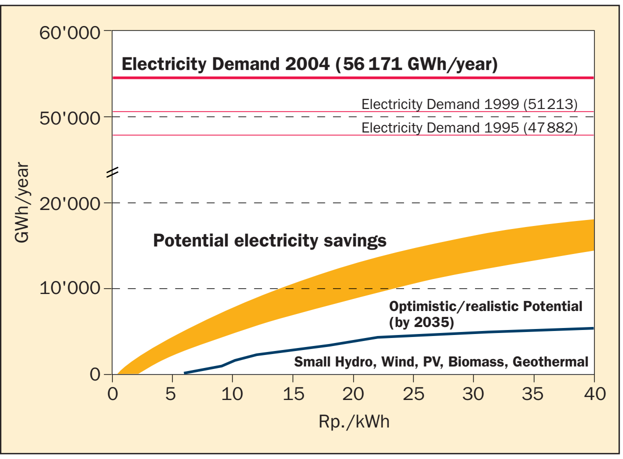

Figure 1: Total potential electricity production and costs of new renewables by 2035 in Switzerland. Electricity savings potential is based on earlier analyses and is given for the purpose of comparison.

If one also includes small hydro plants with a capacity of up to 10 MW, renewables could contribute even more than 10% to Swiss electricity production, even if simultaneously small contributions from biomass and geothermal are assumed. If one wishes to achieve the 10% by the year 2035, this will mean higher production costs of about 0.5 billion CHF per year (based on an average production cost of 15 Rp./kWh for renewable electricity) when compared to nuclear or gas-fired generation (based on current prices for nuclear and the average price over the last few years for gas). Recent strong increases in natural gas prices mean that the additional cost of renewables over gas may drop by up to 40%. The price increase of natural gas has such a strong effect because the fuel cost dominates the overall production cost for natural gas power plants. With nuclear energy the price of uranium only plays a subsidiary role.

In the short and medium term, the potential of saving electricity exceeds renewable generation (and is cheaper). There is still a lot to be gotten in this area, but the incentives for implementation must be further increased.

Promote and Save

The implementation of new renewables depends in its current state of development upon the level of the price which generators can get where they feed into the grid (currently 15 Rp./kWh). For comparison, solar power in Germany is paid up to 60 Euro cents/kWh (or 93 Rp./kWh), depending upon the individual installation. The level of the subsidy is a political question. Certainly renewable technologies must be further developed to achieve higher efficiencies and lower costs. According to the status of each technology, various phases in the development cycle may need support, from basic or applied research through a pilot or demonstration installation to market introduction or - where sensible – market subsidy.

> Stronger, targeted promotion necessary

Importing renewable electricity

Wind power The political framework will determine whether substantial wind power imports in the year 2020 and later will be realistic. The PSI study shows that the prices for imported wind power will hardly lie much lower than the production costs for domestic wind power.

Solar thermal and –chemical power Power imports from solar thermal power plants in the Mediterranean could be interesting after 2030. Solar thermal plants in appropriate locations could be run between 2000 to 3000 hours per year without special energy storage capacity. The resulting current production costs of 14 to 25 Rp./kWh could drop by up to half after 2030. Solar chemical plants allow solar energy to be stored in a flexible way in energy carriers like hydrogen or zinc, and then used to produce electricity upon demand for stationary or mobile applications. The higher costs could be accepted, because the energy is constantly available.

Common limitations For power imports the transmission capacity must first and foremost exist and be available. Potential exporting countries must also first cover their own demand. This makes depending upon imports for a reliable electricity supply very uncertain.

More Courage to Concentrate!

How does Switzerland compare to Europe on renewable energy (RE)?
In policy terms, e.g. models for grid access and regulation, Switzerland just now has a chance to learn from other countries. Germany has great experience with cost-covering grid access tariffs, Sweden with quota regulation and tradable certificates. Switzerland should choose a model that does not distort the economic incentives for the choice and development of renewable energies. The political discussion also often does not deal carefully with renewable resource potential, for example in the case of geothermal where, apart from the technical risks, the low generation efficiency of about 10% means there is an economic need for large heat customers. We also cannot act as though the import of wind energy from installations in the North Sea is possible without any limitations. In R&D we have the tendency to promote technologies with the "watering can" principal, instead of reckoning what technologies can make a significant contribution in Switzerland or can contribute to creating value through employment.

How do the Swiss electricity producers compare to this?
They will certainly make more efforts in the future, both by the promotion of electricity generation from renewable resources as well as by promoting research. I do not have the concrete acquaintance necessary for a general comparison with the European electricity producers. But there are certainly projects in other areas like "Clean Coal Technologies" in which European electricity generators will strongly participate in future demonstration projects.

What research priorities does CORE set for RE? By what criteria?
In the Swiss energy research program 2004–2007, about one third of the budget (circa 50 MCHF) goes to renewable energies. Ambient heat, wind energy, solar thermal energy and the use of biomass are represented, as well as photovoltaics, solar chemistry and geothermal. The research is very broadly laid out. In preparation for the program 2008–2011, CORE is currently concerning itself with possible "Technology-Roadmaps" for the Swiss energy supply and the research recommendations that fall out of these roadmaps. The following criteria play leading role in these choices: Does a technology make a contribution to a sustainable future Swiss energy system? And what do the R&D results bring to the Swiss economy in the broadest sense? I cannot anticipate the CORE results. I personally expect that the energy research program 2008–2011 will demonstrate more courage in concentrating its efforts, including within the area of new renewable energies.

Is the promotion of RE a matter for the state, industry or the people?
All three can contribute: The people by their choice of technology (heat pumps for heating, solar panels for hot water, etc.) and private investment decisions; industry by its long term planning and consideration of sustainability in its products; and the state by better coordinating its research with industry and so strengthening the competitiveness of its industries, as has been the case for decades, particularly in the USA and Japan.

> Better coordination between research initiatives and industry is desirable

There is an interesting awareness of these complex questions in the newest report by the EU on the strengths and weaknesses of European energy research.

PSI research concentrates on biomass and solar chemistry. How do you see that?
The biomass potential of Switzerland is considerable; its use could be tripled. The concentration here should be laid upon clean use (low emissions) and high efficiency. Another consideration should be to apply biomass (biogas) where good alternatives to fossil energy are especially difficult, e.g. in transportation. One project that especially pleases me is the ECOGAS-Project to produce methane from wood. Conceptualization that transcends sector boundaries and criteria that will allow a real discussion of the optimal use of biomass in Switzerland would be very helpful. Solar chemistry is an important effort to use chemical processes for generating electricity in new and creative ways. It is probably to early to make any judgments about the future significance, the practically achievable efficiencies and the possible locations of solar chemical power plants.

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Impressum

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Energy Systems Analysis at PSI: The goal of energy systems analysis at the Paul Scherrer Institute in Villigen is to analyze present and future energy systems in a comprehensive and detailed way, considering in particular health, environmental and economic criteria. On the basis of Life Cycle Assessment (LCA), energy-economic models, risk analysis, pollution transport models and finally multi-criteria decision analysis, it is possible to compare different energy scenarios to create a basis for political decision-making.

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