

Roadmap for Hydropower R&D in Switzerland

Challenges and strategy

According to Energy Strategy 2050 the mean annual hydropower production is aimed to increase by 1.53 TWh/a and 3.16 TWh/a under present framework and optimized conditions, respectively. In view of environmental and socio-economical constraints, this foreseen increase is extremely challenging and can be reached only by innovative and sustainable solutions for new hydropower plants (HPPs) and by the extension and optimization of existing schemes. The expected increase in power production from small hydropower plants (SHPP) requires the development of criteria for a careful site selection as well as strategies to optimize power production within a river network while at the same time minimizing the negative impacts on stream ecology. The effect of climate change will not only change the availability of water resources in time but also change the behavior of the catchment areas by an increased sediment yield and more frequent natural hazards, thus considerably endangering waterpower production in the near future. The critical period of energy supply in Switzerland is still the winter half year. For 10 years, Switzerland had to regularly import on average 4 TWh in the winter half-year. In order to guarantee a safe energy supply also during critical periods, Switzerland has to increase its storage capacity by new reservoirs where possible (e.g. Muttsee Dam) and mainly to increase the volumes of existing ones (e.g. Vieux Emosson Dam).



Muttsee Gravity Dam under construction



Vieux Emosson Arch Dam under construction

Already today, Switzerland plays, thanks to its storage power plants, an important role in supplying peak energy in the European grid and thus contributes significantly to its frequency control. In the future, this position has to be reinforced with the goal to become one of the main “batteries” in Europe able to furnish peak energy at any time. The forced and subsidized European production of mainly solar but also wind energy will further increase the need for regulation and peak energy. After reduction of European subsidies and actual market price distortions, and after economic recovery in Europe, the attractiveness of new pumped-storage power plants, the increased reservoir volume by dam heightening as well as the increased installed capacity of existing power plants by adding new parallel waterway systems and powerhouses will likely be highly attractive again. To make Switzerland’s hydropower production more flexible in the future with the purpose to concentrate it at times of high peak demand is a must for guaranteeing a leading position of Switzerland in a highly competitive electricity market in Europe. Such hydropower production focused on peak energy will also have more severe effects on river flow regimes, so-called hydropeaking, which have to be assessed and mitigated by innovative measures.

Key research directions

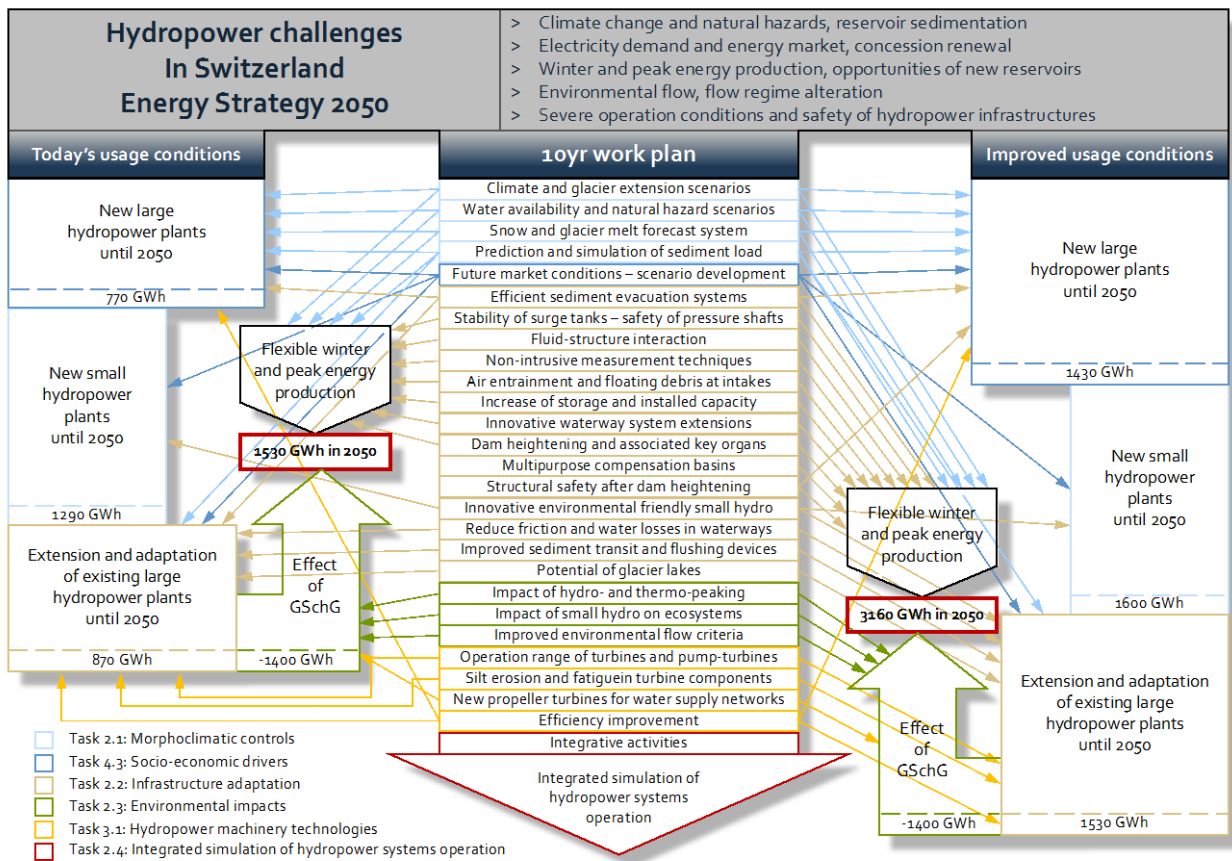
Feedback obtained during Phase I from the hydropower industry as well as recent energy-political developments in Switzerland and Europe were taken into account when planning Phase II (2017-

2020). Besides on-going activities of the 10-year work plan, in Phase II priority is given to five key research directions (KD):

- KD I: Increase of flexibility in hydropower operation – structural and operation requirements
- KD II: Update of climate change impacts on HP production and required adaptation strategies
- KD III: Extreme natural events, hazards and risk of HP operation
- KD IV: Design of new projects under uncertainties
- KD V: Reservoir sedimentation and sustainable use of storage HP

Roadmap presentation and related work plan 2014-2023

The roadmap and the related work plan 2014 – 2023 is shown in the attached figure. By overcoming the challenges for hydropower in Switzerland shown at the top of the figure, the roadmap of any SCCER research has to focus on achieving the above mentioned objectives of energy strategy 2050 regarding the increase of mean annual hydropower production. The goal is graphically shown on the left and right under today's and future usage conditions, respectively.



As can be seen, new large HPPs, new SHPPs as well as the extension and adaptation of existing large HPPs are the drivers to achieve the objectives of energy strategy 2050. After the end of actual water licenses, the requirements of the Federal Law on the Protection of Waters (GschG) have to be applied, which will result in a reduction of mean annual production as graphically shown. Furthermore, as already mentioned, winter energy is a critical issue for safe electricity supply in the future in Switzerland. Besides this, energy production of existing and new large HPPs in Switzerland has to be made more flexible, which will allow Switzerland to be competitive in a highly volatile energy market. This will not result in an increase in mean annual production but increase the flexible winter and peak energy production as shown above. The planned activities of the work plan 2014-2023 are shown in the middle of the figure. The different colors of activities correspond to the

tasks defined in the comprehensive SCCER-SoE work plan. The arrows indicate in a clear way which activity of the work plan will contribute to the achievement of the objectives energy strategy 2050.

Priorities

In principal, all topics mentioned in the work plan are of high significance for any future hydropower development in Switzerland since investments are made on the whole system and not only on single components. The actual market conditions and consequently the investment opportunities will decide which projects will be followed up by a certain hydropower company. These opportunities may be quite different from one company to another and one region to another. Therefore, the roadmap work plan has to cover the full range of possible options in order to be prepared to any project opportunity with advanced developments.

Nevertheless, feedback obtained by the hydropower industry revealed the following concerns, which should guide priorities:

- Under today's difficult market conditions, there is a need for innovative solutions to strongly reduce investment costs for any hydropower development. Industry is not looking for the most optimal solutions but for realistic feasible solutions under today's conditions. Risk participation between designers, construction companies and owners is required in order to avoid superposition of safety margins and to obtain economical projects. Projects, which are not developed today, will not be ready when market conditions are again favorable. Thus, reaching the goals of the energy strategy 2050 may be endangered if projects are delayed.
- Most of the problems being faced by hydropower development are not technical but related to taxes, water rights and legal issues strongly linked to the concession renewal.
- Simple procedures to carry out structural safety assessments of dams and power plants are required.
- There is urgent need to improve the quality of engineering designs of small hydro schemes, often handled by understaffed, unqualified, purely disciplinary teams. Improved designs should enhance management concepts and public acceptance by properly addressing different stakeholders' interests. The operation of SHPPs should be reliable.
- Conflicting interests exist between the extension of small hydropower production and the protection of the remaining near-natural rivers in Switzerland, as well as the river rehabilitation measures required by the Water Protection Act. The development of new innovative environmentally-friendly solutions is required to improve public acceptance. More appropriate rules for environmental flows are of high interest, which could reduce the expected energy loss and at the same time sustain ecological conditions.
- There is a need for developing future socio-economic scenarios, similar to the compromise obtained regarding climatic changes expected in the horizon 2050.

Furthermore, for a complex hydropower scheme representing all technical features and challenges with a promising new dam project related to glacier retreat, a pilot study regrouping large numbers of activities in an interdisciplinary way was started in autumn 2016 (Demonstrator FLEXSTOR). This study, among others, will allow determining quantitatively the effect of outcomes of the research activities on energy production of the pilot scheme (percentage of increase of annual production and flexibility) and consequently the economical position of the latter in a highly competitive market.

The work plan activities will be bundled up within the five key directions and put into operation with the three ambitious demonstrators, namely:

- Demo-5: Small Hydropower Plant (SMALLHYDRO)
- Demo-6: Controlled fine sediment release from a reservoir by a hydrodynamic mixing device (SEDMIX)
- Demo-7: Complex large hydropower scheme (FLEXSTOR)

These will indicate the achievements of the hydropower goals of the Energy Strategy 2050.