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SUPPLY of ELECTRICITY

Hydropower infrastructure - How to make Swiss hydropower more competitive?

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In cooperation with the CTI

Energy
Swiss Competence Centers for Energy Research

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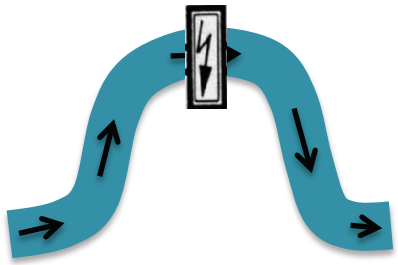
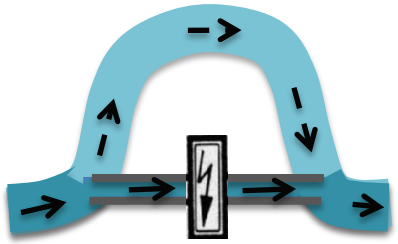
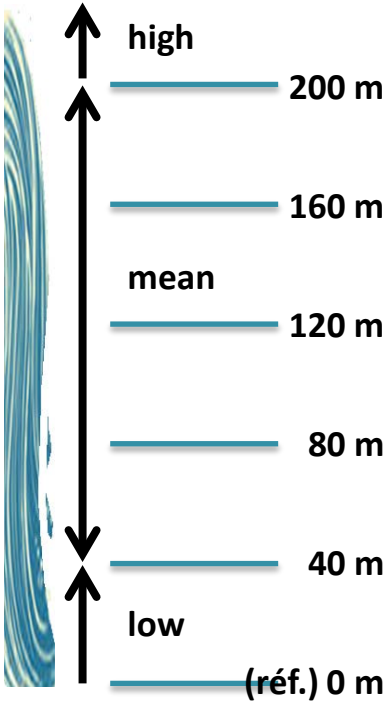
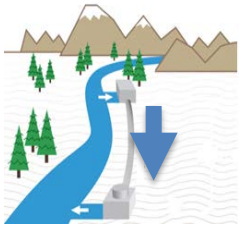
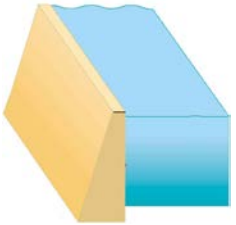
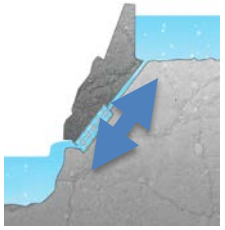
Staumauer Vieux Emosson 2013

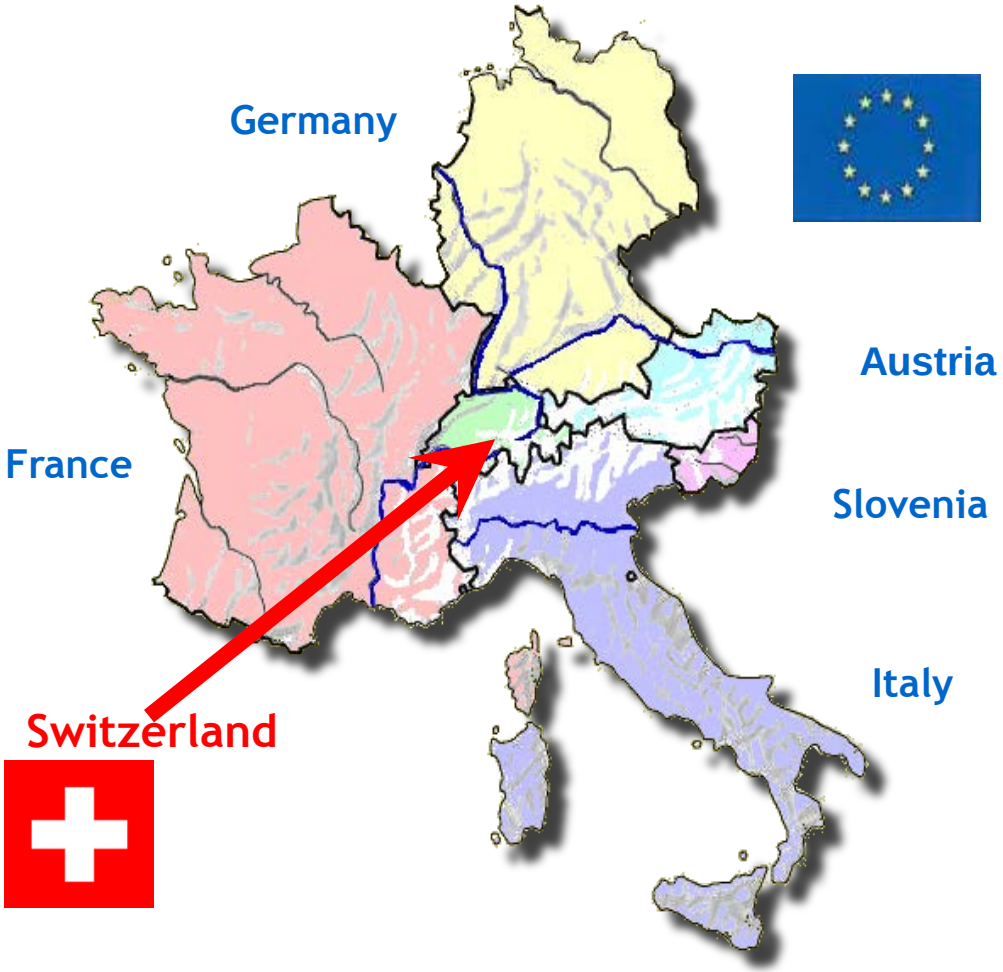
Advantages of hydropower in Switzerland

- Renewable energy without direct emission of CO_2
- Excellent efficiency, production can be easy adapted to the demand (flexible peak energy)
- In-country energy creating jobs and financial resources in remote alpine valleys (taxes and concession fees)
- Improvement of infrastructures and touristic attractiveness
- Contribution to flood protection

Classification criteria of hydropower plants

Arrangement	Gross head	Possibility of storage Use of water	Type of turbines
Without water diversion  With water diversion 		Run-of-river  Storage  Pumped-storage 	Pelton  Francis  Kaplan Bulb Straflo … 

Special role of Swiss hydropower in the Alpine region and Central Europe



Special role of Swiss hydropower in the Alpine region and Central Europe

Hydropower production in the Alps and Europe

Pays	Installed Capacity [MW]	Mean yearly generation [GWh/a]	Part of hydropower in electricity generation
Germany	4'350	19'000	4.2%
Austria	13'200	37'701	62.3%
France	23'000	45'845	8.5%
Italy	17'800	47'756	12.4%
Slovenia	846	3'550	29.0%
Switzerland	13'723	37'795	56.5%
Alpine countries	**72'919**	**191'647**	**12.6%**
Europe*	**181'266**	**531'152**	**≈15 %**

* According Hydropower&Dams,World Atlas 2014

Hydropower storage in the Alps

	Generation [GWh/year]	% of hydropower production
Germany	~ 800	5%
Austria	12'015	32%
France	~ 12'000	17%
Italy	16'871	36%
Slovenia	-	-
Switzerland	18 462	53%

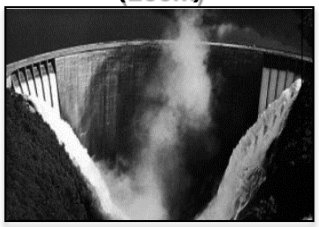
* According Hydropower&Dams,World Atlas 2014

Swiss hydropower can furnish an important part of his electricity production as peak power


Grande Dixence (285m)


Mauvoisin (250m)


Luzzone (225m)


Contra (220m)


Emosson (180m)


Zeuzier (156m)


Göscheneralp (155m)


Curnera (155m)

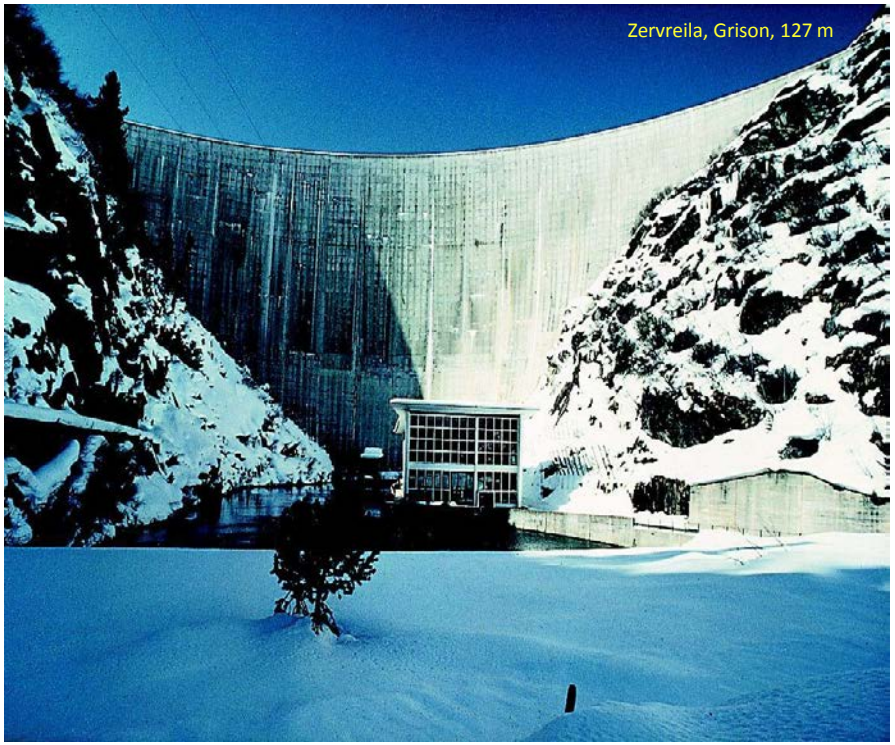

Zervreila (151m)

About 200 large dams are higher than 15 m

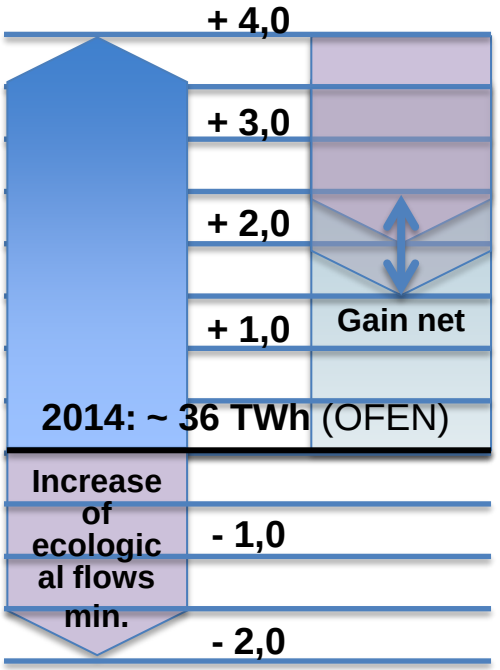
9 dams are higher than 150 m

Future contribution of the Swiss hydropower as a battery in Europe??

Realistic production increase according potential studies until 2050*



Yearly hydro electricity production [TWh]

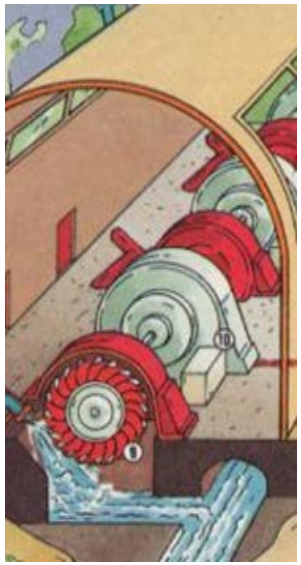


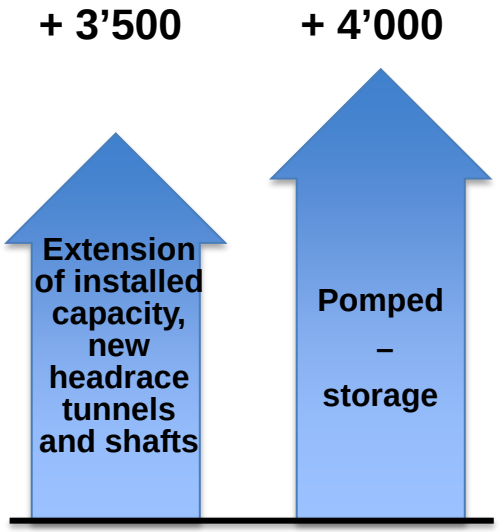
* Elektrowatt-Ekono (2004) et OFEN (2012)

Future contribution of the Swiss hydropower as a battery in Europe??

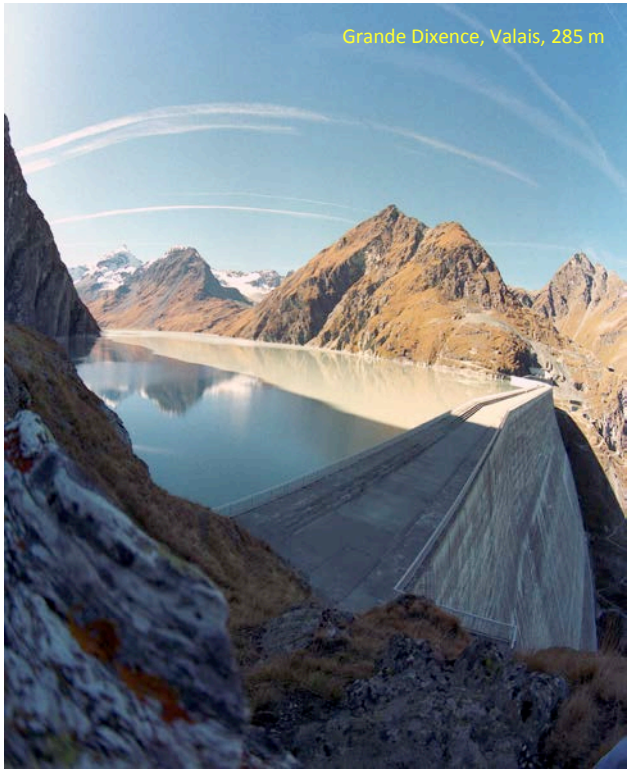
High potential for making hydropower production more flexible

Installed capacity [MW]





2014: ~ 14'500 MW
(OFEN)



Actual challenges and difficulties of hydropower in Switzerland

At the moment electricity prices at the European spot market are very low:

- **Production capacity in Europe is to high (especially conventional thermal as coal)**
- **Cost of CO_2 certificates are very low**
- **The actual market is distorted due to the high subsidize of new renewable energy as solar and wind**

Swiss hydropower is strongly penalized!

How can the competiveness of Swiss hydropower be increased in a highly uncertain electricity market in Europe?

Highly important is the improvement of the flexibility of existing power plants and the increase of the winter and peak energy energy by

- Enhancement of storage capacity
- Extension of the installed capacity
- Increase of pumping capacity
- Additional compensation basins
- New powerhouses and waterway systems parallel to existing ones (tunnels and shafts)

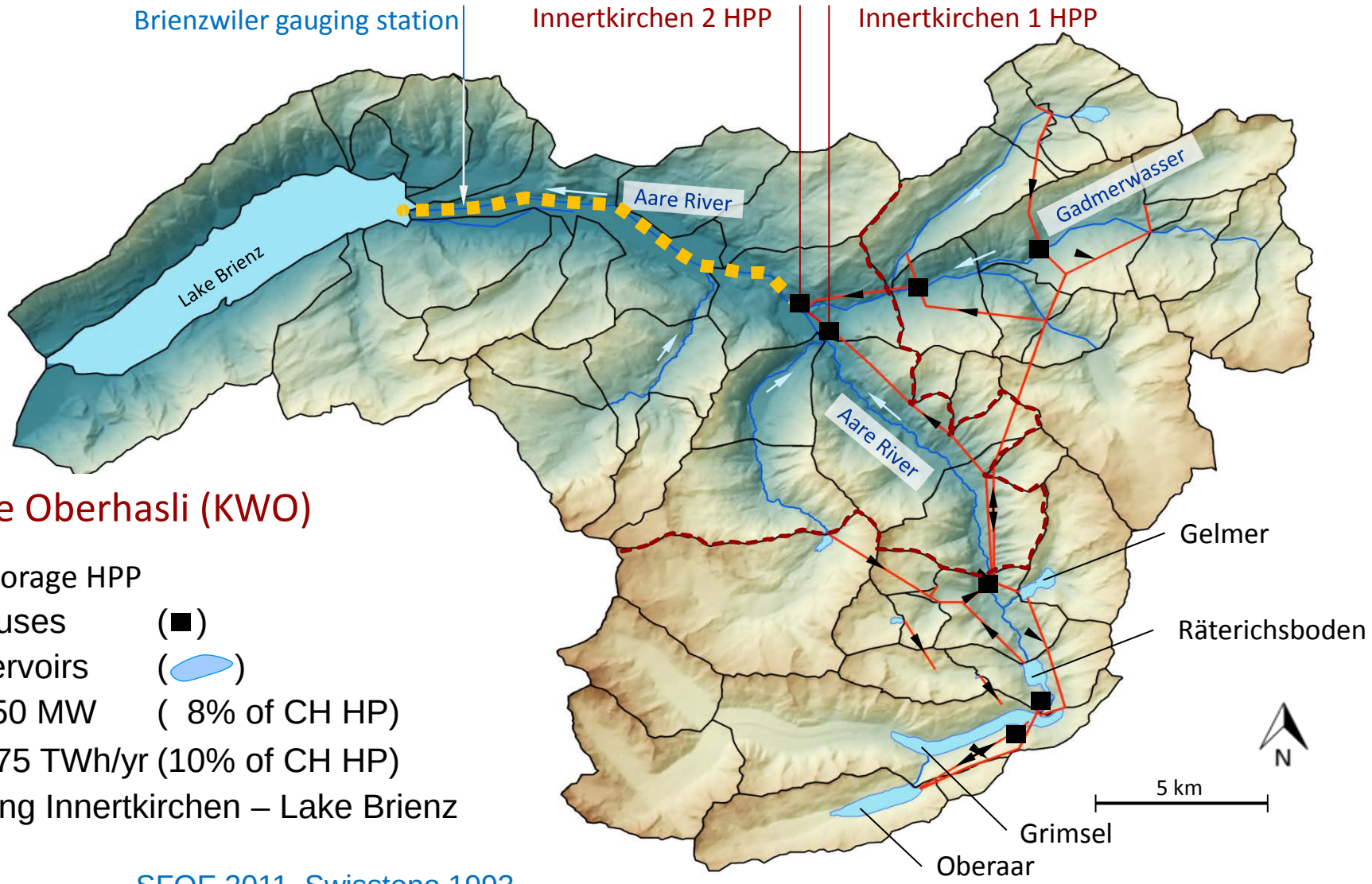
Heightening of Luzzone dam from 208 m to 225 m (TI) 1995 - 1999

Scientific answer to the actual challenge of Swiss hydropower: Interdisciplinary pilot scheme study – KTI project with KWO

Selection of pilot scheme which offers all challenges

- **This study may allow determining quantitatively the effect of outcomes of the research activities on energy production of the pilot scheme (x% increase of annual production and flexibility) and consequently the economical position of the latter in a highly competitive market.**

KWO scheme



Kraftwerke Oberhasli (KWO)

High-head storage HPP

9 power houses (■)

4 large reservoirs ( )

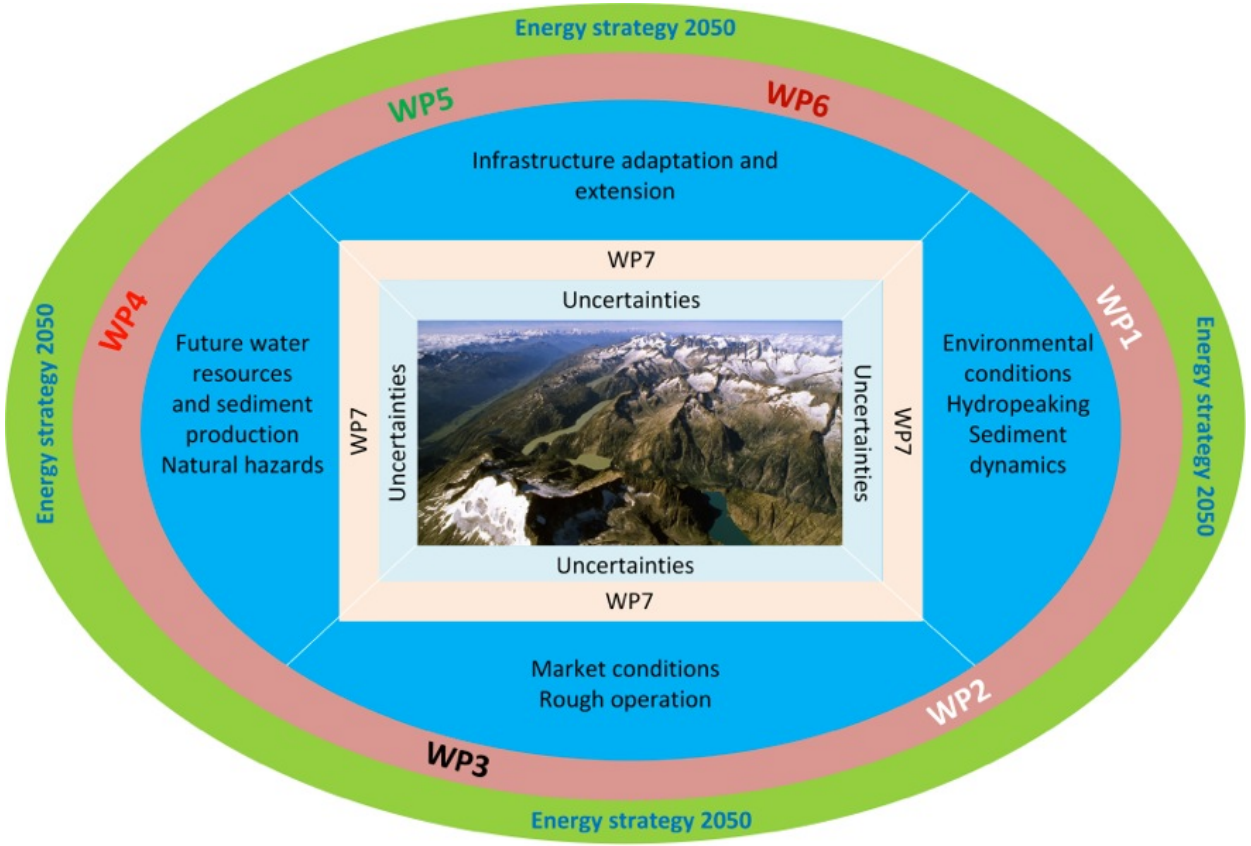
Power: 650 MW (8% of CH HP)

Energy: 1.75 TWh/yr (10% of CH HP)

Hydropeaking Innertkirchen – Lake Brienz

SFOE 2011, Swisstopo 1993

SHS - Sustainable hydropower storage in a changing environment

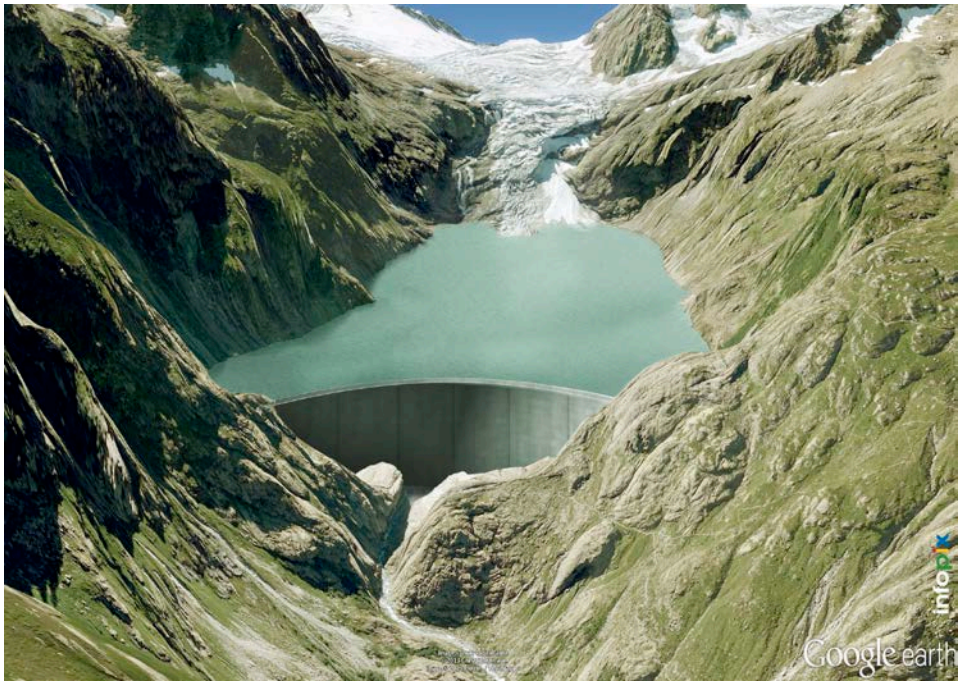


Innovation as means to secure and expand operation and competitiveness of KWO's complex system

SHS - Sustainable hydropower storage in a changing environment

Innovation as means to secure and expand operation and competitiveness of KWO's complex system

Motivation: Improvement of flexibility of KWO system by new Trift Dam and Grimsel dam heightening



Photomontage KWO

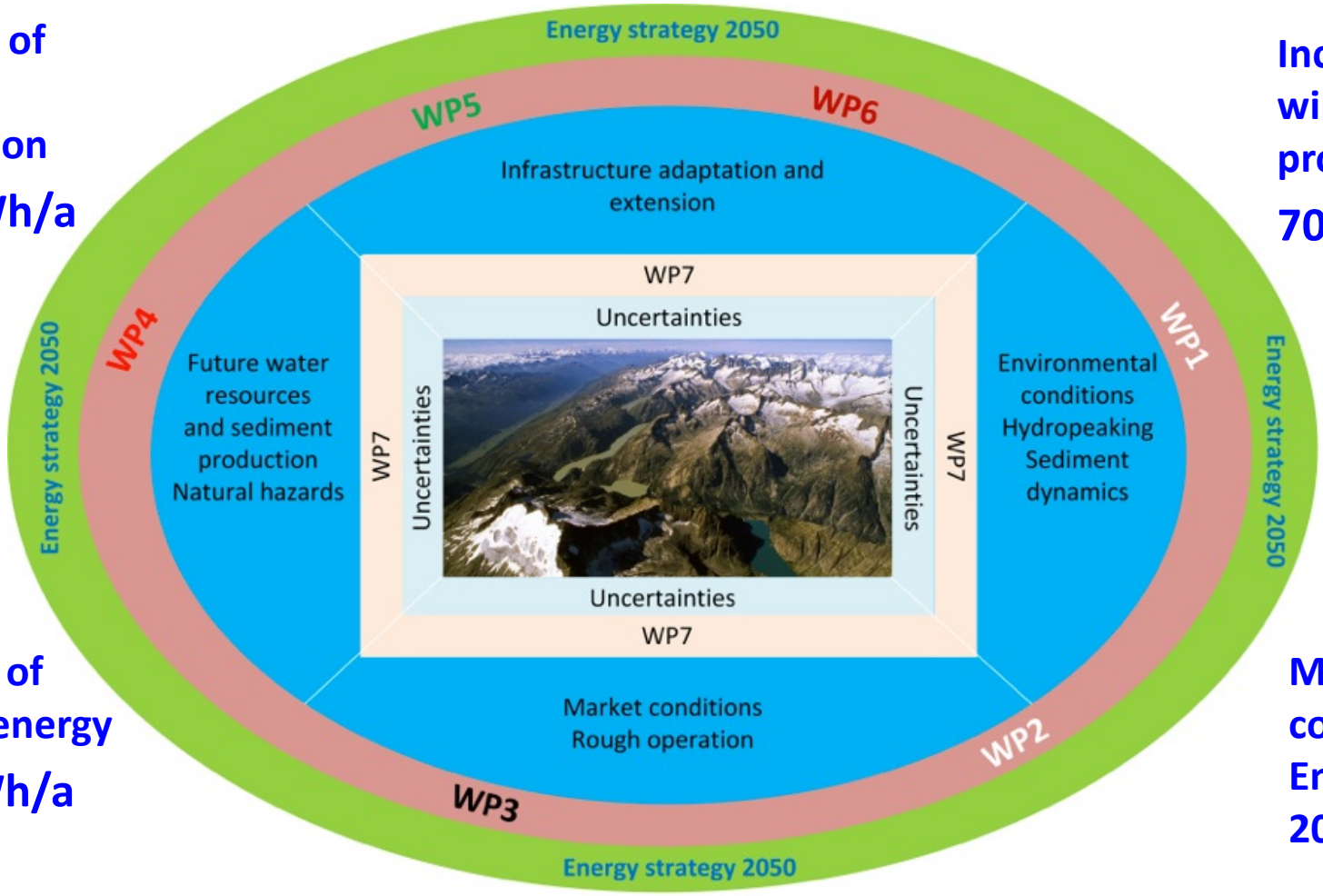
Innovation as means to secure and expand operation and competitiveness of KWO's complex system

Increase of annual production

200 GWh/a

Increase of winter production

700 GWh/a



Increase of storage energy

500 GWh/a

Most significant contribution for Energy Strategy 2050

Innovation as means to secure and expand operation and competitiveness of KWO's complex system

- To explore the operation conditions of existing facilities for hydropeaking mitigation beyond current limits, identifying and documenting the potential for increased operation flexibility, whilst guaranteeing environmental compliance;
- To perform first-ever large-scale field test of artificially generated impulse waves, in view of integrating hazard mitigation measures in future hydropower projects in the periglacial environment, as well as update Dam Design and Safety standards;
- To identify opportunities for future electricity generation by hydropower storage plants according market evolution scenarios, by pattern-finding between water storage availability and electricity demand, based on past operation supply records and hydropower systems behavior;

Innovation as means to secure and expand operation and competitiveness of KWO's complex system

- To develop and implement principles of sediment management in a complex system of cascading reservoirs, to reduce reservoir storage loss by sediment trapping, both in existing and new reservoirs, with particular attention to those in the periglacial environment;

- To identify limits of acceptable turbidity levels for sediment venting through the turbines, by means of field measurements of fine sediment transit, coupled with the assessment of the corresponding turbine wear and operation lifetime analysis;

- To perform measurements of turbine instability in situ, including use of intrusive instrumentation, in view of setting a benchmark for fluid-structure interaction studies and establishing guidelines for new start-up and load rejection paths.

WP1 - Assessing the performance of hydro-peaking remediation measures under future scenarios

Outcomes:

- a set of optimal strategies for operating the compensation basin in conjunction with the power plants will be established and expressed as future operation rules

WP2 - Natural hazards: analytical assessment and field study of impulse waves

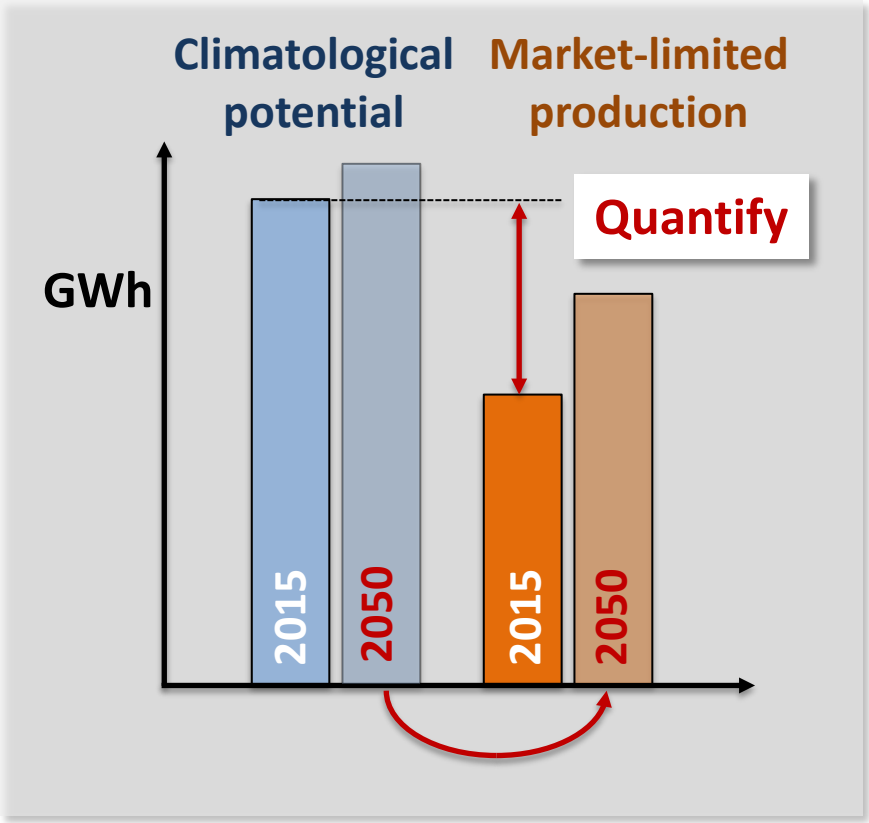
Outcomes:

- Field test data set (for public use) and improved design guidelines (for possible legal implementation)

WP3 - Analysis of hydropower production under future market conditions

Outcomes:

- Climate-based hydropower production potential, market-guided hydropower production rules and actual hydropower production potential



WP4 - Sediment management in multi-reservoir systems under environmental constraints

Outcomes:

- **Sediment budget and dynamics of KWO reservoirs, models for pluri-annual reservoir morphology changes, models for innovative sediment evacuation strategies in a cascade of Alpine reservoirs and guidelines for a KWO Sustainable Sediment Management Plan**

WP5 - Suspended sediment and turbine wear monitoring at Hydropower Plants

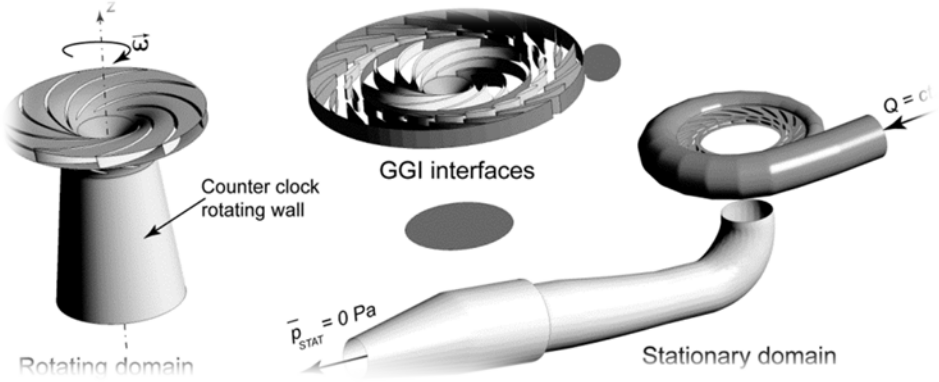
Outcomes:

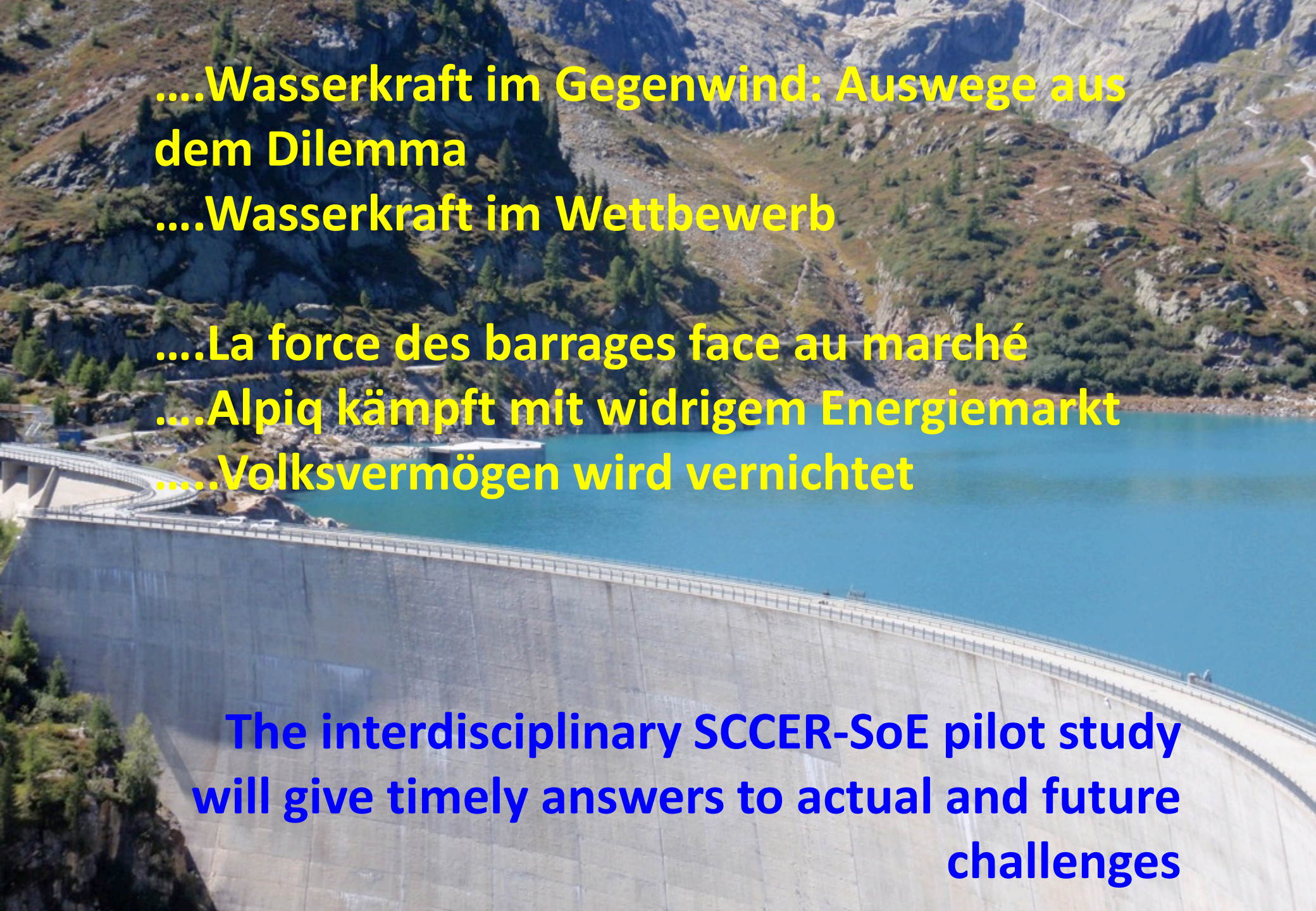
- Quantitative data of suspended sediment characteristics and of turbine abrasion

WP6 - In-situ diagnosis of hydrodynamic instabilities in PSPP

Outcomes:

- **Prototype evidence of FSI damage from in-situ tests, hydrodynamic instability level hill-charts and diagnosis protocol for different hydropower units, alternative less-harmful operation guidelines**




….Wasserkraft im Gegenwind: Auswege aus dem Dilemma
….Wasserkraft im Wettbewerb
….La force des barrages face au marché
….Alpiq kämpft mit widrigem Energiemarkt
…..Volksvermögen wird vernichtet
The interdisciplinary SCCER-SoE pilot study will give timely answers to actual and future challenges