Tapping hidden hydropower potential in the Swiss Alps for the planned nuclear power phase out

A.C. Santos[1,2], B. Schaefli[1,2], P. Manso[2], A.J. Schleiss[2], M.M. Portela[3], A. Rinaldo[1,4]

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

Context

Swiss energy turnaround: Energy Strategy 2050
➔ Strong focus on hydropower (58% of electricity production, Fig. 1) & other renewables.

The government funded 7competence centers for energy research (**SCCER**s), including the Supply of Energy (www.SCCER-SoE.ch) on geoenergies and hydropower (Fig. 2).

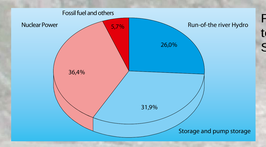


Fig. 1: Electricity production according to type, Electricity statistics 2013, Swiss Federal Office for Energy

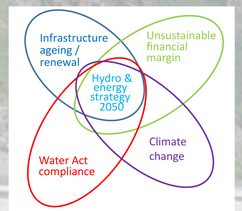
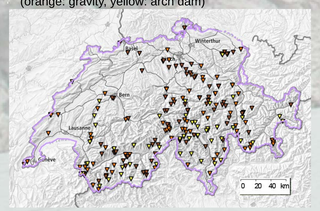


Fig. 2: The role of hydropower in the Swiss energy strategy 2050

Current state

Switzerland has >1300 hydropower production installations (Tab. 1, Fig. 3), incl.22 pump-storage.

Fig. 3: Swiss dams, http://map.geo.admin.ch (orange: gravity, yellow: arch dam)



Tab 1: Expected annual CH production without production from water re-circulation (source: www.swv.ch, with data from BFE, june 2014)

Number	Size category	Power	Share	Expected production	Share
185	> 10 MW	13'725 MW	93.9%	32'749 GWh	89.2%
226	1 - 10 MW	723 MW	4.9%	3'181 GWh	8.7%
217	0.3 - 1 MW	123 MW	0.9%	598 GWh	1.6%
ca. 700	< 0.3 MW	ca. 42 MW	0.3%	ca. 190 GWh	0.5%
1'328		**14'612 MW**		**36'718 GWh**	

➔ Storage hydropower produces electricity in winter when demand is high and inflow is low (snowfall).

➔ Market: low electricity prices, Swiss hydropower is not competitive on EU market, new investments on hold.

Source: Statistik der Wasserkraftanlagen der Schweiz, State 01.01.2014, Federal Office for Energy, BFE; Schweiz. Wasserwirtschaftsverband, http://www.swv.ch

Roadmap

- Energy strategy 2050: yerlyl hydropower (HP) production should increase by
  - ➔ 1.5 TWh under current production conditions
  - ➔ 3.2 TWh under improved water usage conditions (Fig. 4).
- Almost no exploitable streams / catchments left.
- Hidden potential in existing HP schemes: unnecessary spills, new reservoir connections, dam heightening, operation optimisation,..
- Challenge: quantify current water resources

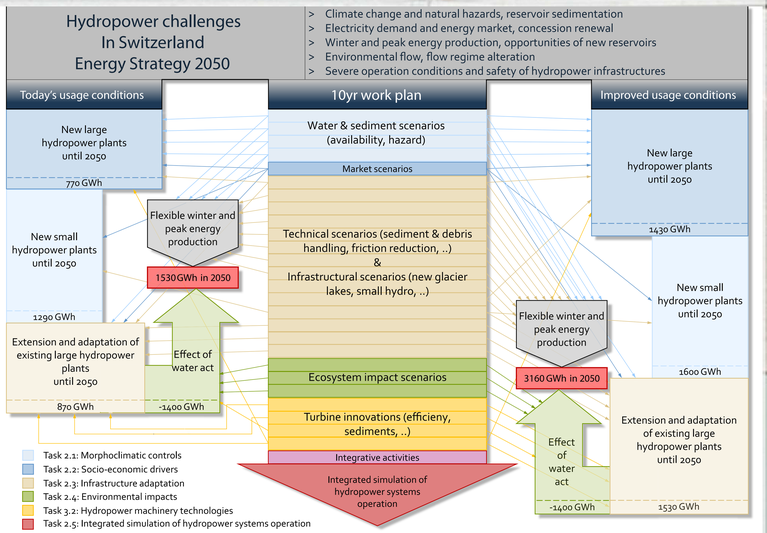


Fig. 4: Hydropower innovation roadmap available on www.sccer-soe.ch summarizing strategies to increase HP production.

Method

Approach:

A) Regional water resources quantification (Fig. 6)
incl. water loss quantification (e.g. water intake overflows)
incl. minimum flow / hydropeaking restriction effects (Fig. 5)

C) Analysis of production increase potential for selected case-studies

Fig. 5: Water intake (left: upstream, right: downstream) of Grande Dixence, illustrating the problem of zero flow conditions (Source: www.pronatura.ch)

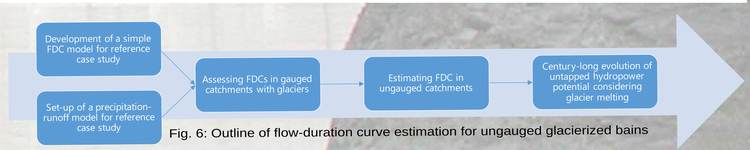


Fig. 6: Outline of flow-duration curve estimation for ungauged glacierized bains

Case study example (ongoing):

Grimsel (KWO), current production 1.5TWh/year
- new glacier lake (dam): 0.22 TWh/a → production increase
- dam heightening: 0.24 TWh/a → production flexibilisation
- operation modification: 0.15 TWh/a → flow management

Outlook

- Account for ongoing shifts in electricity consumption patterns (from winter to summer)
- Project hydropower production under highly uncertain future market conditions

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Affiliations: 1 Ecole Polytechnique Fédérale de Lausanne (EPFL), School of Architecture, Civil and Environmental Engineering (ENAC), Laboratory of Ecohydrology (ECHO), 2 EPFL - ENAC, Hydraulic Constructions Laboratory (LCH), 3: Instituto Superior Tecnico, Centre for Hydrosystems Research (CEHIDRO), Lisbon, Portugal, 4 Dipartimento di Ingegneria Civile, Edile ed Ambientale, Università di Padova, Italy; corresponding author: anaclara.santos@epfl.ch

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