Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

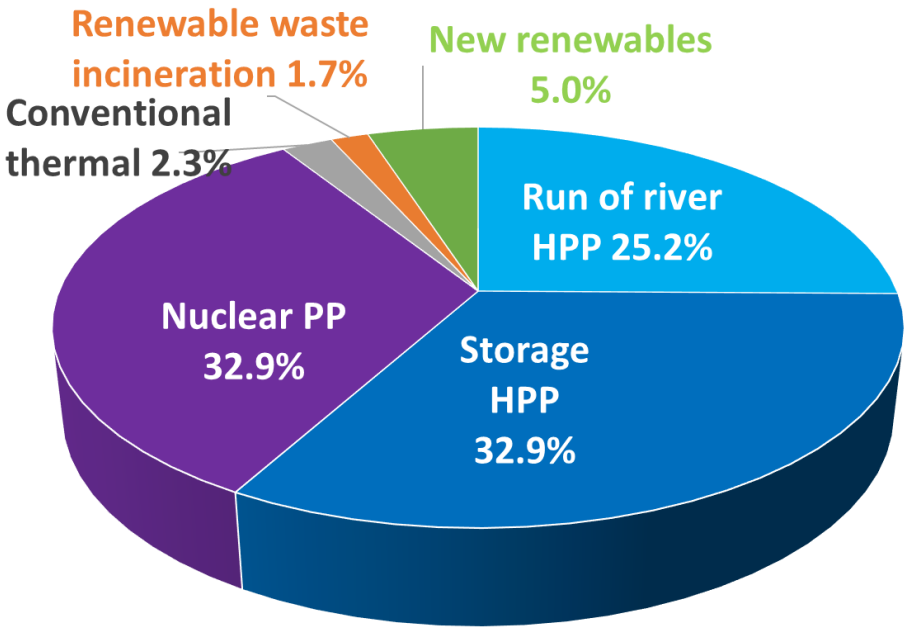
Bundesamt für Energie BFE
Office fédéral de l'énergie OFEN
Ufficio federale dell'energia UFE
Uffizi federal d'energia UFE

IMPLICATIONS OF CLIMATE CHANGE
IMPACTS ON HYDROPOWER

THE RIVER RHINE IN A FUTURE CLIMATE: CHANGES FROM HEADWATERS TO LOWLANDS ▪ CHRISTIAN DUPRAZ ▪ 1./2.6.2022

HYDROPOWER – A MAJOR PILLAR OF THE ELECTRICITY SUPPLY IN SWITZERLAND

682 hydropower plants (with power ≥ 300 kW)
Total installed power: **15.5 GW**
Average yearly expected generation: **37’172 GWh**
-> corresponding to about 55% of total power generation in Switzerland



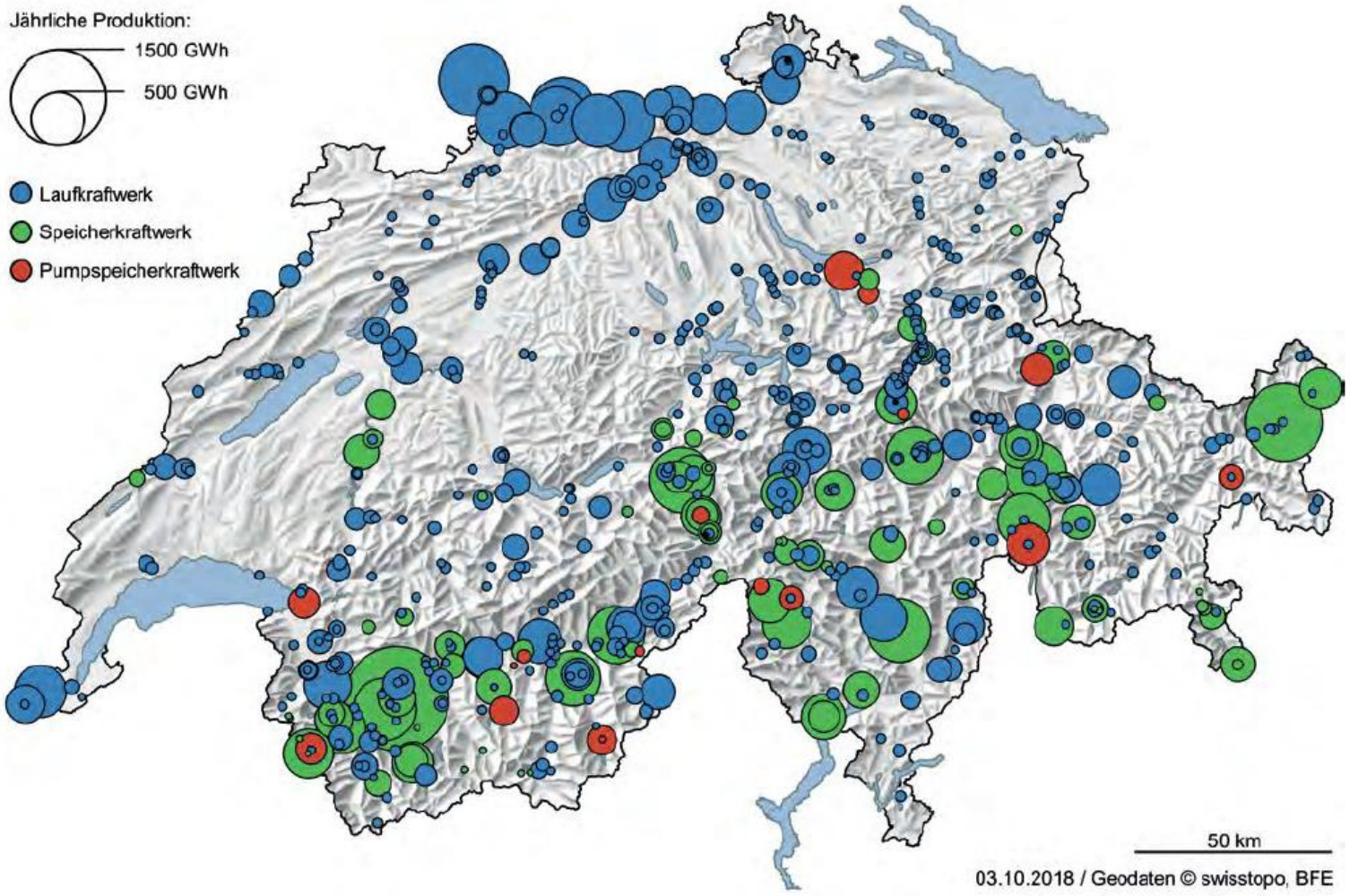
Run-of-river plants: 48.3 %

Storage plants: 47.5 %

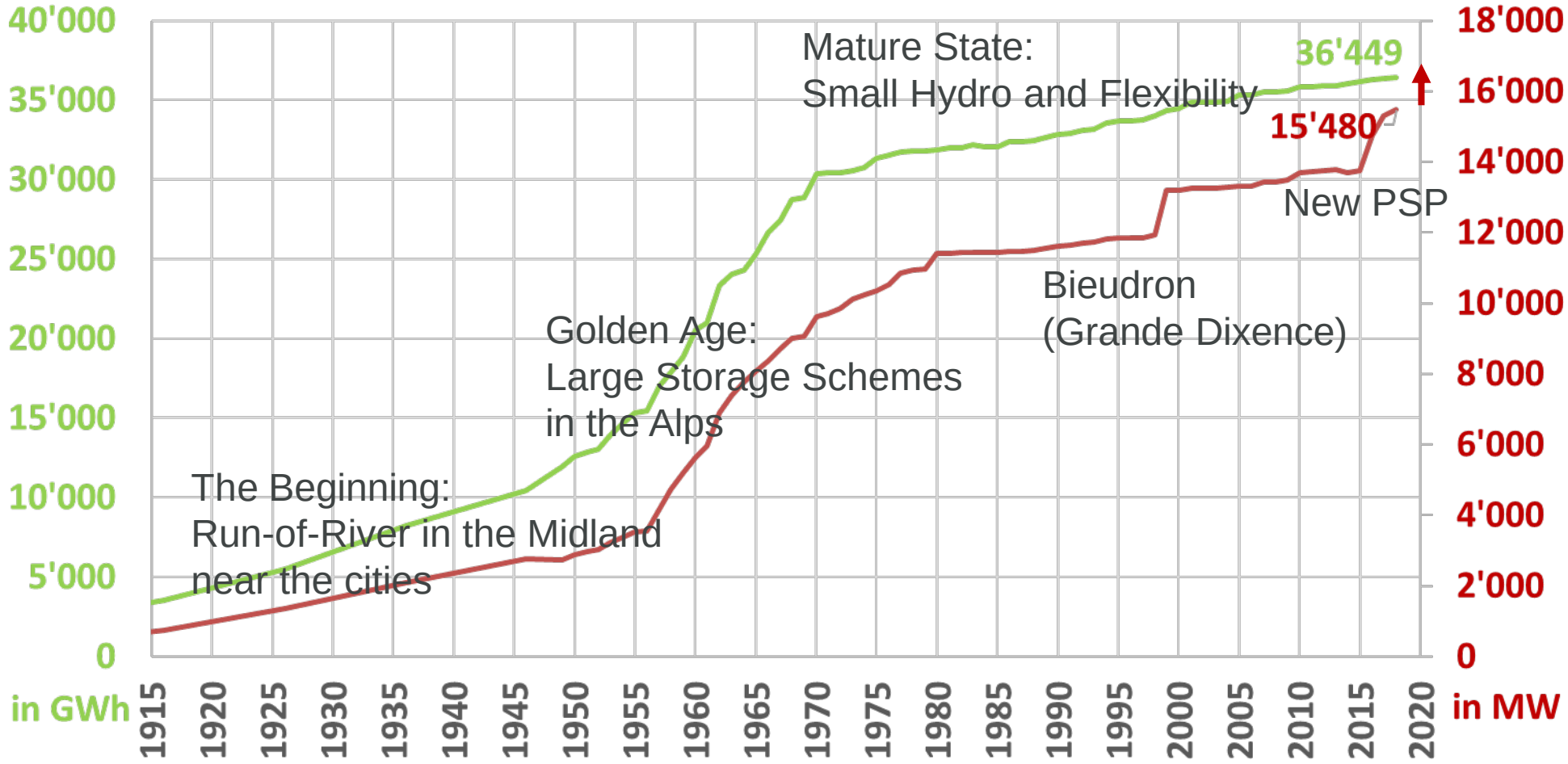
Pump-storage plants: 4.2%

SFOE, 2021, electricity statistics

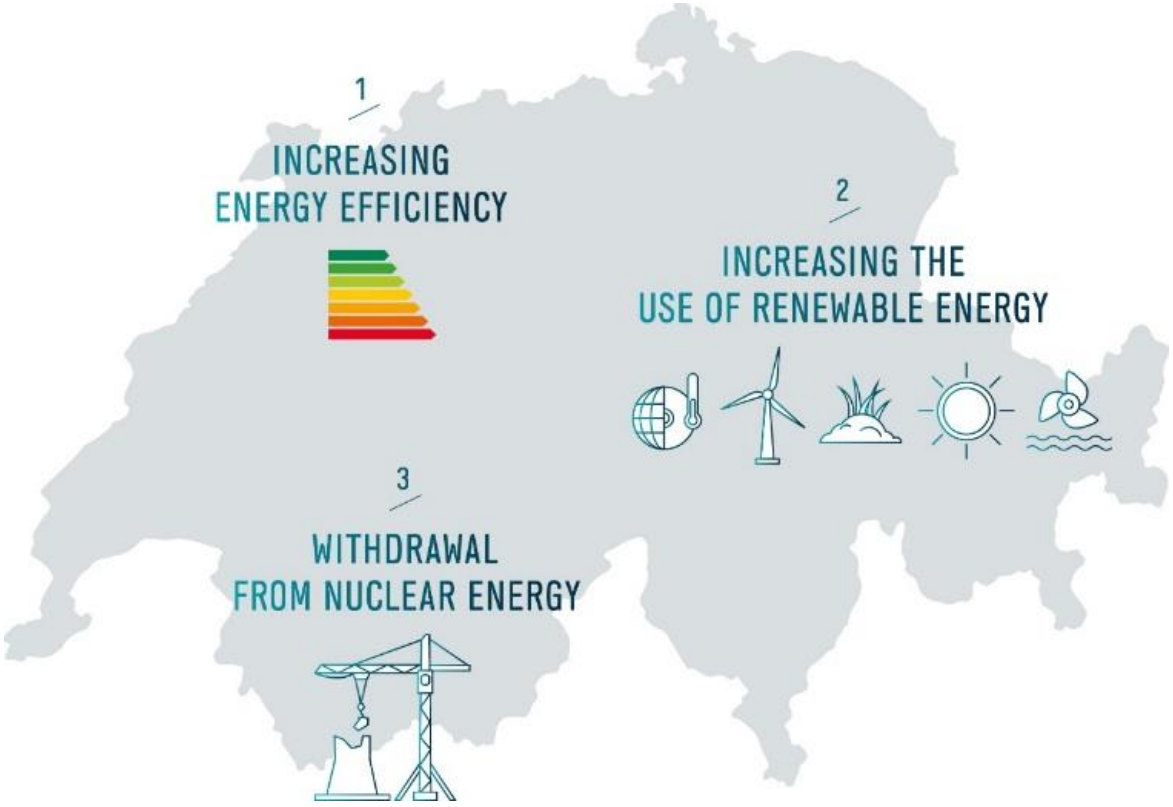
DISTRIBUTION OF HPP'S IN SWITZERLAND



DEVELOPMENT OF SWISS HYDROPOWER



NEW ENERGY ACT: THREE STRATEGIC OBJECTIVES



Measures to increase energy efficiency

- Buildings
- Mobility
- Industry
- Appliances

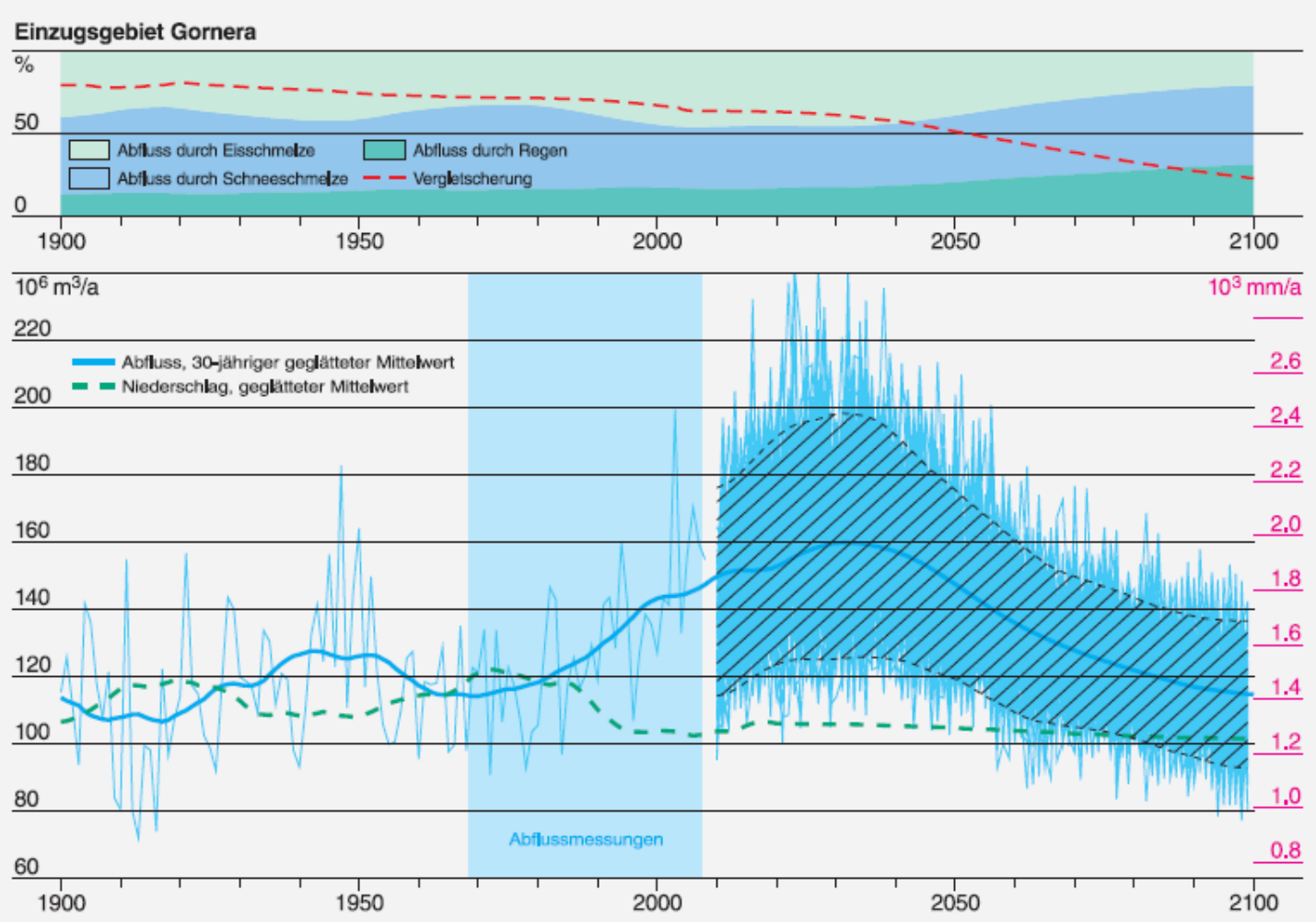
Measures to increase the use of renewable

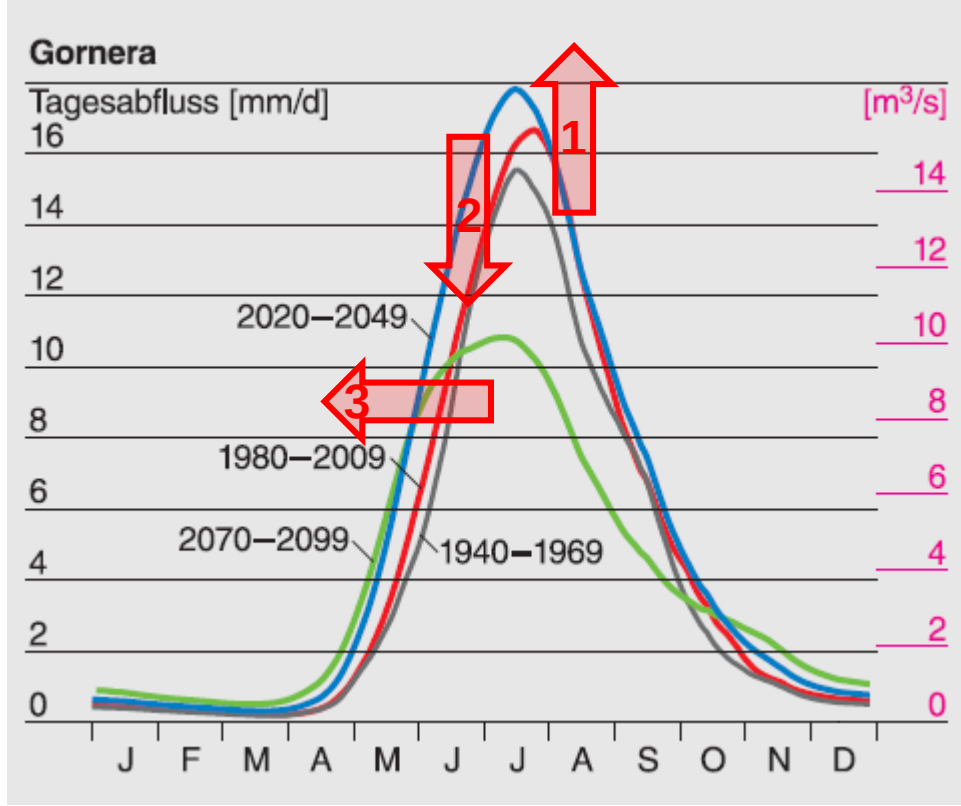
- Energy
- Promotion
- Improvement of legal framework

Withdrawal from nuclear energy

- No new general licences
- Step-by-step withdrawal – safety as sole criterion

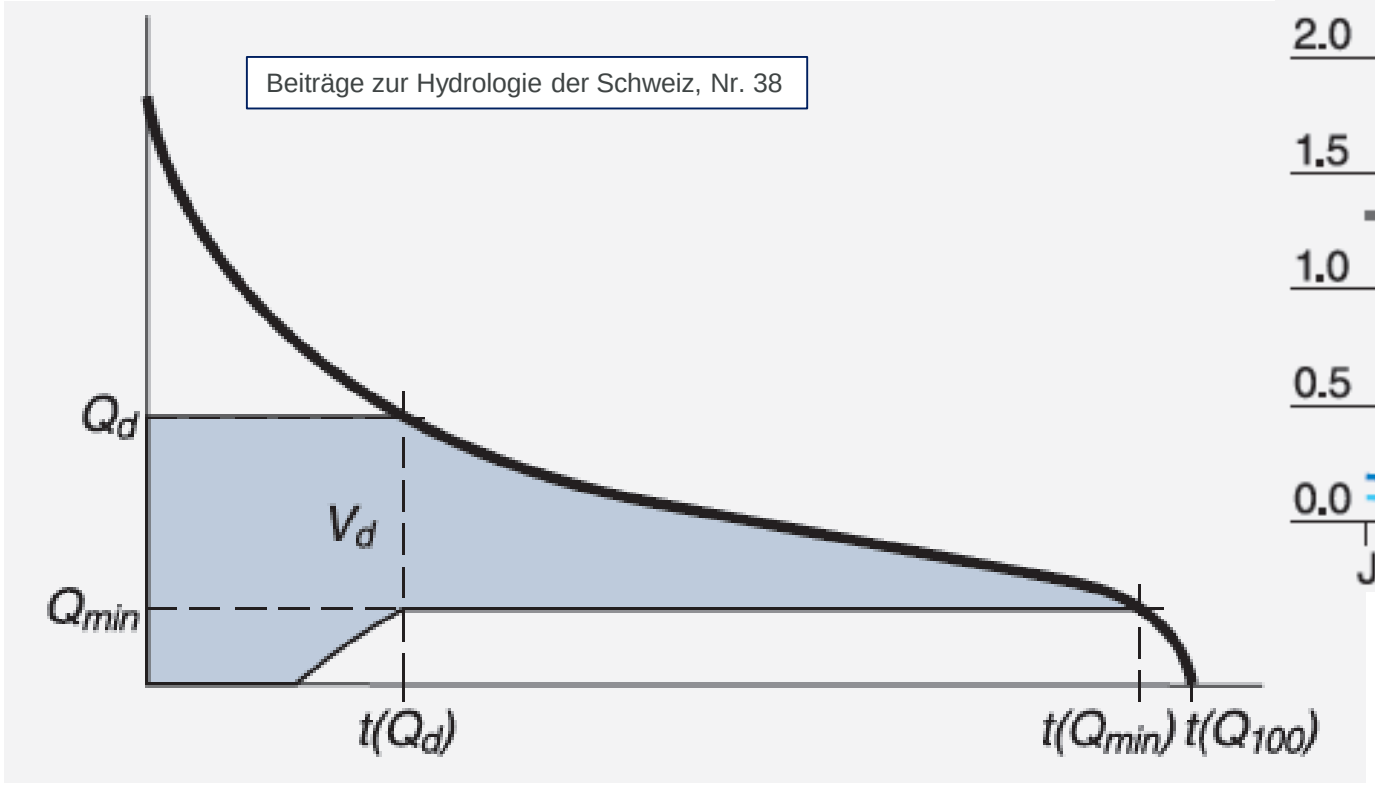
RUNOFF DEVELOPMENT AND WATER AVAILABILITY

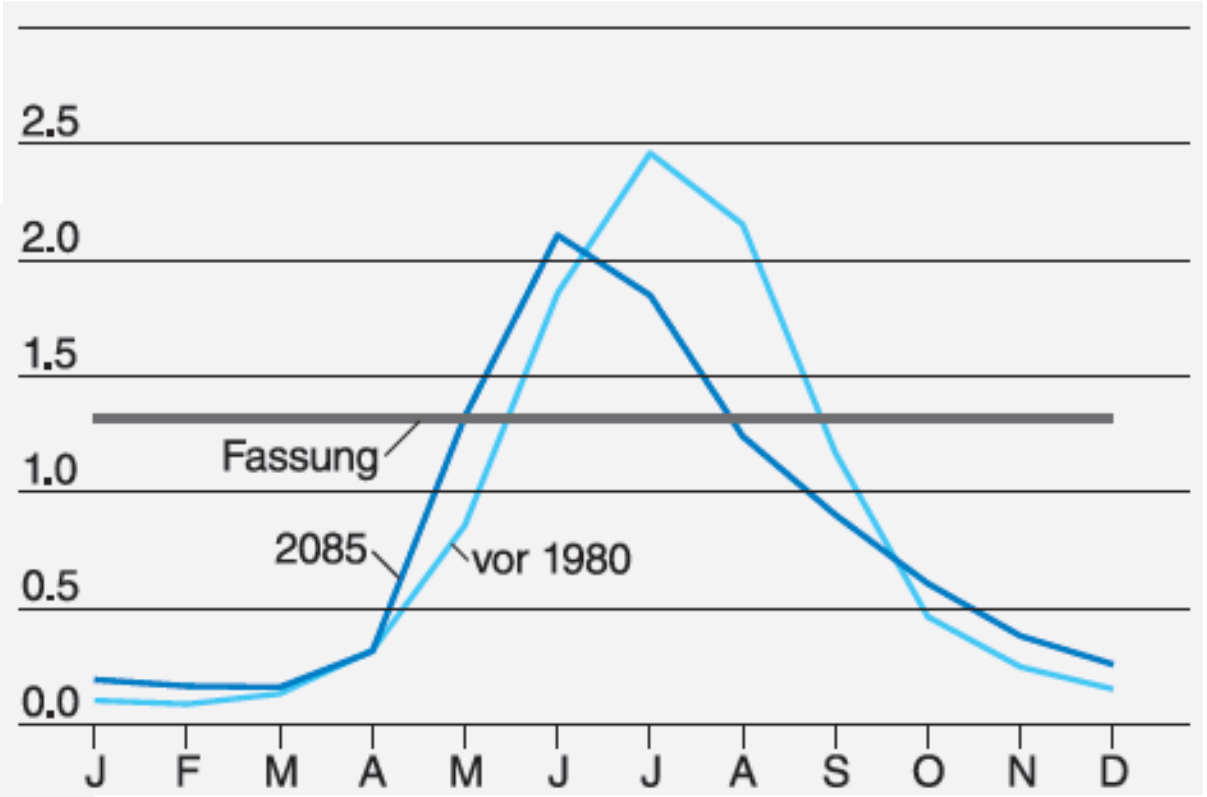




SGHL, Chy, 2011: Auswirkungen der Klimaänderung auf die Wasserkraftnutzung – Synthesebericht

IMPACT ON RUN-OF-RIVER POWER PRODUCTION



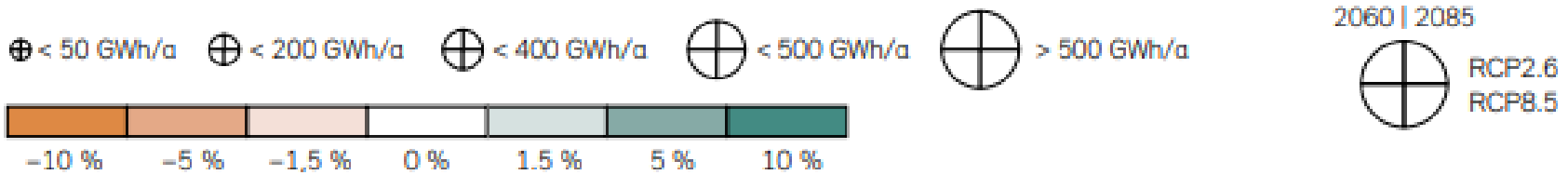


SGHL, Chy, 2011: Auswirkungen der Klimaänderung auf die Wasserkraftnutzung – Synthesebericht

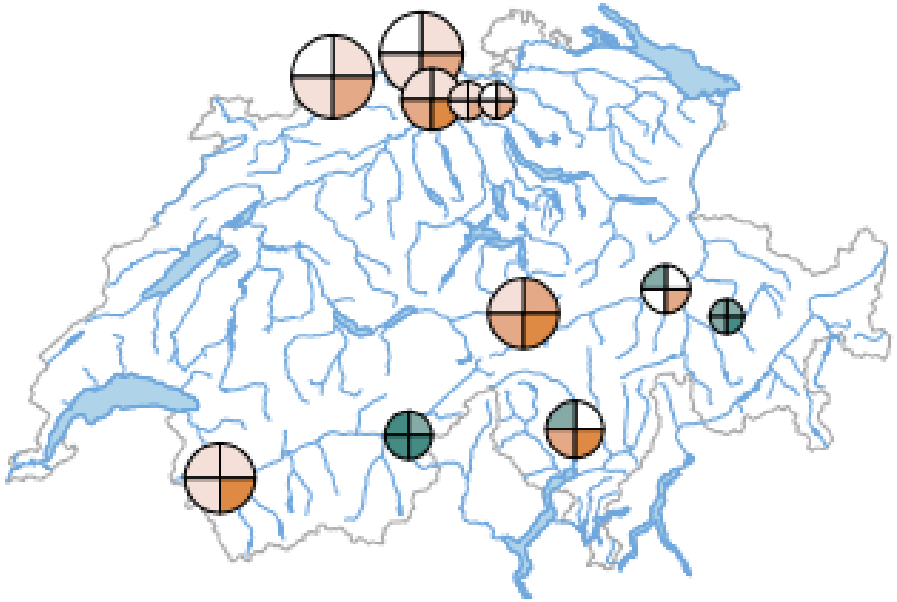
GENERAL IMPACT ON PRODUCTION

- Long-term production in high-altitude storage plants in the Valais is likely to decrease (today's production is above long term mean).
- In snow-covered and less glaciated areas, seasonal inflows will change significantly: there will be more water in winter and less in summer. This often leads to larger quantities of utilizable water and thus to an increase in production - despite lower annual discharge quantities.
- Run-of-river power plants will benefit from runoff changes due to more balanced regimes in the future. The changes are often within the previous fluctuation range (experience range).
- The results from the individual power plant operations cannot be generalized.

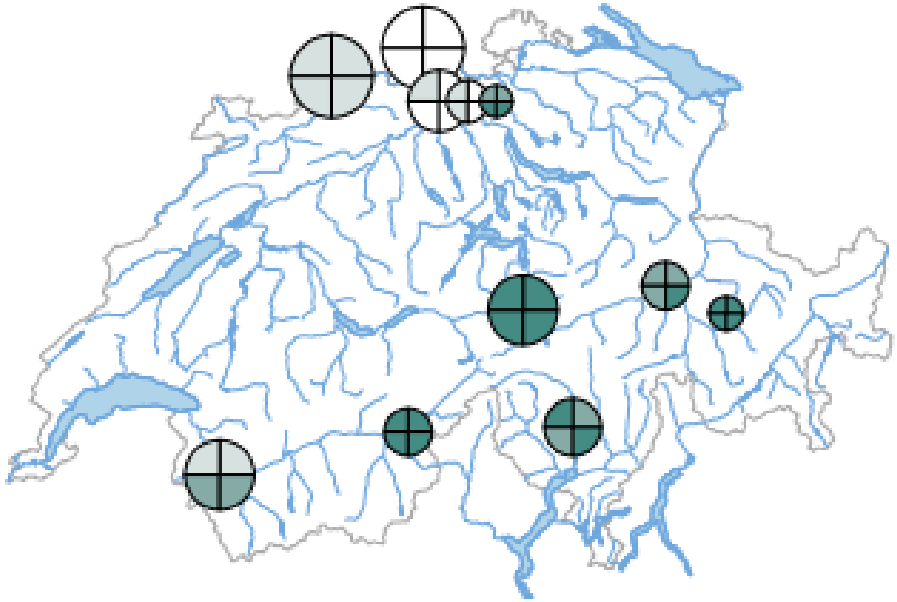
IMPACT ON RUN-OF-RIVER POWER PRODUCTION



Veränderung der Jahresproduktion (GWh/Jahr)

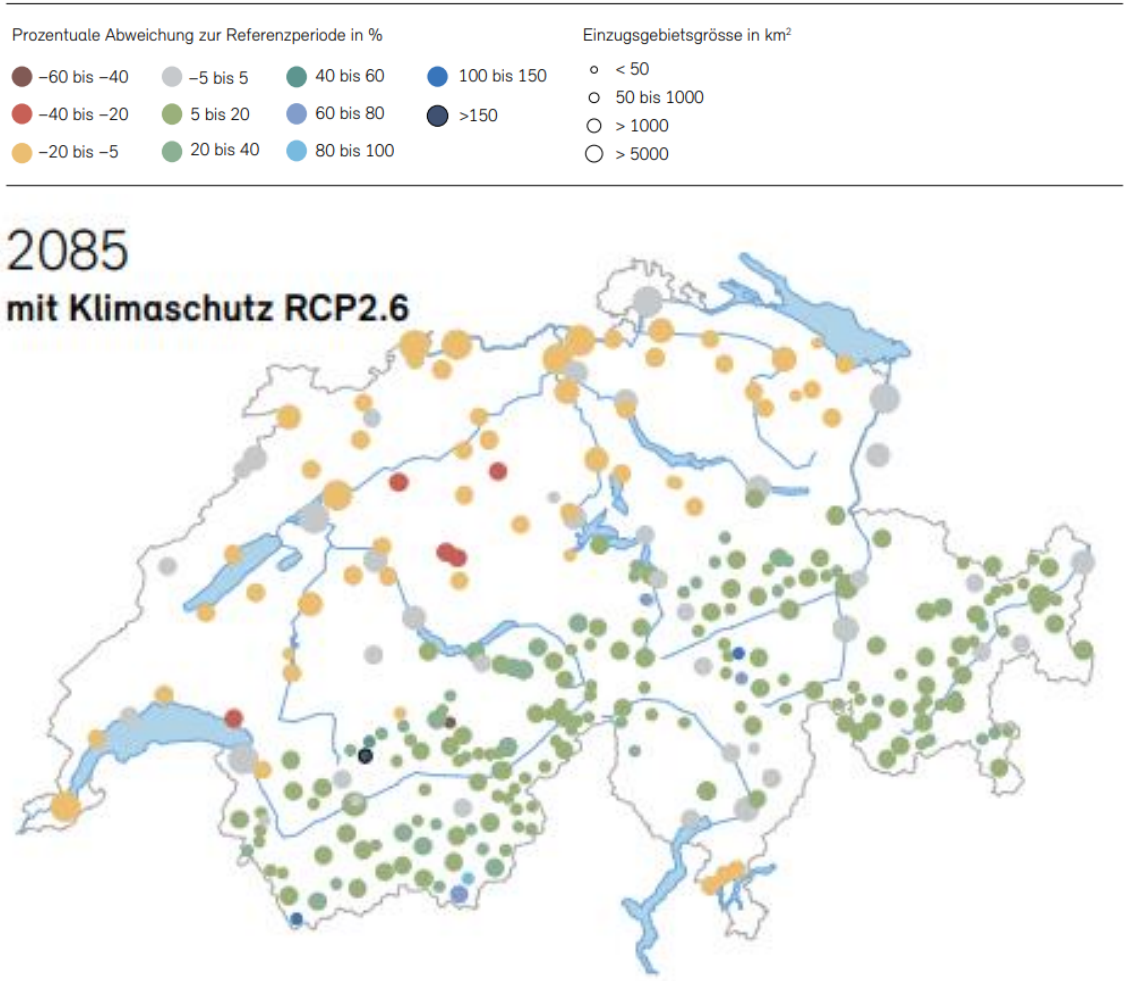


Veränderung der Winterproduktion (GWh/Winter)



BAFU, 2021: Auswirkungen des Klimawandels auf die Schweizer Gewässer

RESIDUAL WATER



In Switzerland the Q_{347} is the starting point for the determination of residual water flows. Other factors are considered thereafter.

Decrease of low-water discharges in the Central Plateau, Pre-Alps and Southern Alps

- Few diversion power plants in these areas, so there is little impact on production from changes in low-water discharges

Increase in low-water discharges in the Alpine region

- Many diversion power plants, therefore potential impact on residual water volumes and production expectations

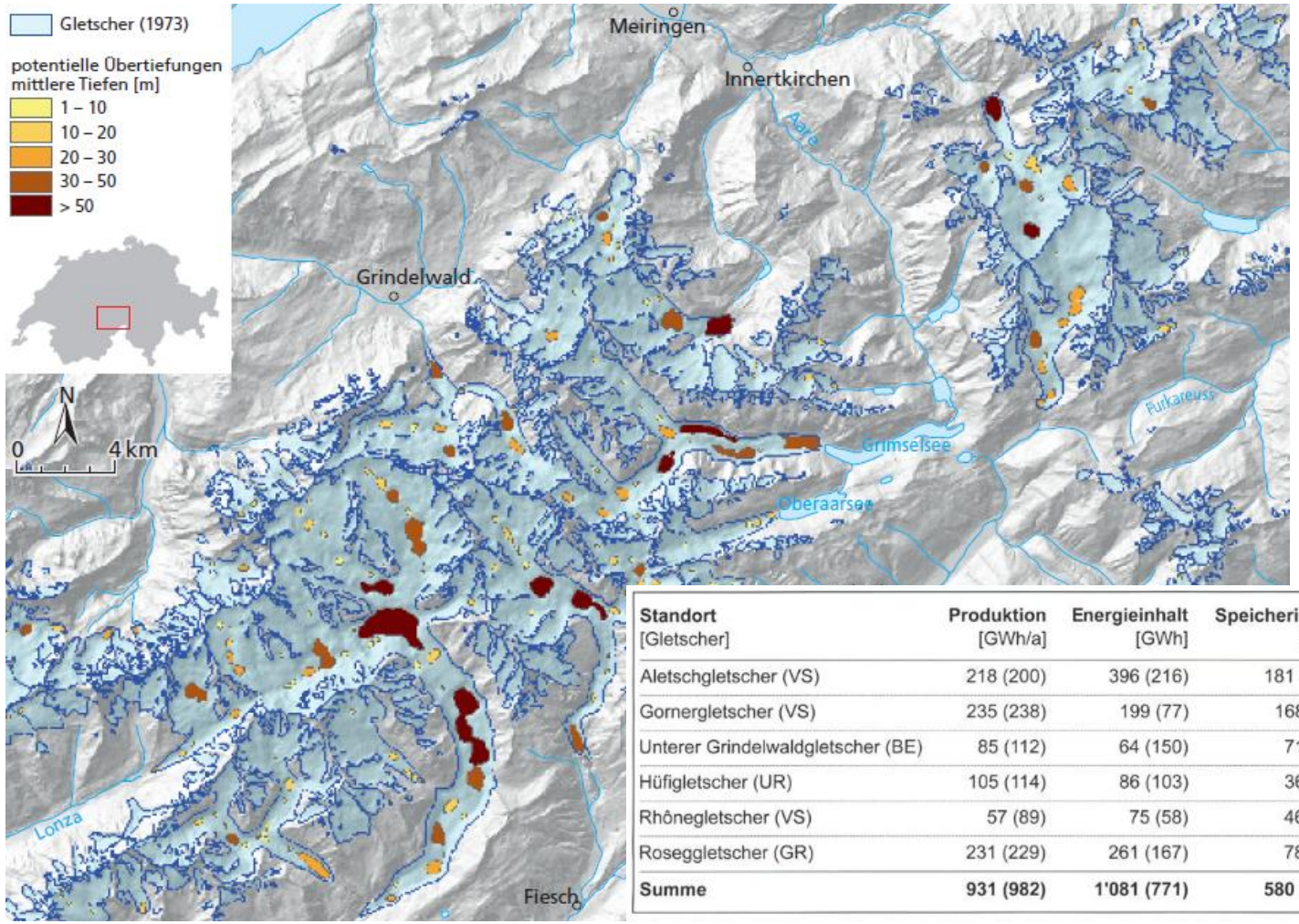
BAFU, 2021: Auswirkungen des Klimawandels auf die Schweizer Gewässer

EXPLOITATION - SEDIMENTATION

- Increase of sediment availability as a consequence of the expansion of proglacial areas and the thawing of permafrost.
- Sediment transport capacity in streams will decrease in the long term, owing to a declining snowmelt contribution to runoff and prolonged low-flow periods

- Damages to infrastructures during extreme events
- Abrasion on turbines
- Loss of storage capacity due to sedimentation
- Loss of water for rinsing

NEW SITES FOR HYDRO DUE TO GLACIAL MELT



Standort [Gletscher]	Produktion [GWh/a]	Energieinhalt [GWh]	Speicherinhalt [hm³]
Aletschgletscher (VS)	218 (200)	396 (216)	181 (106)
Gornergletscher (VS)	235 (238)	199 (77)	168 (34)
Unterer Grindelwaldgletscher (BE)	85 (112)	64 (150)	71 (84)
Hüfigletscher (UR)	105 (114)	86 (103)	36 (60)
Rhônegletscher (VS)	57 (89)	75 (58)	46 (30)
Roseggletscher (GR)	231 (229)	261 (167)	78 (84)
Summe	**931 (982)**	**1'081 (771)**	**580 (398)**

Standort [Gletscher]	Produktion [GWh/a]	Energieinhalt [GWh]	Speicherinhalt [hm³]	Modell A Punkte	Modell A Rang	Modell B Punkte	Modell B Rang	Modell C Punkte	Modell C Rang
Aletschgletscher (VS)	200	216	106	211	3	200	8	198	11
Allalingletscher (VS)	32	47	20	212	2	213	1	218	1
Blüemlisalpgletscher (BE)	16	19	10	188	18	194	12	200	9
Corbassièregletscher (VS)	57	33	16	200	11	200	8	202	6
Fieschergletscher (VS)	174	4	2	190	15	(181)	(22)	(187)	(20)
Findelgletscher (VS)	90	88	38	188	18	(175)	(28)	(170)	(37)
Gauligletscher (BE)	16	75	41	197	12	206	3	191	15
Gornergletscher (VS)	238	77	34	204	8	188	16	192	13
Hohlichtgletscher (VS)	15	24	11	(178)	(28)	(181)	(22)	195	12
Hüfigletscher (UR)	114	103	60	192	14	194	12	190	17
Mellichgletscher (VS)	25	39	16	189	16	188	16	202	6
Momminggletscher (VS)	34	6	3	(184)	(23)	(181)	(22)	190	17
Oberaletschgletscher (VS)	105	60	30	209	5	206	3	192	13
Otemmagletscher (VS)	48	127	60	(187)	(20)	188	16	(171)	(36)
Palügletscher (GR)	14	19	9	195	13	200	8	204	5
Plaine-Morte-Gletscher (BE)	67	9	5	(187)	(20)	(181)	(22)	191	15
hônegletscher (VS)	89	58	30	201	9	194	12	187	20
oseggletscher (GR)	229	167	84	206	6	206	3	207	4
chwarzberggletscher (VS)	19	41	19	201	9	206	3	202	6
lvrettagletscher (GR)	16	11	6	(171)	(37)	188	16	(173)	(34)
eodulgletscher (VS)	46	13	6	187	20	194	12	190	17
iftgletscher (BE)	145	215	85	210	4	206	3	211	2
ianfleurongletscher (BE)	7	19	11	189	16	188	16	(186)	(24)
rtmanngletscher (VS)	36	78	36	205	7	200	8	199	10
nterer Grindelwaldgletscher (BE)	112	150	84	213	1	213	1	210	3
umme Produktion [GWh/a]				**1'764**		**1'564**		**1'609**	
umme Energieinhalt [GWh]				**1'521**		**1'567**		**1'449**	
umme Speicherinhalt [hm³]				**737**		**763**		**705**	

SGHL, Chy: 2011 Auswirkungen der Klimaänderung auf die Wasserkraftnutzung – Synthesebericht
Ehrbar et.al., 2019: Wasserkraftpotenzial in Gletscherrückzugsgebieten der Schweiz. WEL.

EXAMPLE PROJECT TRIFTSEE (BERNESE ALPS)

KWO

85 Mio. m^3 storage volume (energy storage 215 GWh), 80 MW Power,
387 Mio. CHF, 145 GWh additional energy production

MULTI-PURPOSE USE

Jossen, Björnsen Gurung 2018: Möglichkeiten und Grenzen von Mehrzweckspeichern in der Schweiz und ihr Beitrag zur regionalen Resilienz, WEL

Climate change will have an impact on the water demand on competing sectors (agriculture, ecosystem conservation, water for households and industrie, fire-fighting water)

- HP reservoirs in Switzerland may be able to provide additional services in the future
- Additional uses will hardly change the total amount of electricity production by storage power plants, but they will likely modify the production pattern and the revenue under today's conditions

THANK YOU FOR YOUR ATTENTION

Contact:
Christian Dupraz
Head of Hydropower
Swiss Federal Office
of Energy SFOE
christian.dupraz@bfe.admin.ch
+41 58 46 55270