SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Annual Conference 2017

Prof. Domenico Giardini, Head SCCER-SoE

WSL, Birmensdorf

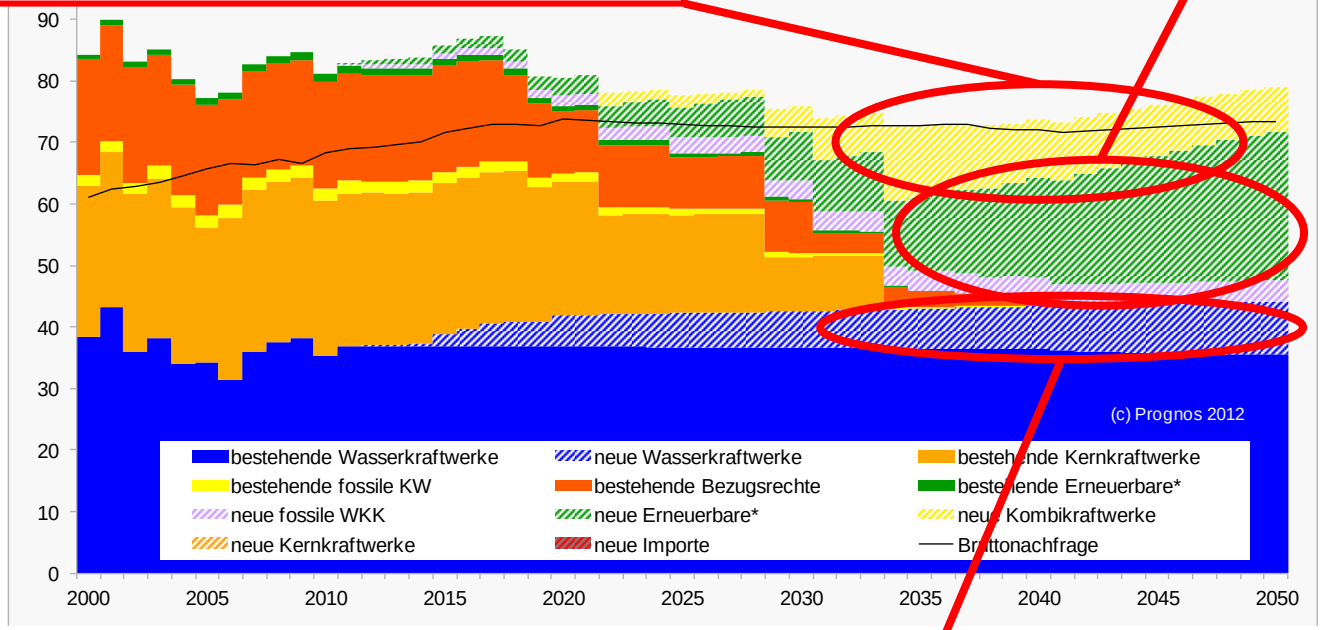
14-15 September 2017

Energy funding programme
Swiss Competence Centers for Energy Research

ES 2050: Targets for supply of electricity

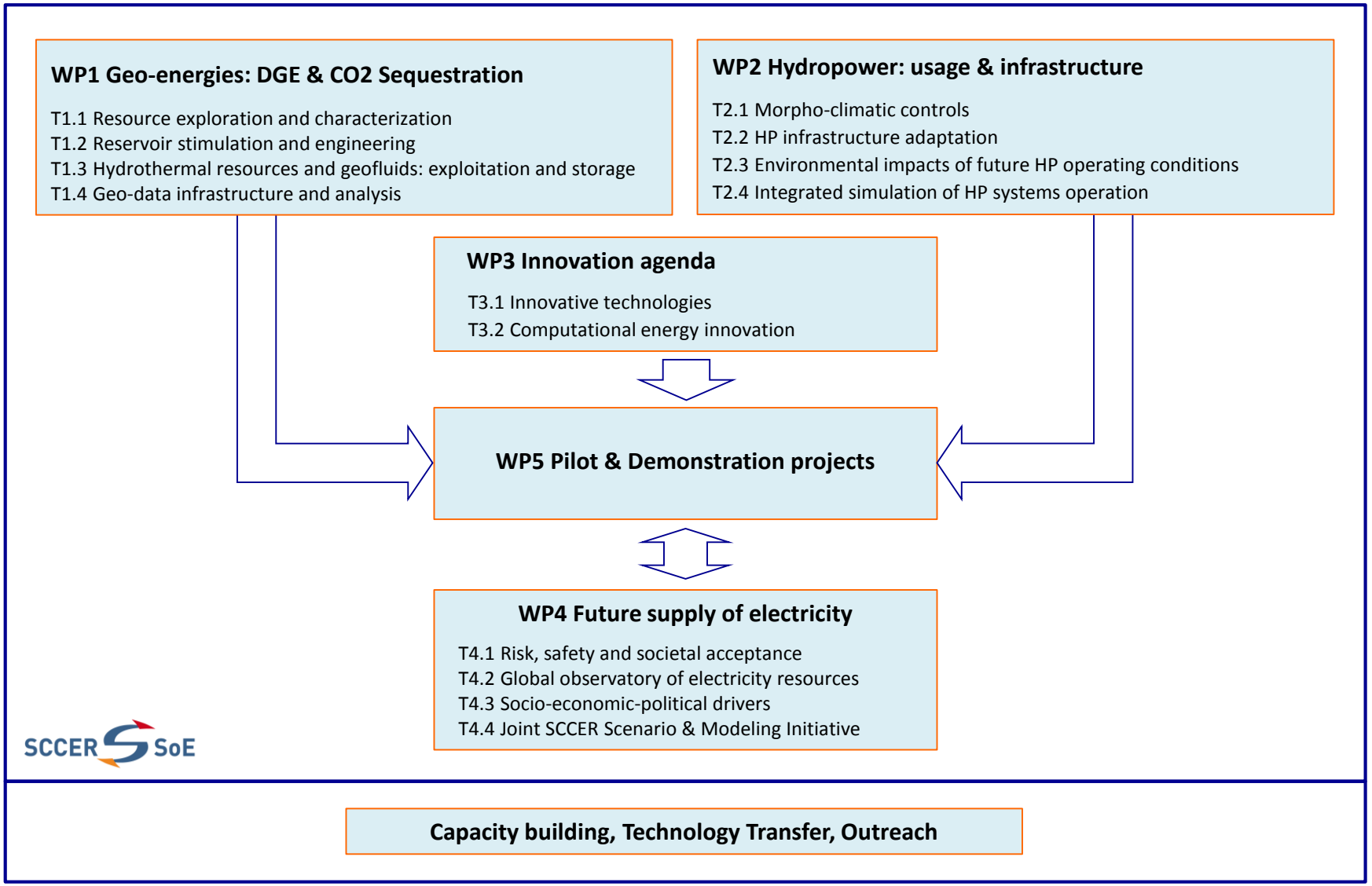
Is the geological capture of CO2 a viable measure to enable carbon-free generation of electricity from hydrocarbon resources ?

Can we extract safely the deep geothermal heat and produce at competitive costs 7% of the national baseload supply ?



Can we increase (i.e. by 10%) the present hydropower electricity production under changing demand, climate and operating conditions ?

Phase 2: architecture



Evaluation 2016

Evaluation 2016 very positive for SCCER-SoE:

→ outperforming in capacity building, third-party funding, all financial criteria!

→ roadmaps, demonstration projects, cooperation, communication, management!

Key points raised:

- Improve publication record
- Intensify training, technology transfer
- Continue increasing industry participation, especially international
- Strengthen innovation agenda
- Expand the presentation of Switzerland's energy science to the outside
- Establish processes to more systematically search for new ideas
- Maintain a constant view of the ES2050 targets

Phase 2: scope I

Taking into account the developments achieved in Phase I and the feedback to the innovation roadmaps developed, the scope for Phase II has been expanded in a number of critical directions:

- A wider perimeter for Geo-Energies (WP1), maintaining the focus on exploration and Deep Geothermal Energy and adding new targets on usage of hydrothermal resources for direct heating and heat storage (new T1.3) and direct applications of CO2 for geothermal heat exchange and sequestration.

- A refocusing of the HydroPower (WP2), with 4 Tasks and five key overarching targets:
  a) Increase of flexibility in hydropower operation - structural and operation requirements
  b) Update of climate change impacts on HP production and needed adaptation strategies
  c) Extreme natural hazards and risk of HP operation
  d) Design of new projects under uncertainties
  e) Reservoir sedimentation and sustainable use of storage HP

Phase 2: scope II

- A clearer focus of the innovation agenda (WP3), now including innovative technologies (T3.1) and computational energy innovation (T3.2), with the opening of a new AP in Computational Energy at USI
- A clear track for technology developments, with SCCER funding for the selected technologies for up to four years, resulting in either (i) industry support after reaching TRL 5-6 and implementation in P&D projects, or (ii) abandonment if not promising (a possible outcome for high-risk low-TRL technologies)
- A more integrated approach to the future supply of electricity (WP4), with
  I. an expanded scope of the risk assessment activities to encompass also risk of large dams (T4.1)
  II. a wider scope of the evaluation of global electricity resources and technologies (T4.2)
  III. new resources and a closer integration with CREST on the socio-economic-political drivers of electricity supply (T4.3)
- A new SCCER Joint Activity on *Scenario and Modeling* (T4.4), encompassing all eight SCCERs (lead SCCER-SoE)
- A new SCCER Joint Activity on *Socio-political conditions of the extension of hydropower and geothermal energy*, complementing T4.3, with CREST (Lead) and SCCER-SoE

Phase 2: scope III

- A new focus (WP5) on P&D projects, with 7 P&D projects under implementation or in an advanced stage of planning, for the implementation of innovative technologies (WP3) and of the integrative approaches and solutions developed in WP1-2:

  Demo-1: Flagship stimulation experiment in the Deep UnderGround Laboratory
  ETHZ, NAGRA, UniNe

  Demo-2: Reservoir engineering for heat exchange in Haute Sorne
  GeoEnergie Suisse, ETHZ, UniNe

  Demo-3: Geneva basin-scale hydrothermal play for heat extraction and storage
  UniGe, UniBe, SIG

  Demo-4: CO2 geological storage pilot, *ETHZ, EPFL, UniGe, UniGE*

  Demo-5: Small Hydro-Power Plant, *HES-SO, WP2*

  Demo-6: Controlled fine sediment release from a reservoir by a hydrodynamic mixing device, *EPFL, WP2*

  Demo-7: Complex large hydropower scheme, *EPFL, WP2*

Research partners

SCCER SoE

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Hes·so

GEO ENERGIE SUISSE

FMV

eawag
aquatic research

HSR
HOCHSCHULE FÜR TECHNIK RAPPERSWIL
FHO Fachhochschule Ostschweiz

Università della Svizzera italiana

BKW

SIG

unine
UNIVERSITÉ DE NEUCHÂTEL

UNI BASEL

axpo

KWO
GRIMSELSTROM

EPFL
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Unil
UNIL | Université de Lausanne

GE

nagra.

PAUL SCHERRER INSTITUT
PSI

u^b
UNIVERSITÄT BERN

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office of Topography swisstopo
www.swisstopo.ch

SULZER

sarmap

esr
énergies sion région
avec nous vous êtes bien chez vous.

UNIVERSITÉ DE GENÈVE

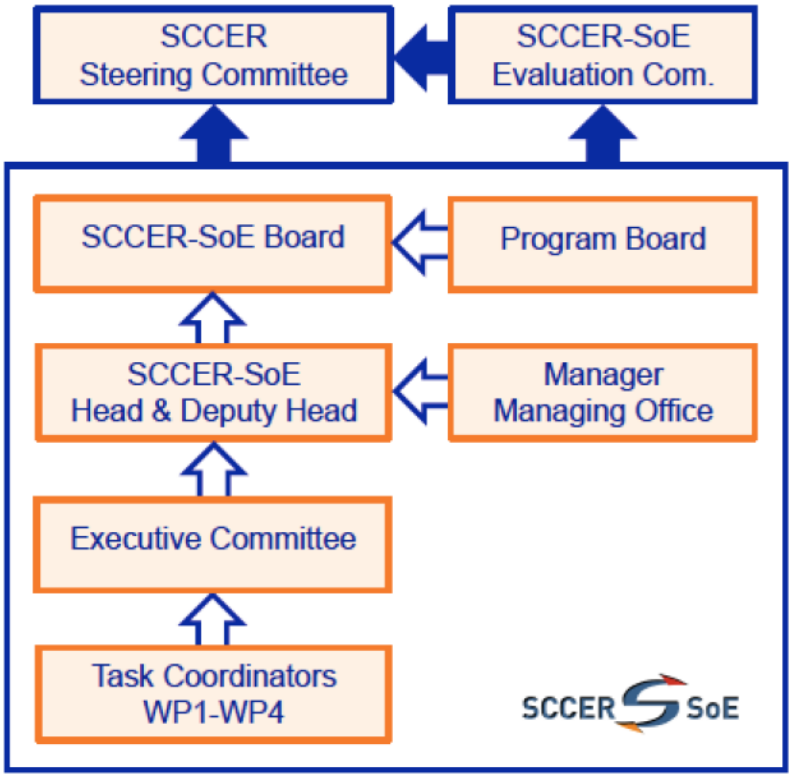
Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN

WSL

ALPIQ

groupe E

Governance



Head (Prof. D. Giardini, ETHZ) and
Deputy Head (Prof. F. Avellan, EPFL)

Program Manager: Gianfranco Guidati, ETHZ

KTT Officer: Ueli Wieland, ETHZ

Outreach: Anja Tamburini, ETHZ

Tasks Coordinators

SCCER-SoE Board: representatives of the Leading House (Chair), of all Academic Research Partners and of 2 Cooperation Partners (M. Ladwig, GE; P. Meier, GES)

Program Board, composed by representatives of all Research Partners

Executive Committee, composed by the Head and Deputy Head, Manager, and one representative for each of the five Work Packages:

- WP1: Dr. Th. Driesner, ETHZ (→ Prof. Lyesse Laloui, EPFL)
- WP2: Prof. A. Schleiss, EPFL (→ Prof. Robert Boes, ETHZ)
- WP3: Prof. C. Münch-Alligné (HES-SO)
- WP4: Dr. P. Burgherr (PSI)
- WP5: Prof. A. Moscariello (UNIGE)

Budget

Research Partner	CTI-funding
UNIBE	690
UNIGE	897
UNIL	460
UNINE	805
USI	667
ETHZ	8425
EPFL	2461
PSI	851
EAWAG	483
WSL	782
HES-SO	1104
HSR	230
HSLU	345
Total	**18200**

All numbers in kCHF

Funding source	Budget
CTI-funding	18200
Own contribution	~22000
Competitive federal funds	~14000
Third party (e.g. EU)	~12000
Total	**~66200**

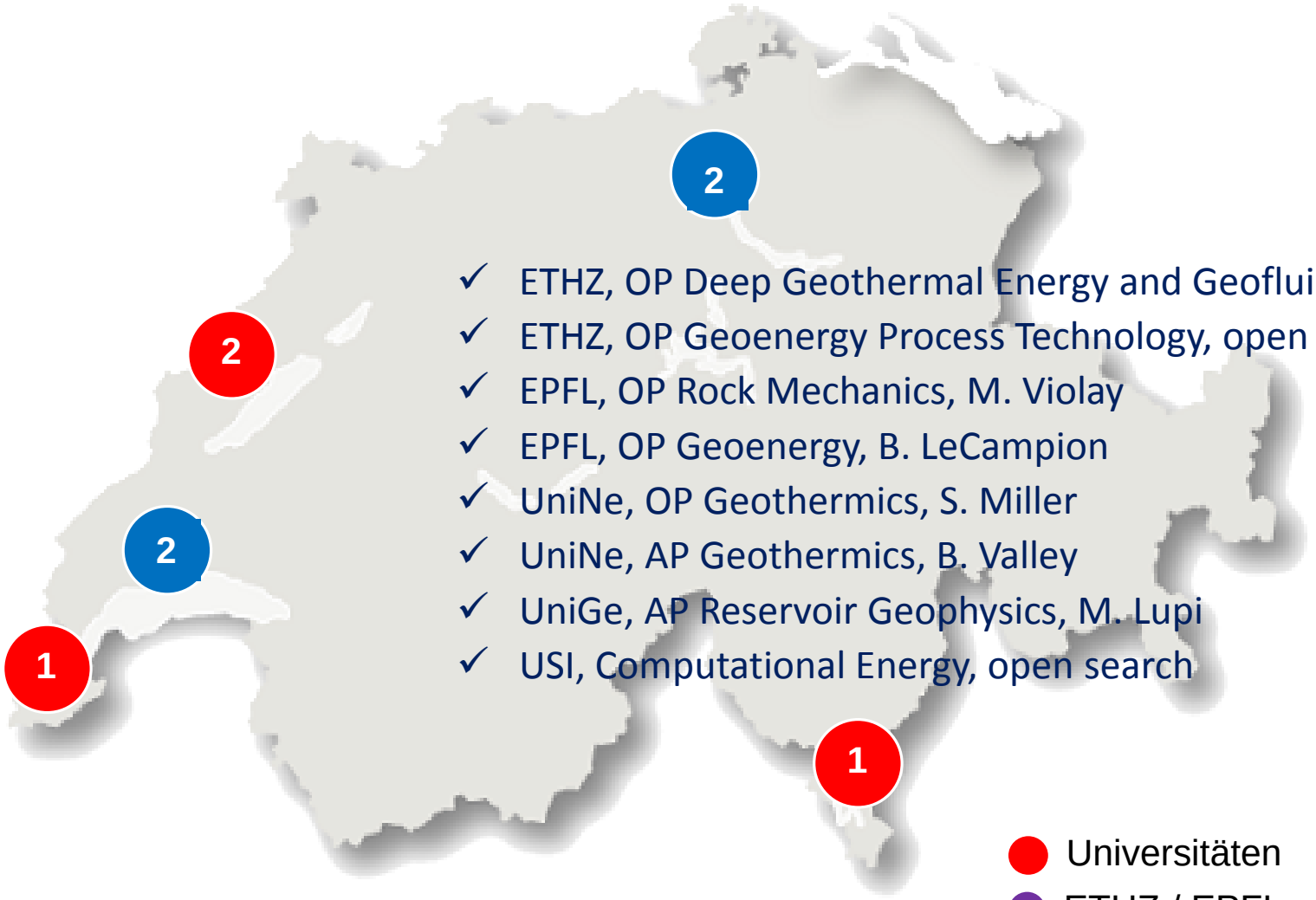
Matching funds

More than 60 MCHF are invested over 4 years to boost electricity production in support of the Energy Strategy 2050 !

Capacity building

	2016	2015
Personnel SCCER-SoE		
Head Count (HC) researchers including professors	247	240
HC researchers without professors	218	
Full time employee (FTE) researchers without professors	171	
Percentage of female researcher	22 %	
PhD students (HC on September 1st)	94	82
Percentage of female PhDs	28 %	27 %
Participation at the PhD school	50	43
Master theses	55	41
Percentage of female students having written a master thesis	38 %	25 %

SCCER-SoE: 8 new AP and OP in Geo-Energies

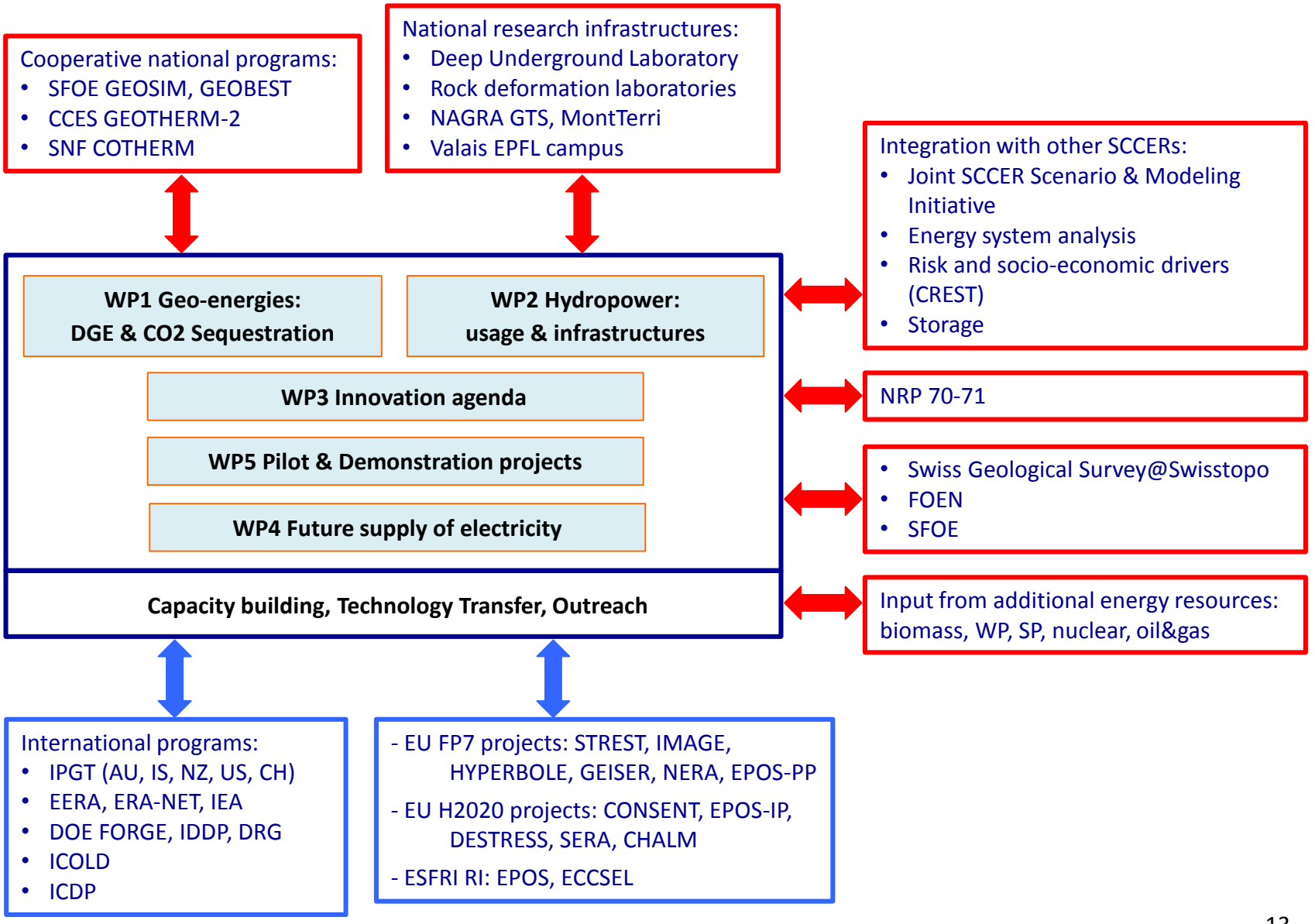


- ✓ ETHZ, OP Deep Geothermal Energy and Geofluids, M. Saar
- ✓ ETHZ, OP Geoenergy Process Technology, open search
- ✓ EPFL, OP Rock Mechanics, M. Violay
- ✓ EPFL, OP Geoenergy, B. LeCampion
- ✓ UniNe, OP Geothermics, S. Miller
- ✓ UniNe, AP Geothermics, B. Valley
- ✓ UniGe, AP Reservoir Geophysics, M. Lupi
- ✓ USI, Computational Energy, open search

Universitäten

ETHZ / EPFL

Integration



Academic cooperations

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

Hes·so

eawag aquatic research

HSR Hochschule für Technik Rapperswil FHO Fachhochschule Ostschweiz

unine Université de Neuchâtel

EPFL École polytechnique fédérale de Lausanne

UNIL | Université de Lausanne

Università della Svizzera italiana

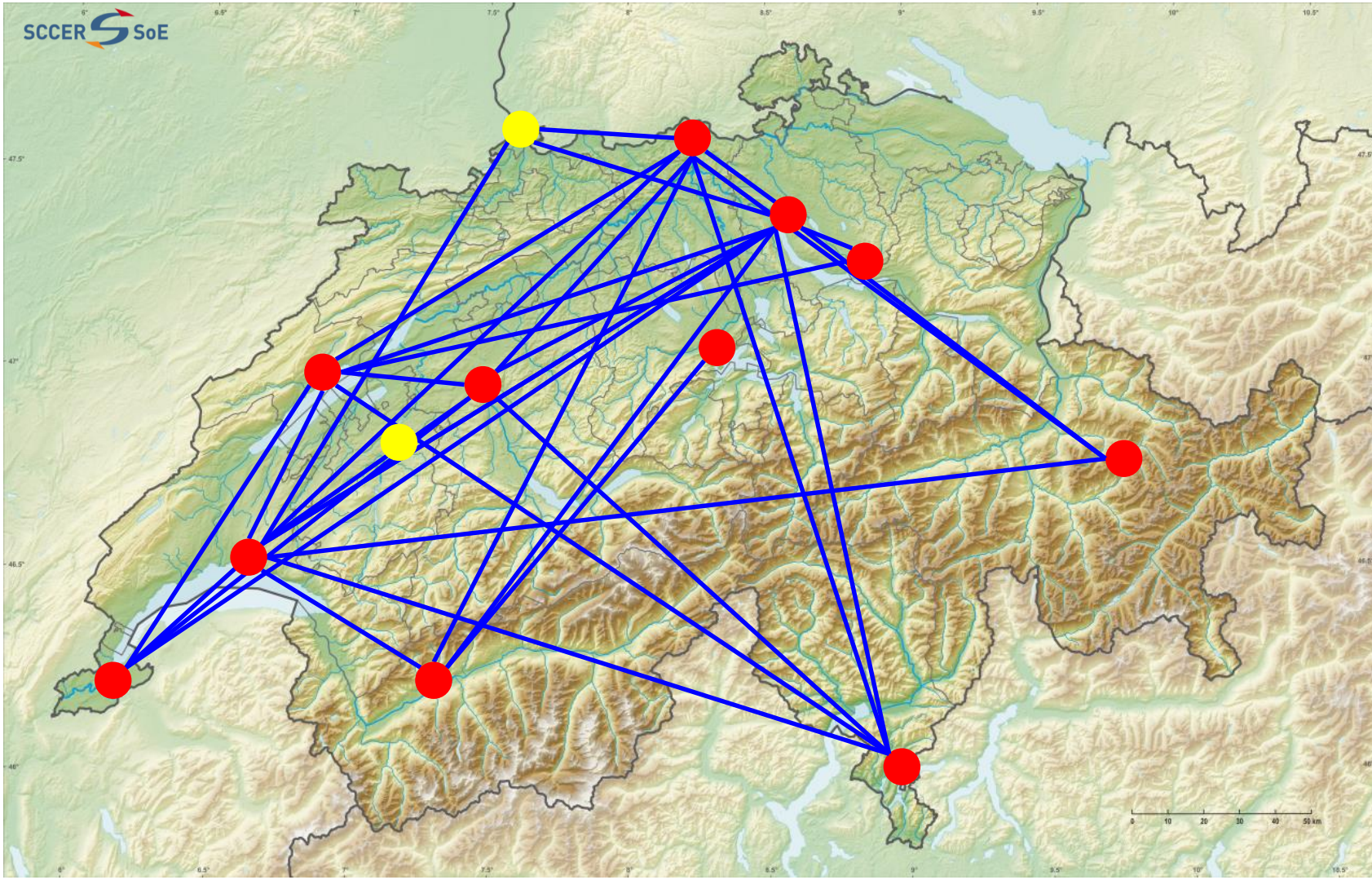
Paul Scherrer Institut PSI

Université de Genève

Lucerne University of Applied Sciences and Arts Hochschule Luzern

u^b Universität Bern

WSL



Activity Overview of GeoEnergy

SCCER SoE

Target electricity production for 2050: 4400 GWh

Key goals:

- extract safely the deep geothermal heat and produce electricity at competitive cost
- geological capture of CO2 to enable carbon free electricity from hydrocarbon resources

Roll-out
Prototyping
Validation
Concept
System

Petro-thermal plants
20MWe per year

Hydro-thermal plants
Heat and Storage

CCS-CCUS
Industry & air capture

EGS Pilot 1: Project Haute Sorne
EGS Pilot 2
EGS Pilot 3

Hydrothermal P&D 1: Geneva basin
Hydrothermal P&D 2
Hydrothermal P&D 3

CCS field-scale demonstrator 1
CCS Demo 2

Laboratory and Deep-Underground Laboratory testing

Phase 1-2

Innovation technologies

- Advanced cementious grouts
- Corrosion resistant heat exchanger
- Sensor for harsh environment
- Optimisation of geothermal energy conversionn
- Next generation numerical methods and simulation tools for DGE reservoir eng.
- Real time, data driven reservoir characterization and risk assessment

Integrated solutions

- Resource exploration and characterization
- Reservoir enhancement and engineering
- Limit induced seismicity while creating an efficient reservoir
- Hydrothermal and aquifer resource exploitation and storage
- Chemical processes in the reservoir

Phase 3
New innovation technologies and integrated approach

Risk, safety and societal acceptance– Technology assessment– Energy economic modeling

GeoData infrastructure and resource exploration on national scale

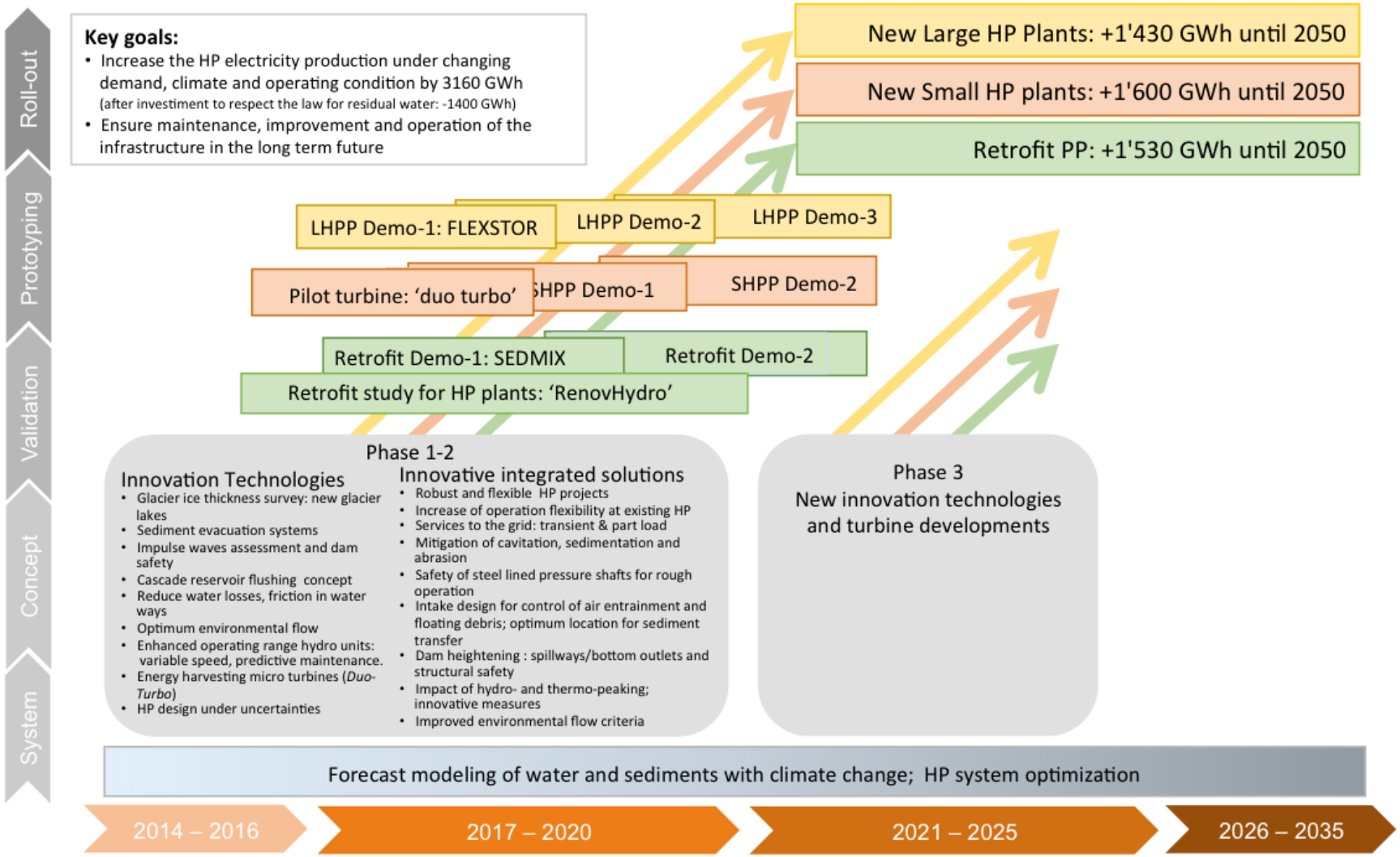
2014 – 2016 | 2017 – 2020 | 2021 – 2025 | 2026 – 2035

Energy funding programme
Swiss Competence Centers for Energy Research

Activity Overview of Hydropower

SCCER SoE

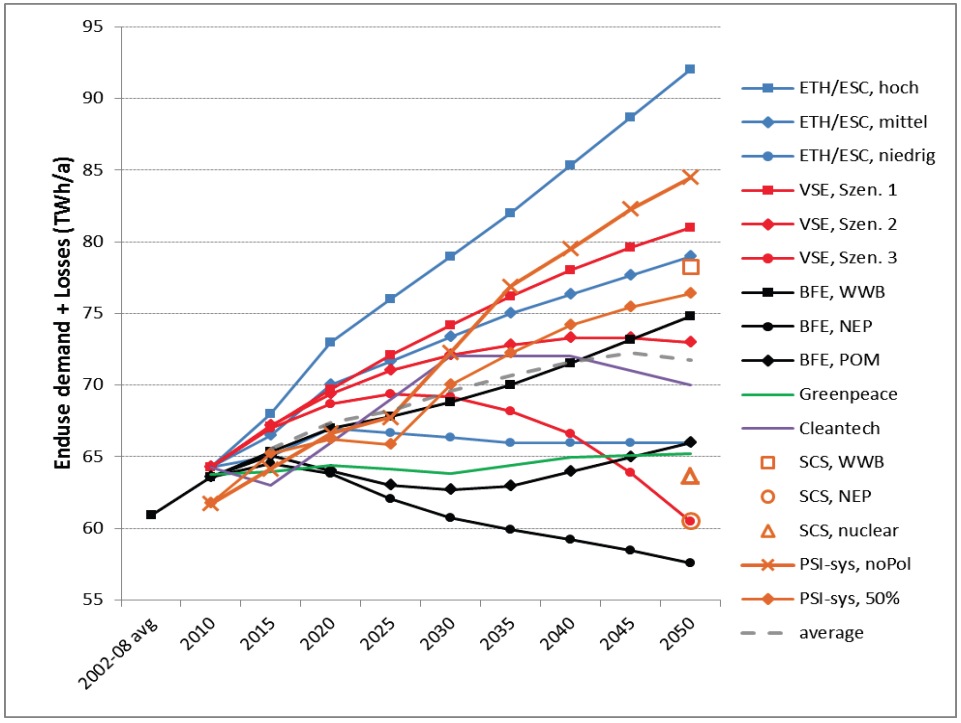
Key goals:
- Increase the HP electricity production under changing demand, climate and operating condition by 3160 GWh (after investment to respect the law for residual water: -1400 GWh)
- Ensure maintenance, improvement and operation of the infrastructure in the long term future



Energy funding programme
Swiss Competence Centers for Energy Research

SCCER JA: Scenario & Modeling

- Each SCCER conducts scenario modeling in its field and has dedicated personnel in its program.
- In Phase II, a joint SCCER activity has been initiated to enable further developing and combining different models while preserving the specificity of the individual approaches.
- All SCCER equally involved, with SCCER-SoE lead
- Participation of industry (VSE)



SCCER SoE

SCCER EIP EFFICIENCY OF INDUSTRIAL PROCESSES

HP Storage

sccer mobility

SCCER CREST

biosweet
Biomass for Swiss Energy Future
Swiss Competence Center for Energy Research

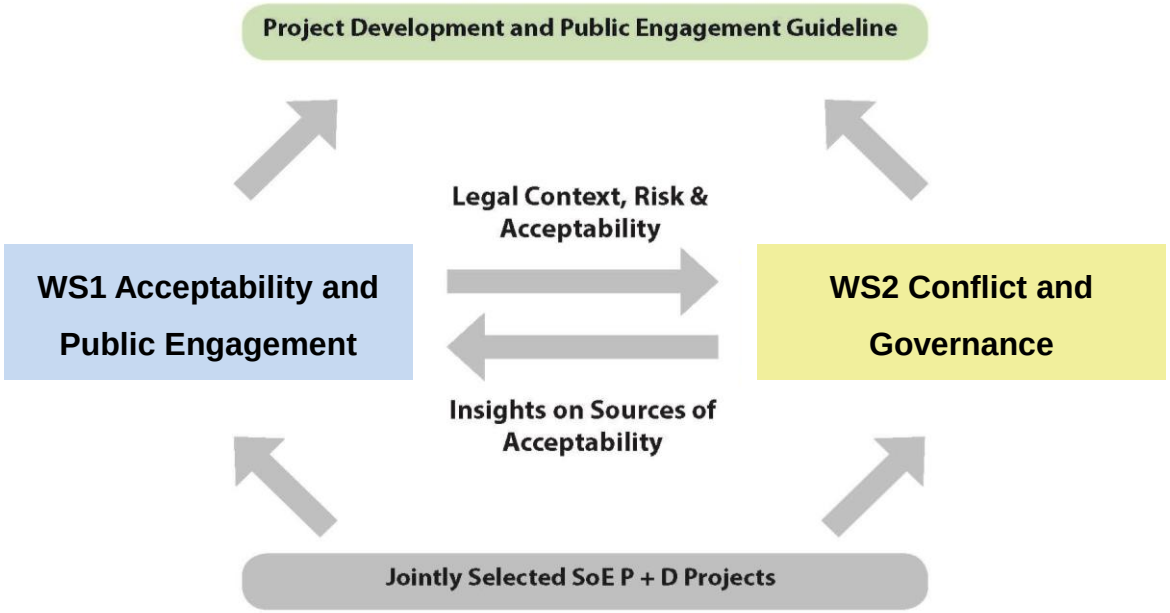
SCCER – FURIES
Shaping the FUtuRe SwIss Electrical InfraStructure

SCCER JA: Integrated development processes for HP and DGE projects

OBJECTIVES: Provide **recommendations** how

a. project development processes (public engagement),
b. the legislative framework,
c. governance structures

could be enhanced to facilitate the **resolution of conflicts** among stakeholders and thus **reduce project risks**.



Energiewende
Nationales Forschungsprogramm NFP 70

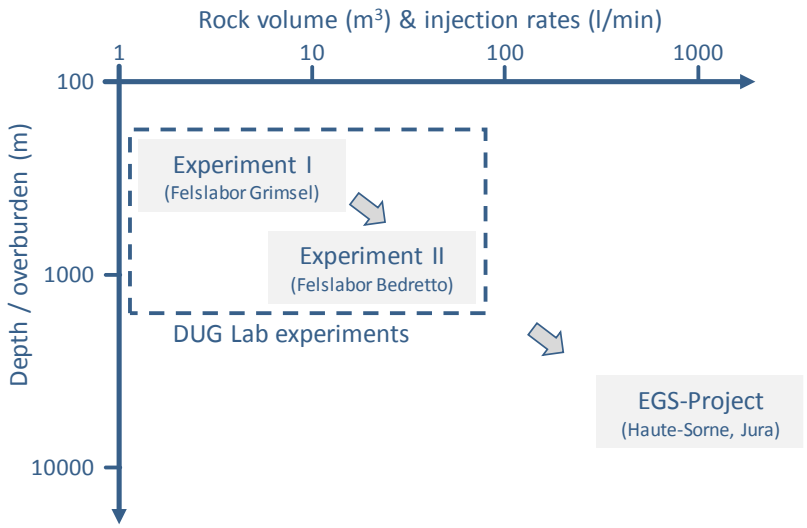
SCCER SoE

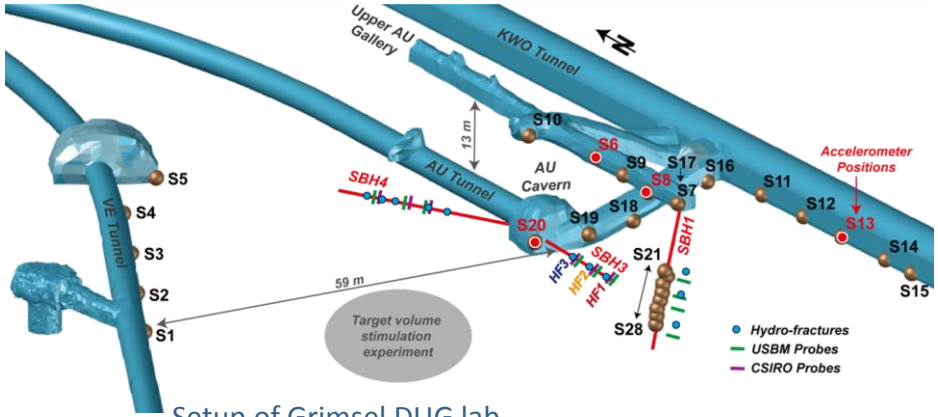
NFP70 started in November 2014 and supports PhDs for the SCCER-SoE implementation. Three cluster projects are involved:

- ✓ **SoE-HPGE (Supply of Electricity – Hydropower and geoenergy)** is a cluster of seven projects supporting 20 PhD students for fundamental R&D in key SCCER-SoE domains (lead SCCER-SoE, budget 4.1M)
  - P1-P2: fundamental research in Geo-Energies
  - P3-P4: development of HydroPower operations and infrastructures
  - P5-P6: future hydropower operations
  - P7: comprehensive risk governance for both HydroPower and GeoEnergies
- ✓ **The future of Swiss HydroPower** develops an integrated assessment of the chances, threats and solutions for future HydroPower utilization and expansion (lead UniBasel, budget 1.2M)
- ✓ **Hydro-ecology and flood-plain sustainability in application** (HyApp; lead EPFL)

Demo-1: Flagship stimulation experiment in the Deep UnderGround Laboratory

ETHZ, NAGRA, UniNe





Setup of Grimsel DUG lab

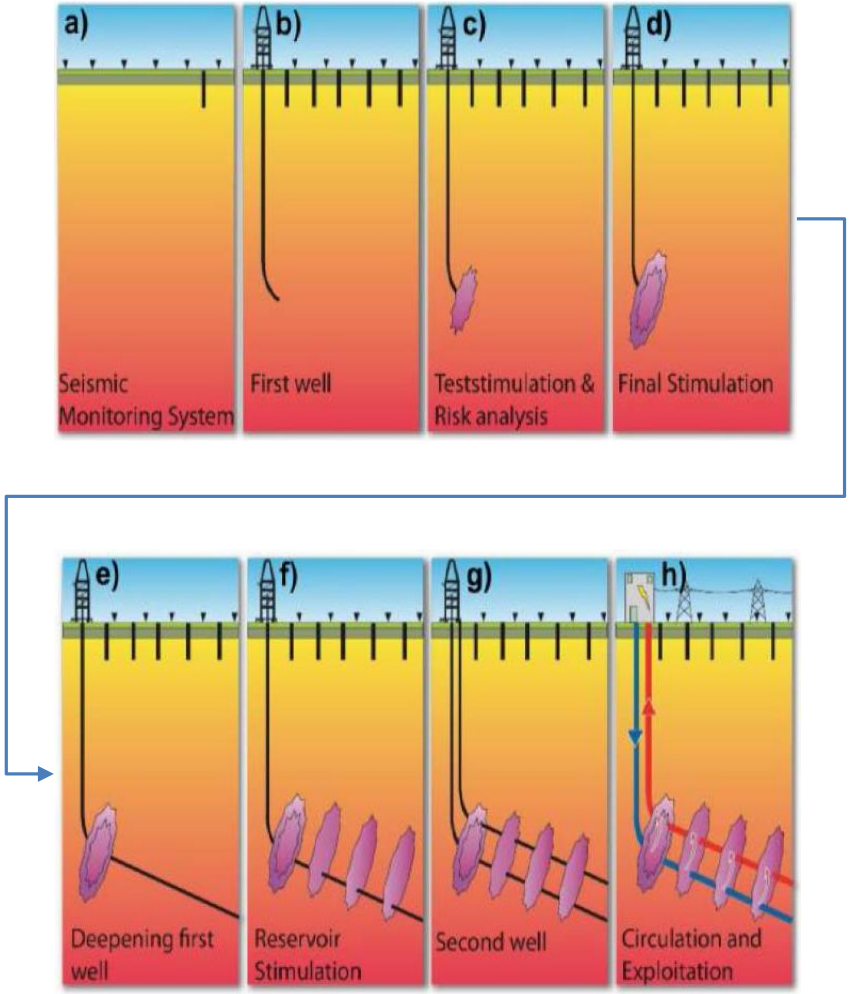
Petrothermal electricity production requires the creation of a fracture network – a geothermal heat exchanger – without triggering felt or damaging earthquakes.

The technology of hydraulic stimulation is being developed in a systematic step-wise approach. After successful stimulation tests in the Grimsel DUG lab preparation are underway to scale up testing in the Bedretto tunnel.

Funded, on-going, outlook +++

Demo-2: Reservoir engineering for heat exchange in Haute Sorne

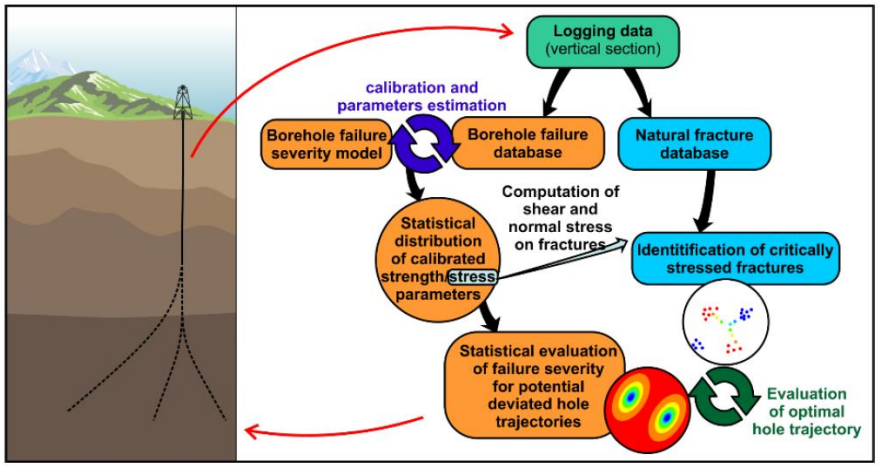
GeoEnergie Suisse, ETHZ, UniNe



Single hydraulic injection is not the most efficient way to create permeability while limiting induced microseismicity

Multistage hydraulic stimulation enabled by directional drilling and zonal isolation could be more appropriated.

Requires workflow for efficient analyses of data from the vertical well section to minimize risk and optimize trajectory.

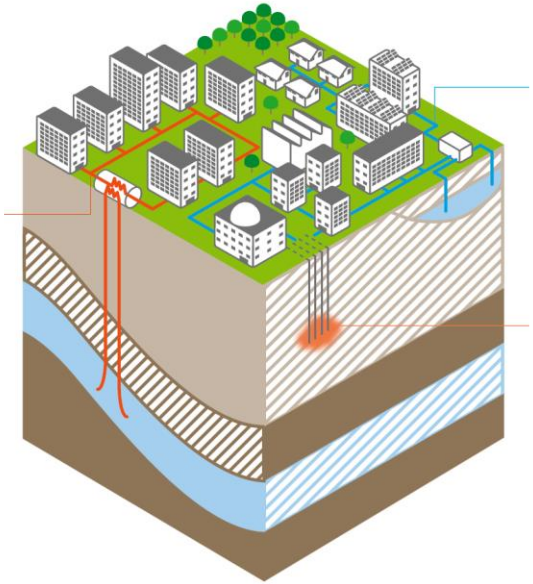


Permit pending, outlook +

Demo-3: Geneva basin-scale hydrothermal play for heat extraction and storage

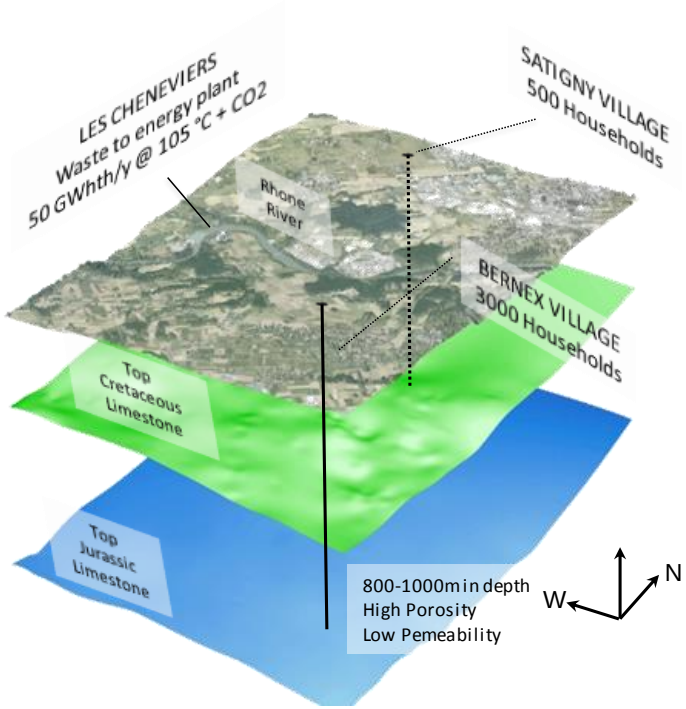
UniGe, UniBe, SIG

Medium-deep geothermal can provide heat for direct use, also for older buildings that require higher temperature



Shallow geothermal provides heat or cooling for new buildings using heat pumps. Storage of heat and cold is also possible

The underground – both rocks and aquifers – can be used for thermal energy storage



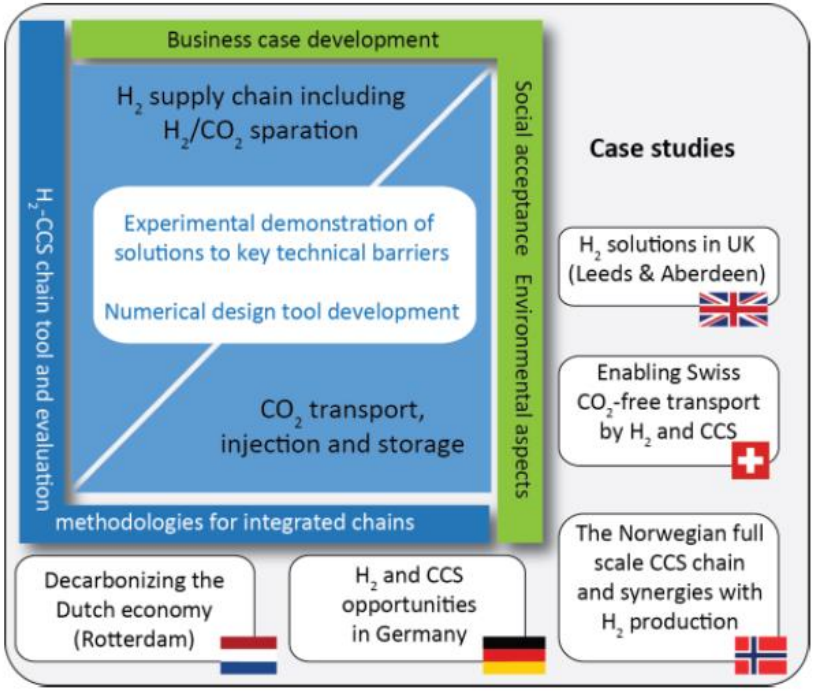
Demo project: Seasonal heat storage from waste to energy plant

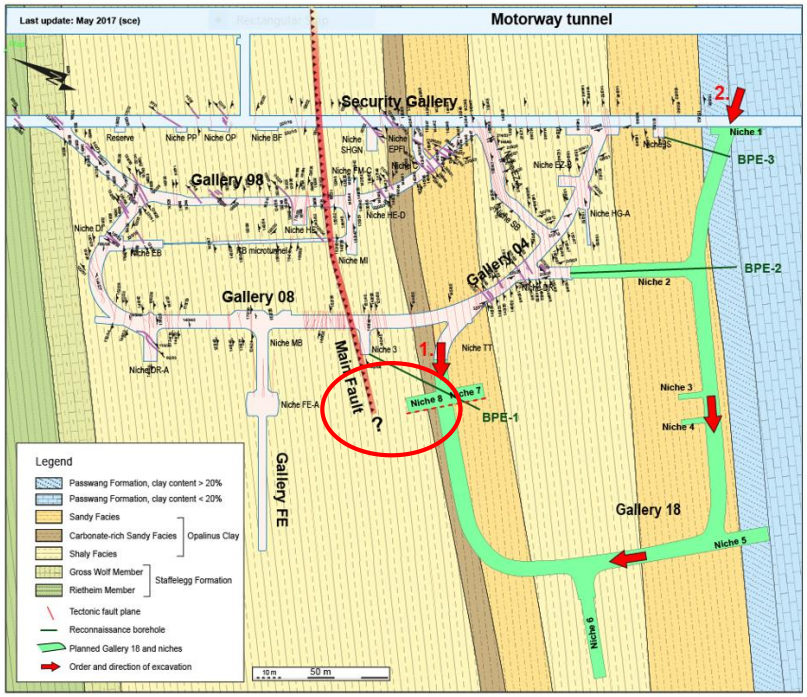
- Exploration wells to be drilled in Q4/2017 and 2018
- Target the Cretaceous limestone located at 800-1000 m depth
- Objectives:
  - Characterize geological and petrophysical anisotropies
  - Increase subsurface knowledge for future extended drilling campaign
  - Industry and University collaboration to optimize positioning of the well
  - Predictive 3D reservoir modelling
  - Economic Assessment of the Heat Storage Potential

Funded, on-going, outlook +++

Demo-4: CO2 geological storage pilot

ETHZ, EPFL, UniGe, UniGE





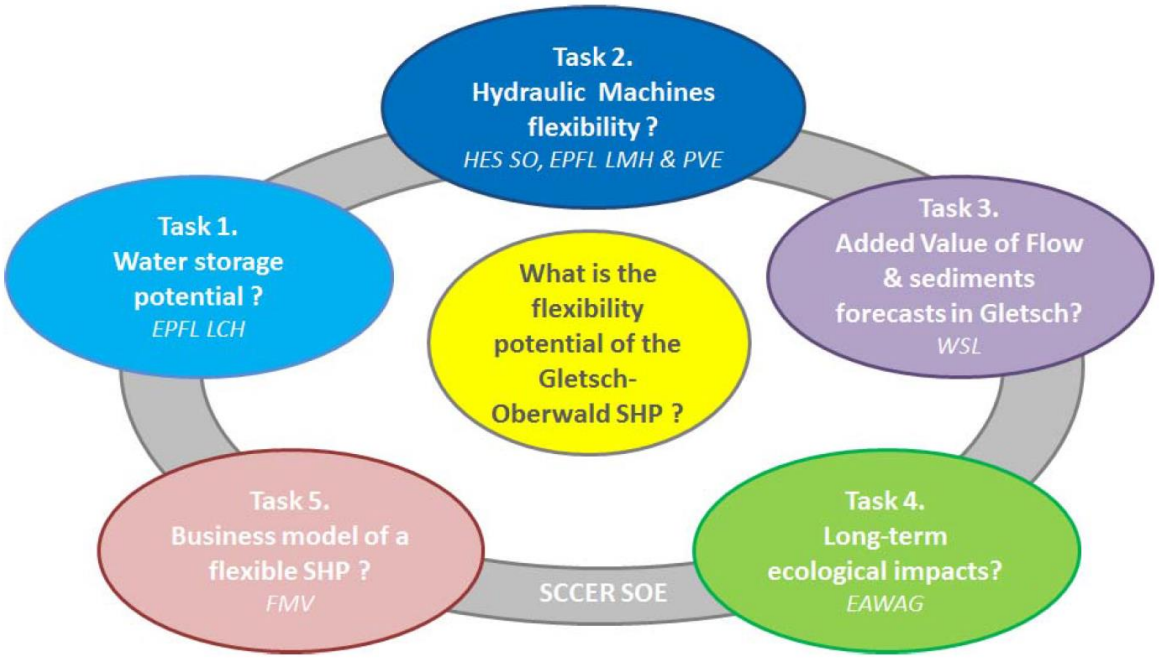
The SCCER participates in the European ELEGANCY project via a BFE-funded P&D project.

The overall mission of ELEGANCY is to provide clean H_2 for heat and mobility based on steam-methane-reforming. CO_2 storage is an essential part of this concept.

Underground experiments at the Mt Terri Lab will study the potential CO_2 migration through a fault in the caprock and the effects of fault activation. This is complemented by lab experiments on rock samples, modelling of injection and CO_2 migration and the identification of suitable regions in the Swiss sedimentary basin.

Partially funded; outlook ++

Demo-5: Small Hydro-Power Plant
HESSO, EPFL, eawag, WSL, FMV



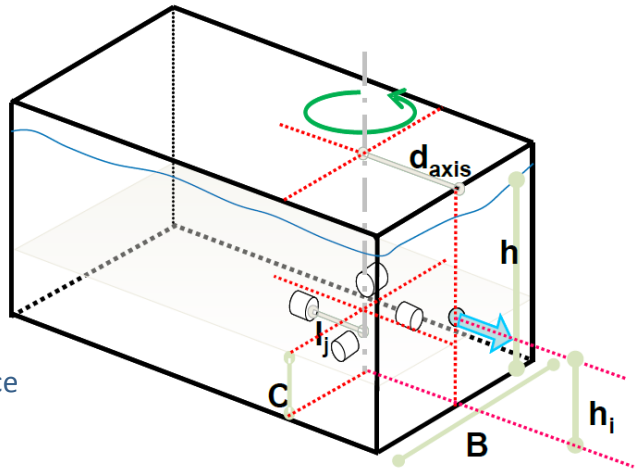
The objective is to show the ability of a small hydropower station to produce clean energy while offering ancillary services

- How can intra-day, intra-week or intra-monthly storage be added?
- What are the consequences of enlarging the operational range?
- What is the added-value of meteorological forecasts in terms of power generation and prediction of sediment inflows?
- What are the consequences of a more flexible operation to the downstream river reach (e.g. hydropeaking)?

Partial funding; outlook ++

Demo-6: Controlled fine sediment release from a reservoir by a hydrodynamic mixing device

EPFL



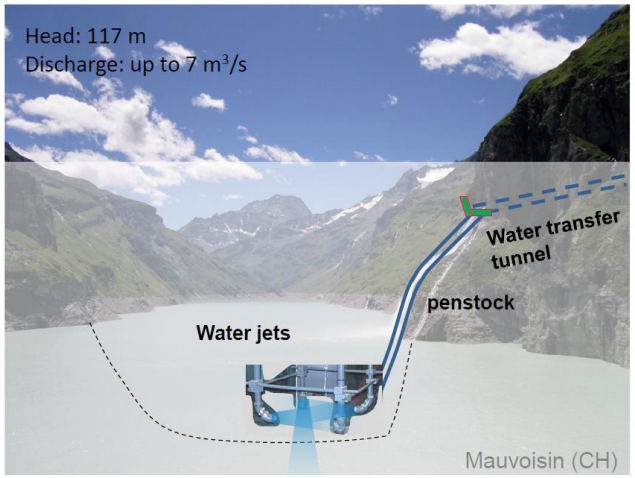
Principle of SEDMIX device

Reservoir sedimentation reduces storage volume and can create safety problems

A stirring device re-suspends fine sediments that can be removed with the flow through the power intakes.

The SEDMIX prototype will be tested in the Trift reservoir.

Prototype

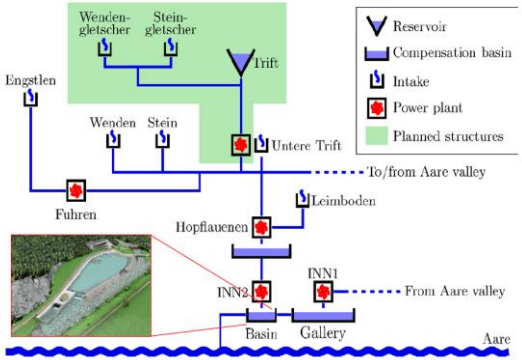


Possible implementation

Funding pending; outlook +

Demo-7: Complex large hydropower scheme (Flexstor)

EPFL, ETHZ, eawag, WSL, HESSO, KWO

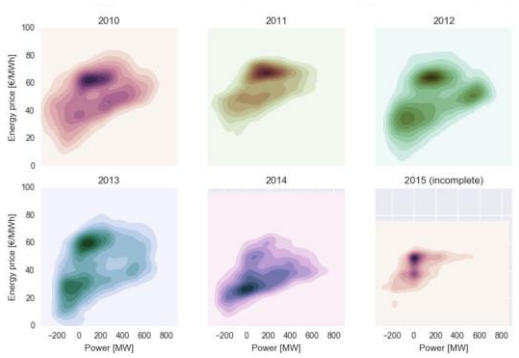


WP1: Minimize hydropeaking impact through optimization of basins and PP schedules

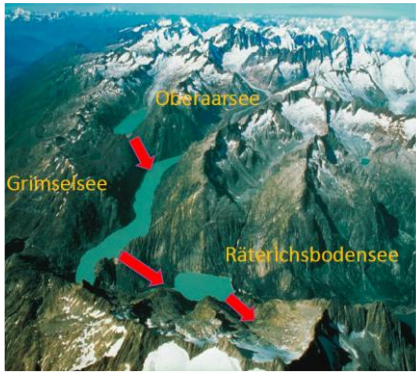
WP2: Quantify impulse waves through small/large scale testing

Hydropower projects face new issues linked with operation flexibility and sediment management, impacting their intra-day/annual competitive profile.

The FLEXSTOR projects addresses these issues in a systematic way.

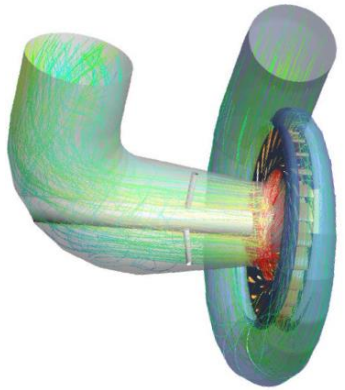


WP3: Optimize storage management under future market/climate scenarios



WP4: Holistic approach to optimize cascade sediment flushing

WP5: Suspended sediment and turbine wear monitoring



WP6: Identify start/stop paths preventing instabilities

Funded; on-going; outlook +++

PhD Schools

Grimsel, 2015

Leukerbad, 2016

→ SCCER School on Energy Transition @ Engelberg, 17-20 October 2017

Technical Reports

- ✓ *Review of Swiss Electricity Scenarios 2050* Densing, Hirschberg & Turton, SCCER-SoE, PSI Bericht Nr.14-05, 2014
- ✓ *Switzerland Energy Transition Scenarios* Kannan & Turton, PSI, BFE SI/500517-01/8100087, 2014
- ✓ *Energy from the Earth: Deep Geothermal as a Resource for the Future?* Hirschberg, Wiemer & Burgherr eds., TA Swiss, DOI 10.3218/3655-8, 2015
- ✓ *Potentiale, Kosten und Umweltbewertung von Stromproduktions-technologien*, Hirschberg et al., PSI & SCCER-SoE, exp. fall 2017

Annual conferences

- ✓ 2015 Neuchatel; 2016 Sion
- ✓ Highly successful, with over 250 participants
- ✓ Interaction with stakeholders: industry, federal offices, policy makers
- ✓ Science presented in posters, building the annual Science Report

- ➢ The Annual Conference 2017, hosted by WSL in Birmensdorf, with over 140 registered posters, promises to be even more successful !

Communication & Outreach

Additional activities:

- ✓ New web site, with highlights, news, events
- ✓ Blog, 1/m, 1’500 readers
- ✓ Internal newsletter, 3/yr
- ✓ External newsletter, 3/yr, 400 recipients
- ✓ Brochures, SCCER-SoE flyer, CTI SCCER flyer
- ✓ Media events
- ✓ Media releases

New energy law provides strong support to HP and DGE

Aujourd'hui	Dans SE 2050
Garantie de risques pour forages (< 50%) (art. 35 loi sur l'énergie)	Garantie de risques pour forages (< 60%), intégrant les études préalables (notamment géophysique)
	Subvention à l'exploration (< 60%), intégrant les études préalables
Rétribution à prix coûtant de l'électricité géothermique (40 ct / kW/h)	Idem

Electricité	Chaleur
Prélèvement de maximum 0,1 ct / kWh électrique vendu (sur 2,3 ct / kWh au total) (art. 38 al.1 loi sur l'énergie)	Max. 30 mio / an, sur la base de la rétrocession financière de la taxe sur le CO2 (sur max. 450 mio)

→ Approved by Parliament on 30.9.2016, referendum passed in May 2017 !

Outlook beyond 2020

- ✓ The SCCER program is
  - ➢ unique in the Swiss research area, providing the opportunity for focused R&D and integrating all the key strengths and partners from ETHD, UNIES, UAS, industry and Federal Offices
  - ➢ complementary to the research programs of SNF, schools, EU
  - ➢ successful in reaching the targets
  - ➢ working on longer-term roadmaps (to 2025 for SoE)
- ✓ Reaching the 2050 targets will require a continuous effort beyond 2020
  → The need for coordinated, focused R&D will remain!
- ✓ With the beginning of Phase 2, the strategic evaluation of the SCCER program will be conducted to define strategy, structure, focus and resources for a follow-up program/center/institute/FA beyond 2020.
- ✓ This definition should be completed by early 2018, for inclusion in the Law of Education 2021-2024 → a first meeting should be organized in spring 2017 with all relevant stakeholders: participating schools (ETHD, UNIES, UAS), CTI, SNF, BFE, SCCER Heads.
- ✓ Input from SCCER-SoE Kick-off event