SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

# Annual Conference 2016

Prof. Domenico Giardini, SCCER-SoE Head, ETH Zurich

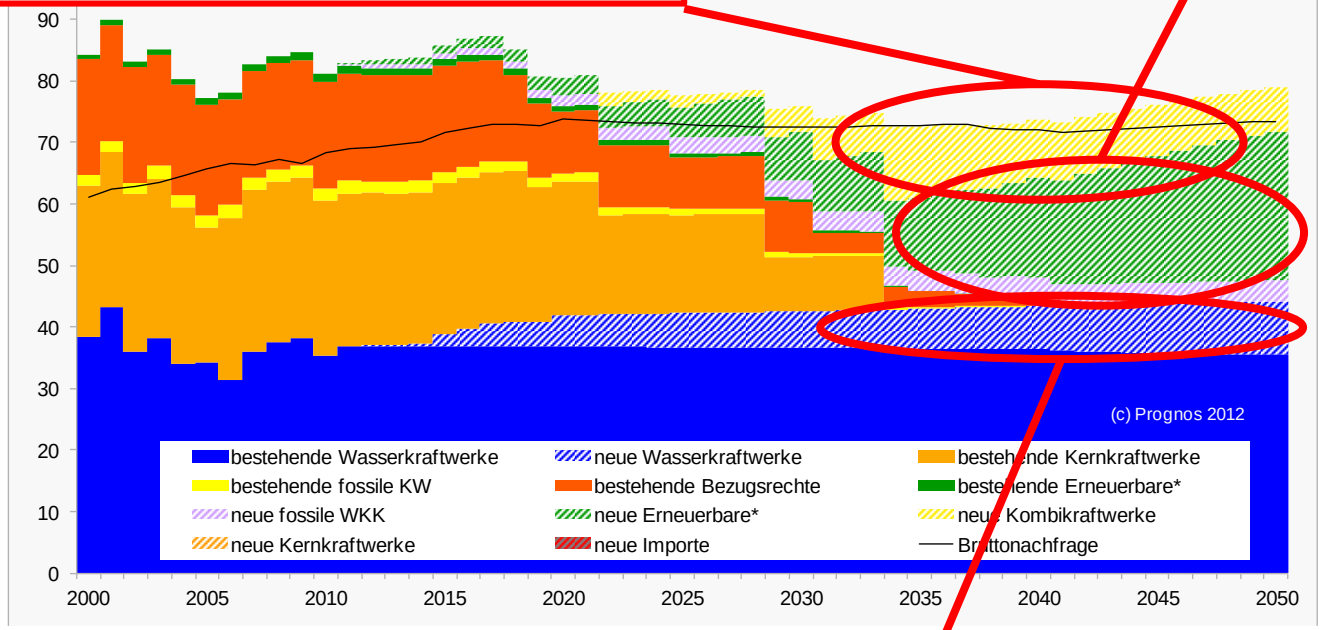
Sion, September 12, 2016

**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 ?

# Structure Phase 1

## Deep Geothermal Energy & CO2 Sequestration

### WP1 Geo-energies

T1.1 Resource exploration, assessment and characterization
T1.2 Reservoir modeling and validation
T1.3 P&D for reservoir creation
T1.4 Geo-data infrastructure

## HydroPower: usage & infrastructure

### WP2 Hydropower

T2.1 Morphoclimatic controls of future HP production
T2.2 Socio-economic drivers of future HP production
T2.3 HP infrastructure adaptation
T2.4 Environmental impacts of future HP operating conditions
T2.5 Integrated simulation of HP systems operation

### WP3 Innovative technologies

T3.1 Geo-energy technologies
T3.2 Hydraulic machines

### WP4 Integrative activities

T4.1 Risk, safety and societal acceptance
T4.2 Global observatory of electricity resources
T4.3 SCCER-SoE modeling facility

### Capacity building, Technology Transfer, Outreach

# Evaluation 2015

Evaluation 2015 very positive for SCCER-SoE and NFP70

Key points raised:

- Focus more stringently on the quantitative targets of the ES2050 and envisage concrete, substantial contributions
- Strengthen the collaboration with the interested industry
- Energy turnaround is a huge venture affecting the whole society, think big and not in incremental improvements
- Reopen technology portfolio
- Clear TRL track for GE technologies, as for HP
- Expand training activities
- Collaboration and joint activities with other SCCERs
- Integrate PV, WP and Bioenergy in energy system modeling
- Calibrate focus on SHPP
- Include risk analysis and safety for LHPP
- Push for P&D

# SCCER-SoE Phase 2

The Phase 2 SCCER-SoE proposal, covering the period 2017-2020, was submitted on March 30, 2016, with the following objectives:

- Expand scope and reach
- Maintain the funding level of 2016-2017
- New emphasis on P&D projects
- Innovation update
- Expand KTT
- Risk analysis
- Develop Joint Activities across SCCERs
- Beyond 2020
- Propose 80% and 120% scenarios, in addition to the 100% baseline

- **The proposal has been (very) positively evaluated, the 100% scenario is confirmed and 2 Joint Activities have been approved !**

# SCCER-SoE P2: expanded scope, 1

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

- A wider perimeter of the Geo-Energies, 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

# SCCER-SoE P2: expanded scope, 2

- A clearer focus of the innovation agenda (WP3), now including innovative technologies (T3.1) and computational energy innovation (new T3.2, formerly T4.3), 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 (new T4.3, expanded from former T2.4)
- A new SCCER Joint Activity on *Scenario and Modeling* (new 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*, with CREST (Lead) and SCCER-SoE.

# SCCER-SoE P2: expanded scope, 3

- 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; dedicated resources as part of the Phase II budget will be devoted to P&D project management:

  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*

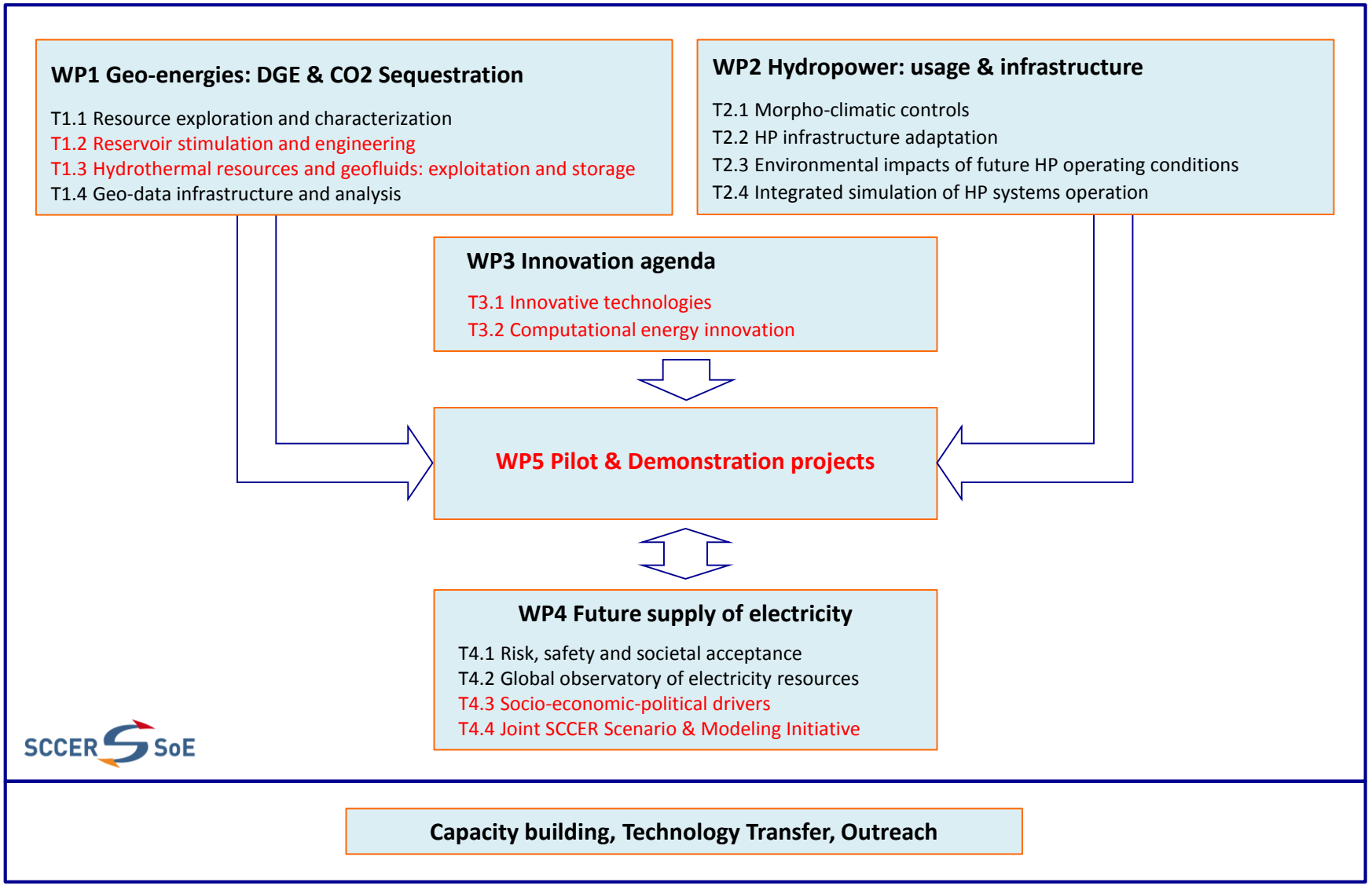
  Demo-4: CO2 geological storage pilot, *ETHZ, EPFL, UniGe, UniGE*

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

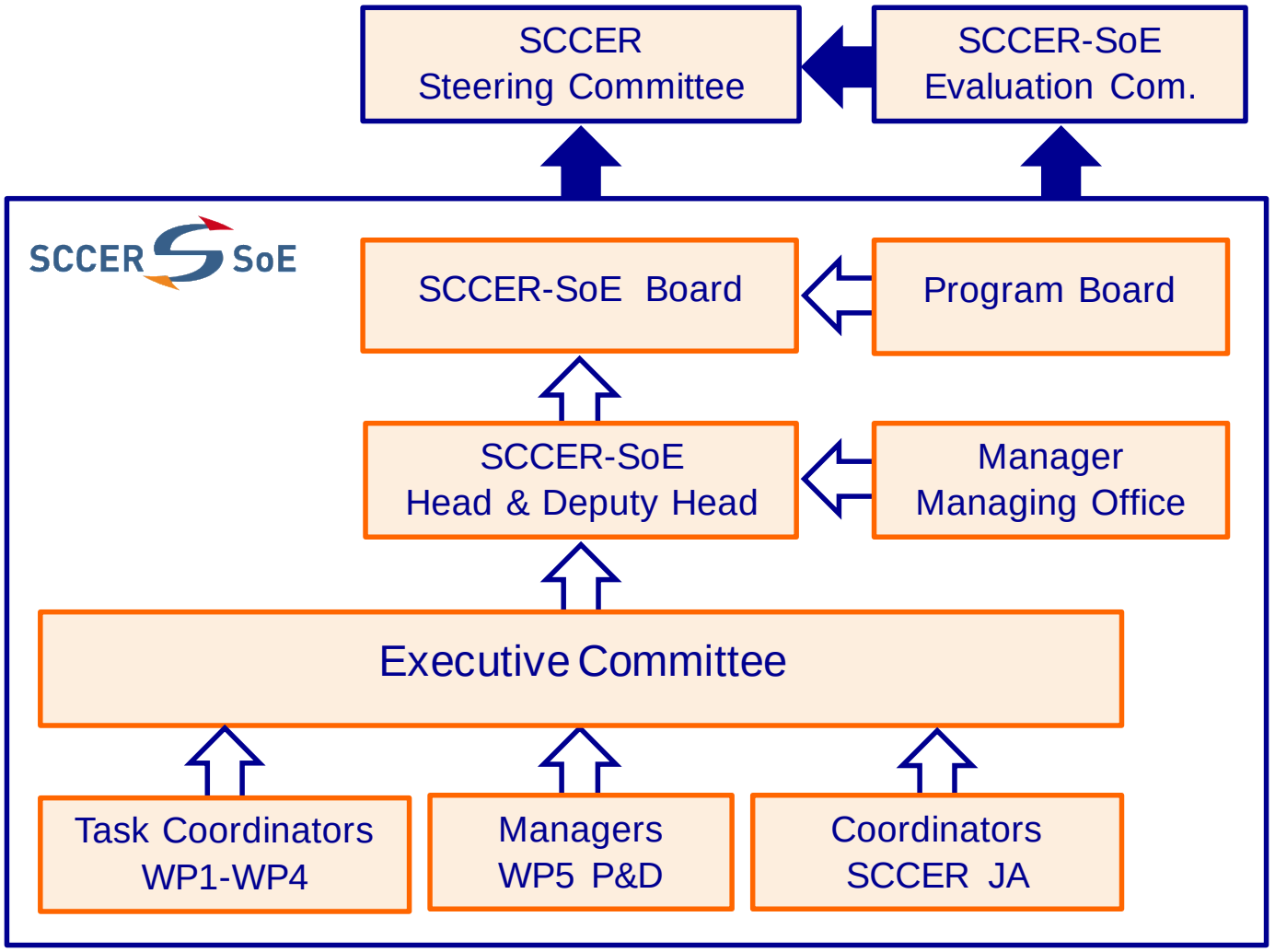
  Demo-6: Controlled fine sediment release from a reservoir by a hydrodynamic mixing device, *EPFL, WP2*

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

# SCCER-SoE P2: expanded architecture



# SCCER-SoE P2: governance



# SCCER-SoE P1: research partners






















# SCCER-SoE P2: 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
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SULZER

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esr
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avec nous vous êtes bien chez vous.

UNIVERSITÉ DE GENÈVE

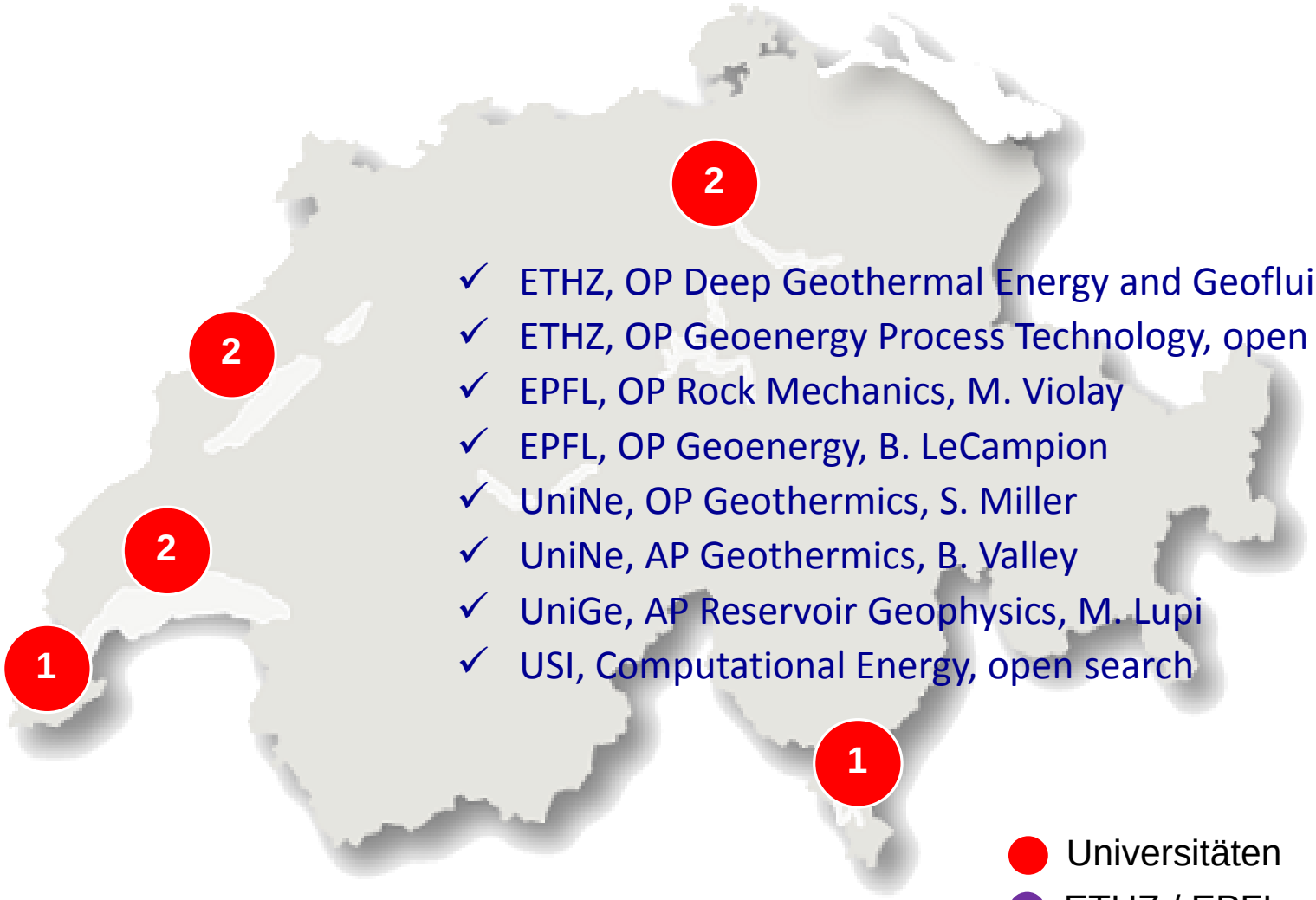
Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN

WSL

ALPIQ

groupe e

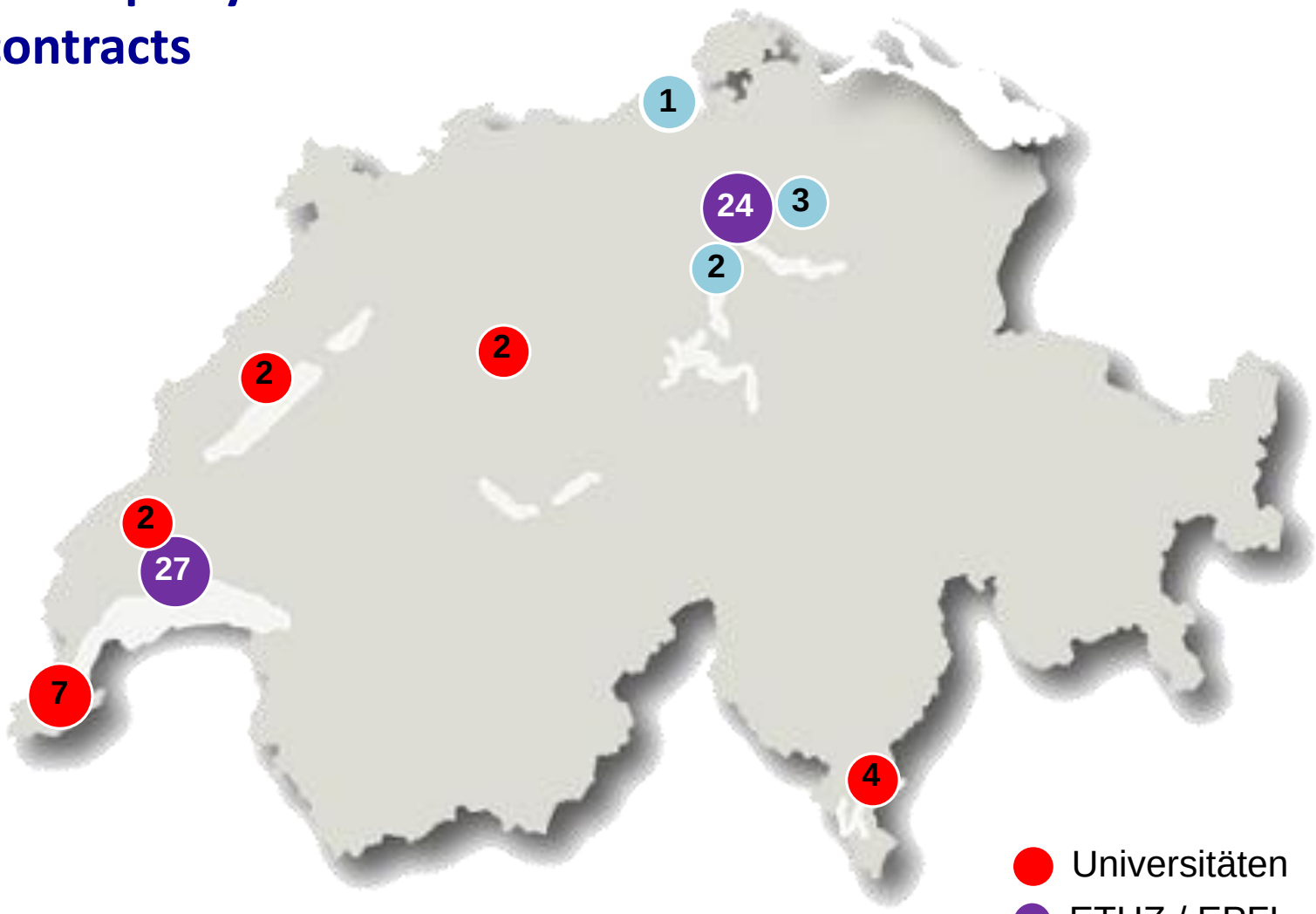
# SCCER-SoE: 8 new AP and OP in Geo-Energies



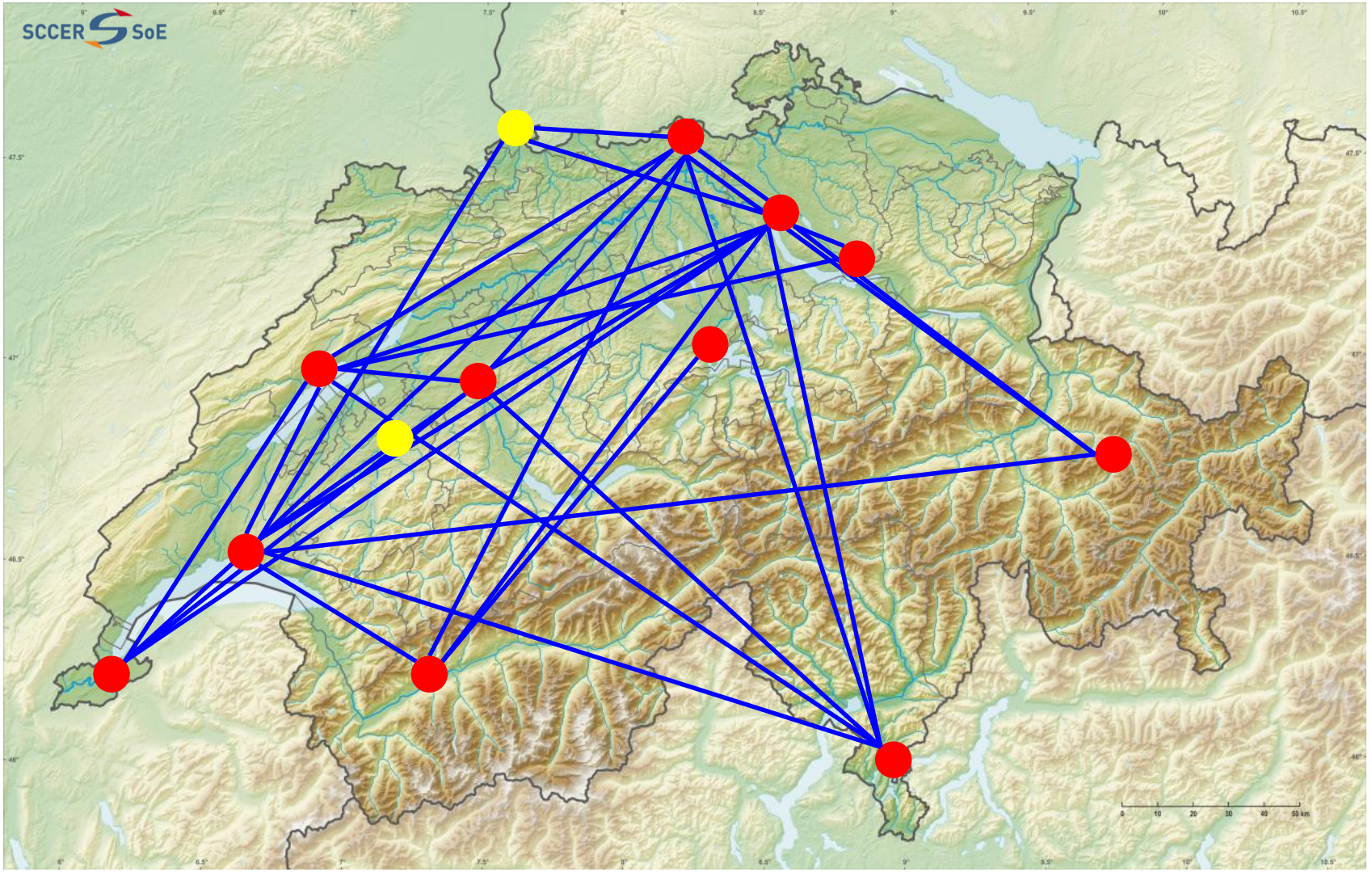

- ✓ ETHZ, OP Deep Geothermal Energy and Geofluids, M. Saar
- ✓ ETHZ, OP Geoenergy Process Technology, open search
- ✓ EPFL, OP Rock Mechanics, M. Violay
- ✓ EPFL, OP Geoenergy, B. LeCampion
- ✓ UniNe, OP Geothermics, S. Miller
- ✓ UniNe, AP Geothermics, B. Valley
- ✓ UniGe, AP Reservoir Geophysics, M.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

- Universitäten
- ETHZ / EPFL
- Forschungsanstalten

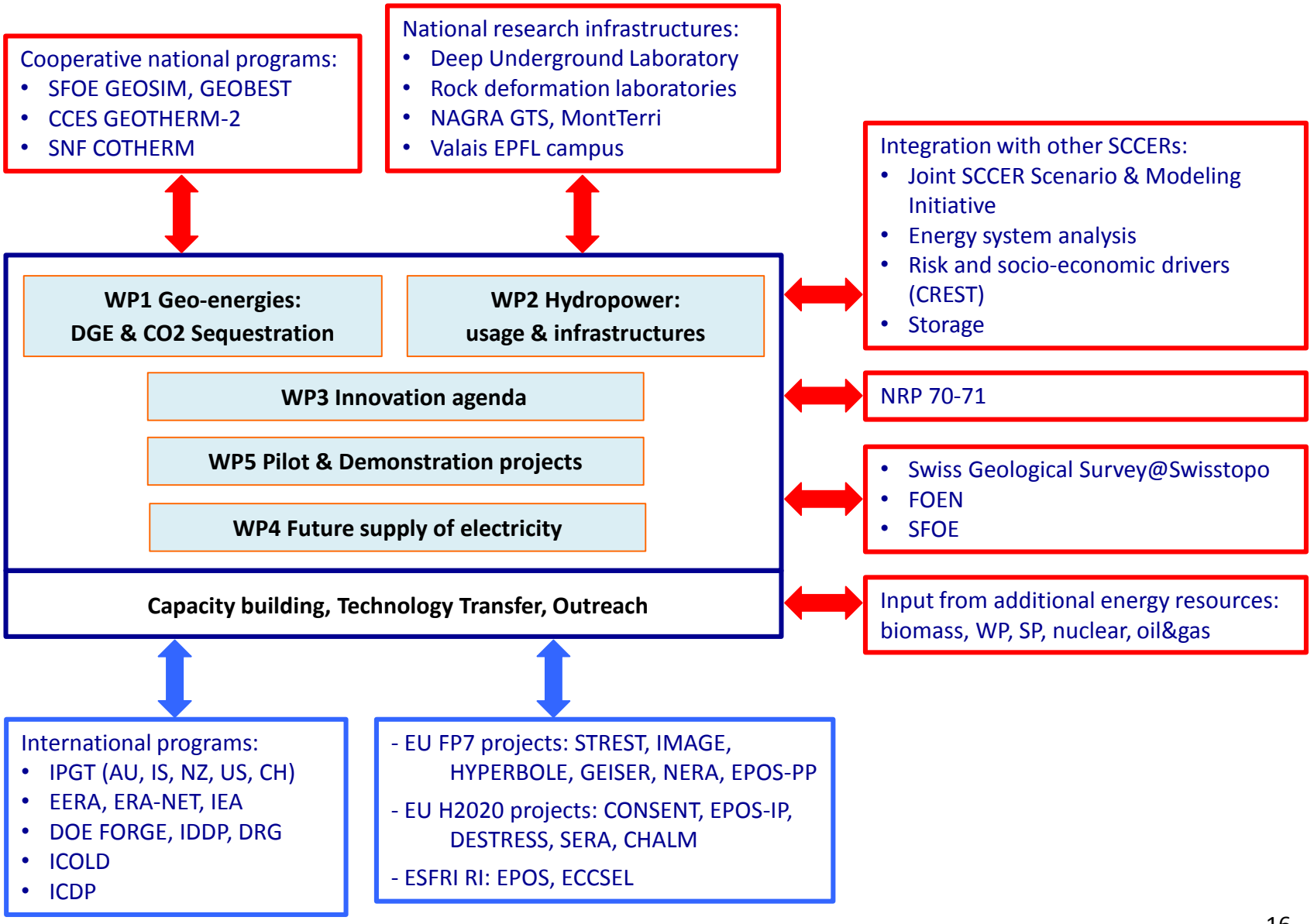
# SCCER-SoE: 74 PhD students on 3rd party and other contracts



# Networking



# Integration



# 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

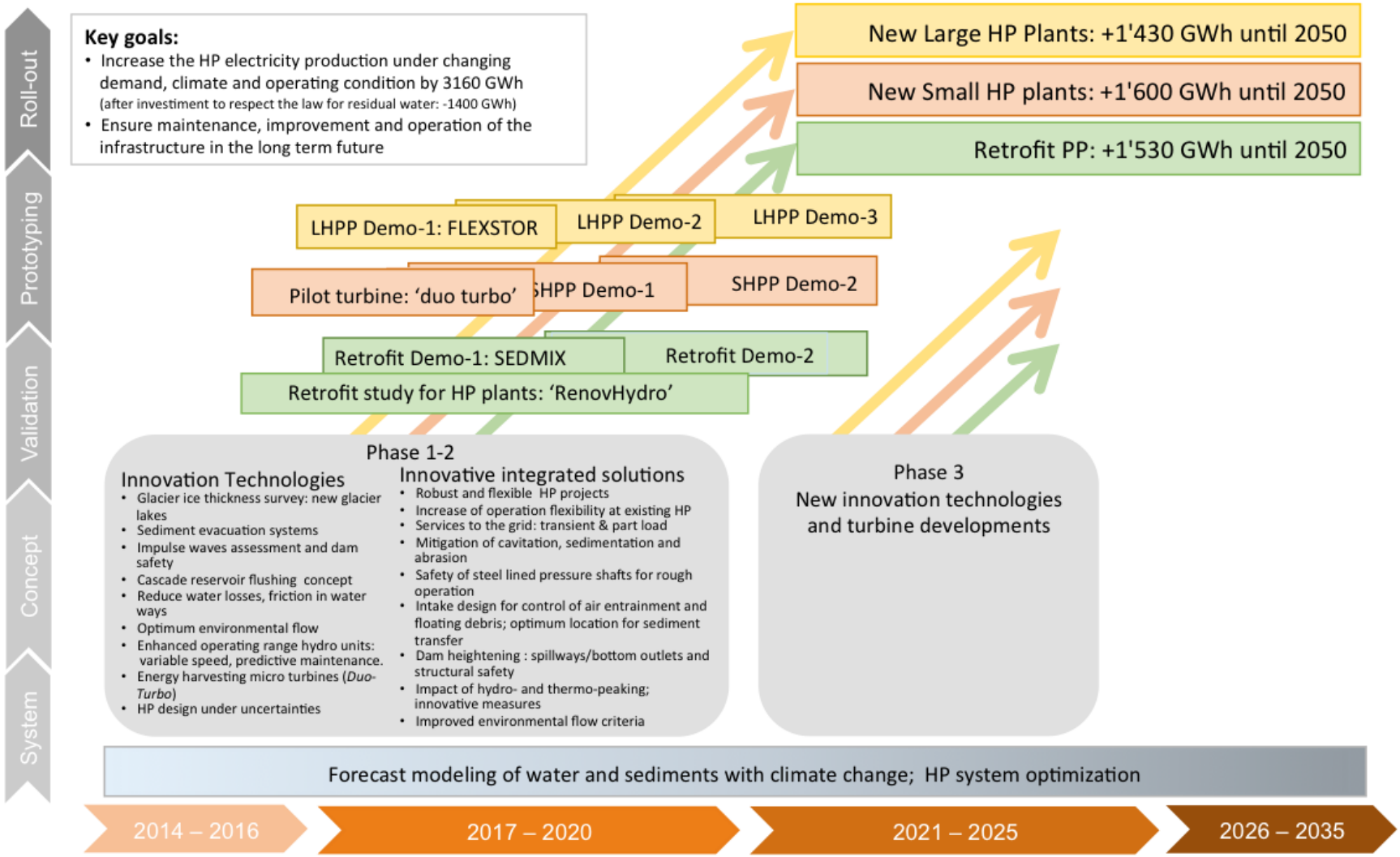
2014 – 2016 | 2017 – 2020 | 2021 – 2025 | 2026 – 2035

**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-SoE P2: budget and positions

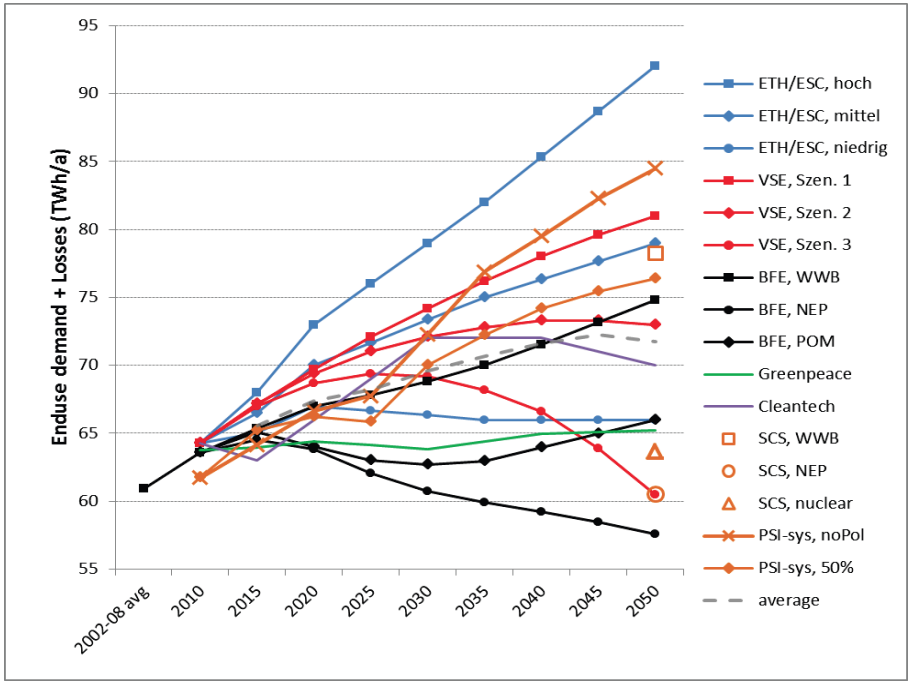
| SCCER-SoE Phase II: Summary of budget and personnel on SCCER KTI contract | | | | | | | Scenario 100% (2016 value) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **School** | **Positions** | **SR** | **JR** | **AP** | **PI** | **OP** | **2017** | **2018** | **2019** | **2020** | **4 yr** | **2016** |
| UNIBE | 1 SR | 1 | | | | | 150 | 150 | 150 | 150 | 600 | 150 |
| UNIGE | AP Fluid Dynamics in Basins + 0.5 P&D manager | 0.5 | | 1 | | | 210 | 210 | 180 | 180 | 780 | 200 |
| UNIL | 1 JR | | 1 | | | | 100 | 100 | 100 | 100 | 400 | 100 |
| UNINE | AP Geothermics | | | 1 | | | 220 | 160 | 160 | 160 | 700 | 200 |
| USI | AP Computational Energy | | | 1 | | | 100 | 160 | 160 | 160 | 580 | 100 |
| **Total Universities** | | **1.5** | **1** | **3** | | | **780** | **780** | **750** | **750** | **3,060** | **750** |
| ETHZ | WP1 (1.6SR+ JR), WP2 (1.2SR+2JR), WP3 (1JR), WP4 (3SR+1JR), WP5 (1 P&D manager), 30% OP 2019-20 | 7 | 6 | | | 0.3 | 1,540 | 1,540 | 1,600 | 1,600 | 6,280 | 1,550 |
| EPFL | HP & modelling (3.1 JR), WP5 (1 P&D manager), geosciences (1.5 JR) | | 5.6 | | | | 550 | 550 | 520 | 520 | 2,140 | 550 |
| PSI | 1.7 JR | | 1.7 | | | | 170 | 170 | 200 | 200 | 740 | 168 |
| EAWAG | 0.8 SR | 0.8 | | | | | 120 | 120 | 90 | 90 | 420 | 120 |
| WSL | 1.7 JR | | 1.7 | | | | 170 | 170 | 170 | 170 | 680 | 168 |
| **Total ETH** | | **7.8** | **15.0** | | | **0.3** | **2,550** | **2,550** | **2,580** | **2,580** | **10,260** | **2,556** |
| HES-SO | 10% 2 PI + 1.5 JR + 0.5 P&D manager | | 2 | | 0.2 | | 240 | 240 | 240 | 240 | 960 | 240 |
| HSR | 0.5 JR | | 0.5 | | | | 50 | 50 | 50 | 50 | 200 | 50 |
| HSLU | 0.8 JR | | 0.8 | | | | 75 | 75 | 75 | 75 | 300 | 100 |
| **Total UAS** | | | **3.3** | | **0.2** | | **365** | **365** | **365** | **365** | **1,460** | **390** |
| **Total capacity building incl. 15% overhead** | | | | | | | **4,250** | **4,250** | **4,250** | **4,250** | **17,000** | **4,250** |
| Administration/management | | | | | | | 300 | 300 | 300 | 300 | 1,200 | 300 |
| **TOTAL SCCER-SoE** | | **9.3** | **19.3** | **3.0** | **0.2** | **0.3** | **4,550** | **4,550** | **4,550** | **4,550** | **18,200** | **4,550** |
| Cost key: Senior Researcher (SR), 150k; Junior Researcher (JR), 100k; Assistant Professor (AP), 150k; PI (AUS, FA), 200k; Full Professor ETH (OP), 300k | | | | | | | | | | | | |

# SCCER-SoE P2: meeting the targets

| | Proposal Phase 1 | Financial report 2015 | | | | | | Budget 2017 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B+C+D | A SCCER CTI | B competitive | C 3rd party | D own | B+C+D | Total | A SCCER CTI | B competitive | C 3rd party | D own | B+C+D | Total | B+C+D/A | f |
| **ETHD** | 7,877 | 2,947 | 2,548 | 2,030 | 3,578 | 8,156 | 11,103 | 2,933 | 2,550 | 2,100 | 3,530 | 8,180 | 11,113 | 2.8 | 1 |
| **UAS** | 724 | 449 | 282 | 281 | 264 | 827 | 1,276 | 420 | 285 | 350 | 264 | 899 | 1,319 | 2.1 | 2 |
| **UNI** | 2,282 | 854 | 715 | 281 | 1,736 | 2,732 | 3,586 | 897 | 715 | 500 | 1,704 | 2,919 | 3,816 | 3.3 | 3 |
| | 10,883 | 4,250 | 3,545 | 2,592 | 5,578 | 11,715 | 15,965 | 4,250 | 3,550 | 2,950 | 5,498 | 11,998 | 16,248 | 2.8 | |
| | | | | | | | | 26 | 22 | 18 | 34 | % of total | | | |
| | | | | | | | | | 84 | 69 | 129 | % of A | | | |
| | | | | | | | | max 40% | B/A > 50% | C/A > 50% | D/A > 50% | % criteria | | | |

# SCCER JA on Scenario & Modeling

- Each SCCER conducts scenario modeling in its field and has dedicated personnel in its program.
- In Phase II, targeted scenario modeling will be continued in each SCCER and we aim at building an overarching initiative that will enable further developing and combining different models while preserving the specificity of the individual approaches.
- All SCCER equally involved, with SCCER-SoE lead



Energiewende
Nationales Forschungsprogramm NFP 70

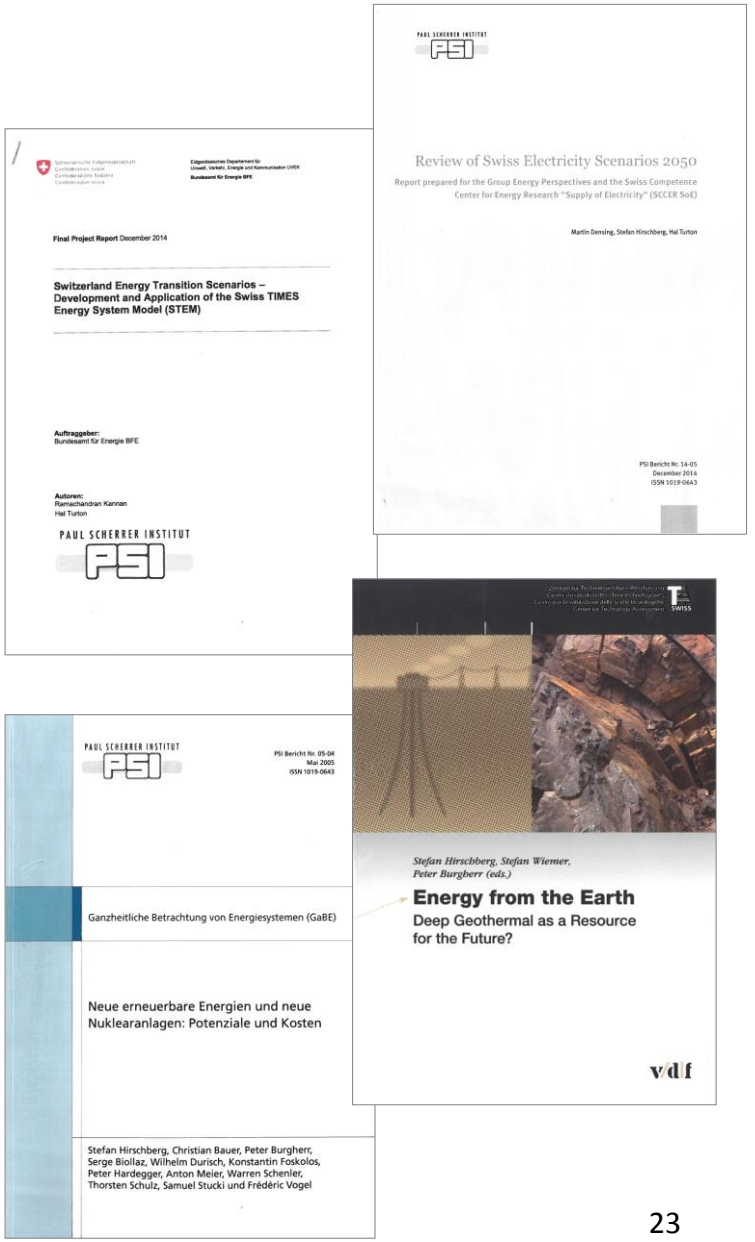
SCCER SoE

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)

# KTT

- ✓ *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 2016



# PhD School @ Grimsel, Oct 13-16, 2015

SCCER SoE

- 43 PhD students
- 28 teachers
- 2 excursions: GTS, KWO


→ PhD School @ Leukerbad, Oct 18-21, 2016

# Annual Conference 2015

- ✓ Highly successful: 130 participants for HP, 140 for DGE
- ✓ Interaction with stakeholders: industry, federal offices, policy makers
- ✓ 120 posters, the basis for the SCCER-SoE Science Report 2015


- ➢ **The Annual Conference 2016 promises to be even more successful !**