SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Annual Conference 2019

Prof. Domenico Giardini, Head SCCER-SoE

EPFL, Lausanne

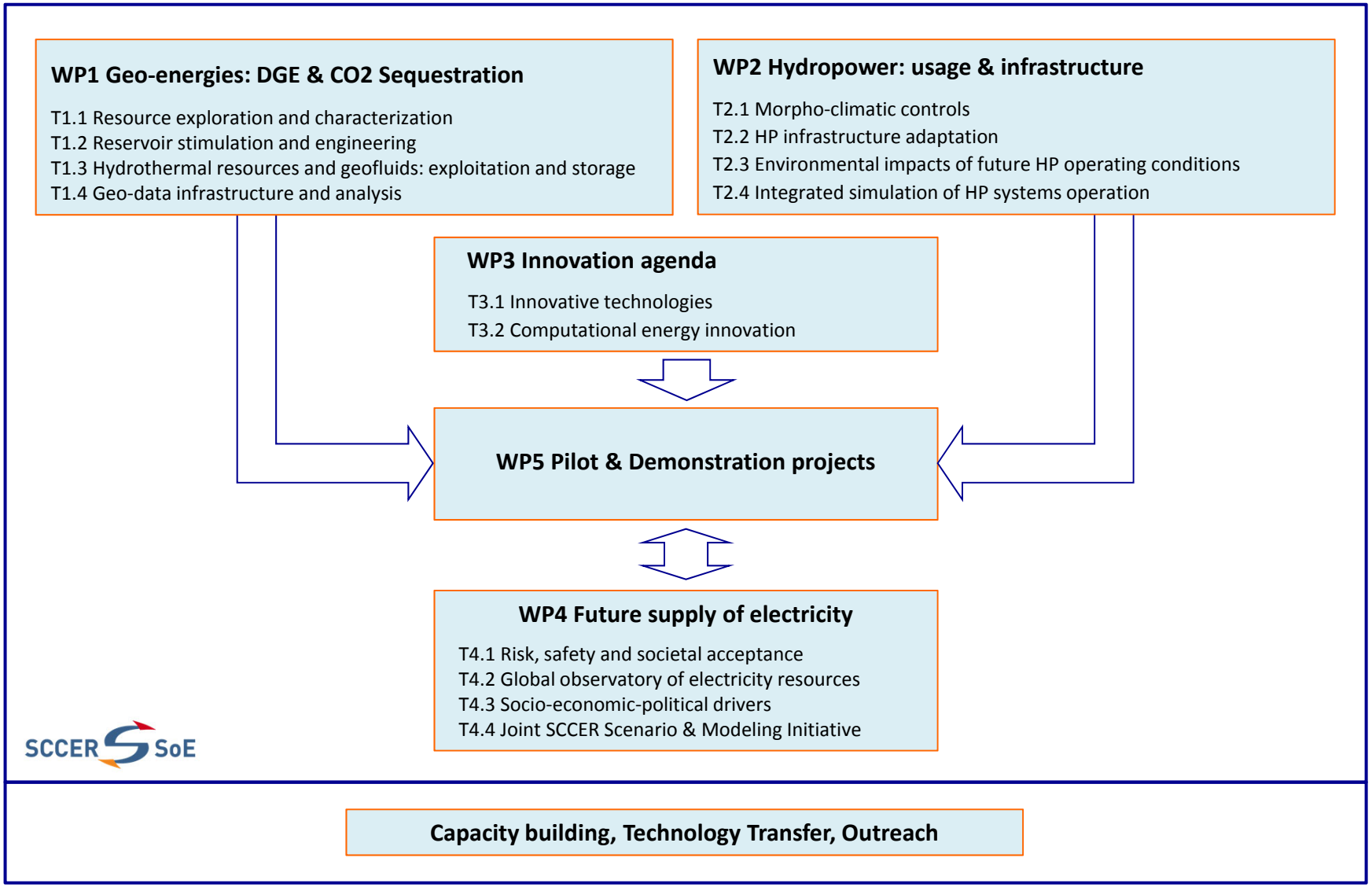
3-4 September 2019

Energy funding programme
Swiss Competence Centers for Energy Research

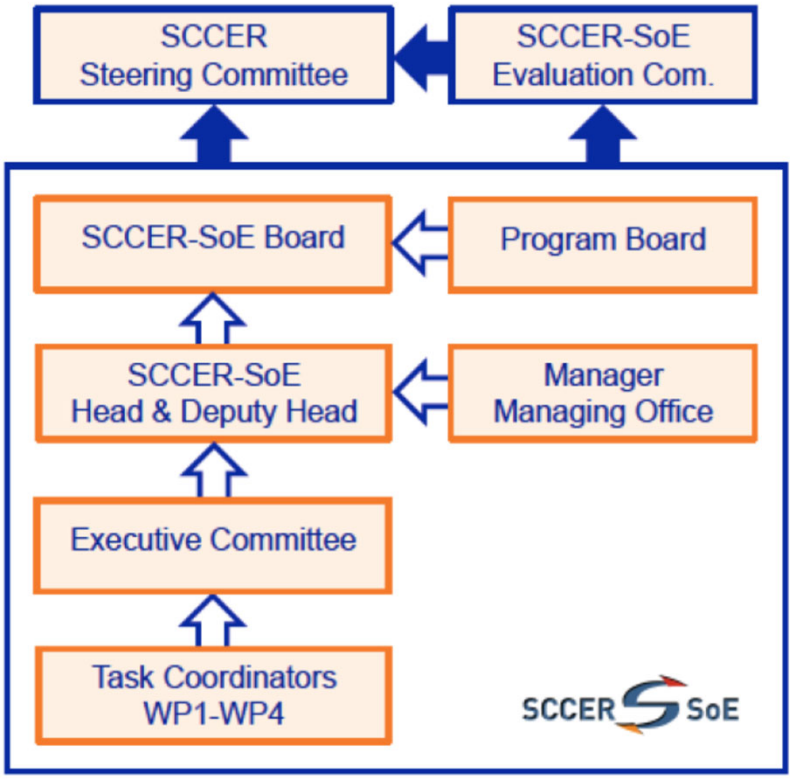
Annual conferences

- ✓ 2015 Neuchatel (Uni); 2016 Sion (HESSO); 2017 Birmensdorf (WSL); 2018 Horw (HSLU)
- ✓ Highly successful, each with almost 200 participants
- ✓ Interaction with stakeholders: industry, federal offices, policy makers
- ✓ Science presented in posters and invited presentations
- ✓ Annual Science Reports as outcome

Phase 2 architecture



Governance



Head: Prof. D. Giardini, ETHZ

Deputy Head: Prof. F. Avellan, EPFL

Program Manager: Gianfranco Guidati, ETHZ

KTT Officer: U. Wieland → G. Guidati, ETHZ

Outreach: Barbara Nägeli, ETHZ

Task 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:

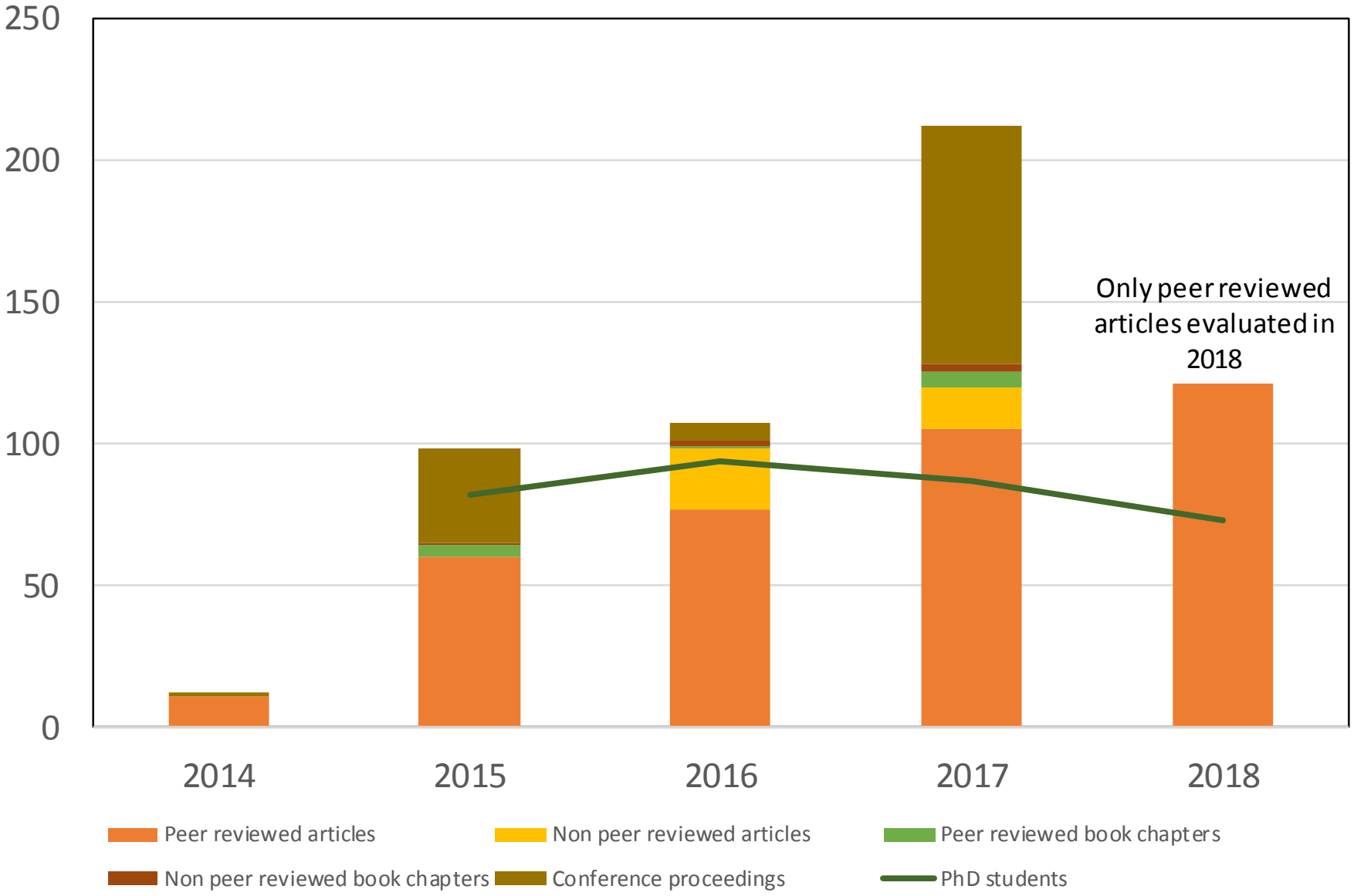
- WP1: Prof. Lyesse Laloui (EPFL)
- WP2: Prof. Robert Boes (ETHZ)
- WP3: Prof. C. Münch-Alligné (HES-SO)
- WP4: Dr. P. Burgherr (PSI)
- WP5: Prof. A. Moscariello (UNIGE)

SCCER-SoE research partners

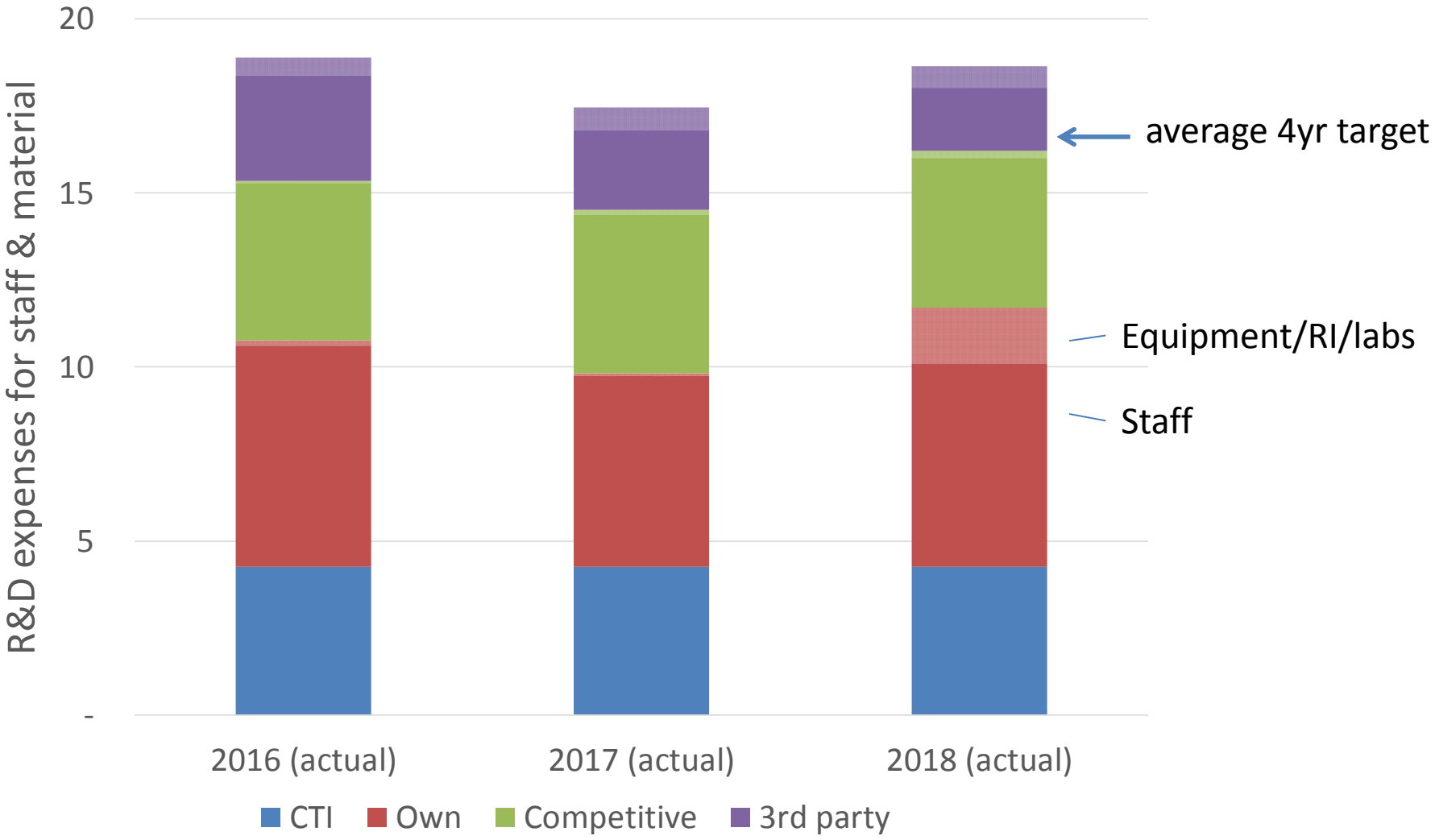
Capacity building

	2018	2017	2016	2015
Personnel SCCER-SoE				
Head count (HC) researchers incl professors	229	226	247	240
HC researchers w/o professors	199	194	218	
Full time employee (FTE) without professors	152	150	171	
Percentage of female researchers	26%	26%	22%	
PhD students				
Head count	70	87	94	82
Percentage of female PhDs	35%	28%	28%	27%
Participation at the PhD school		160	50	43

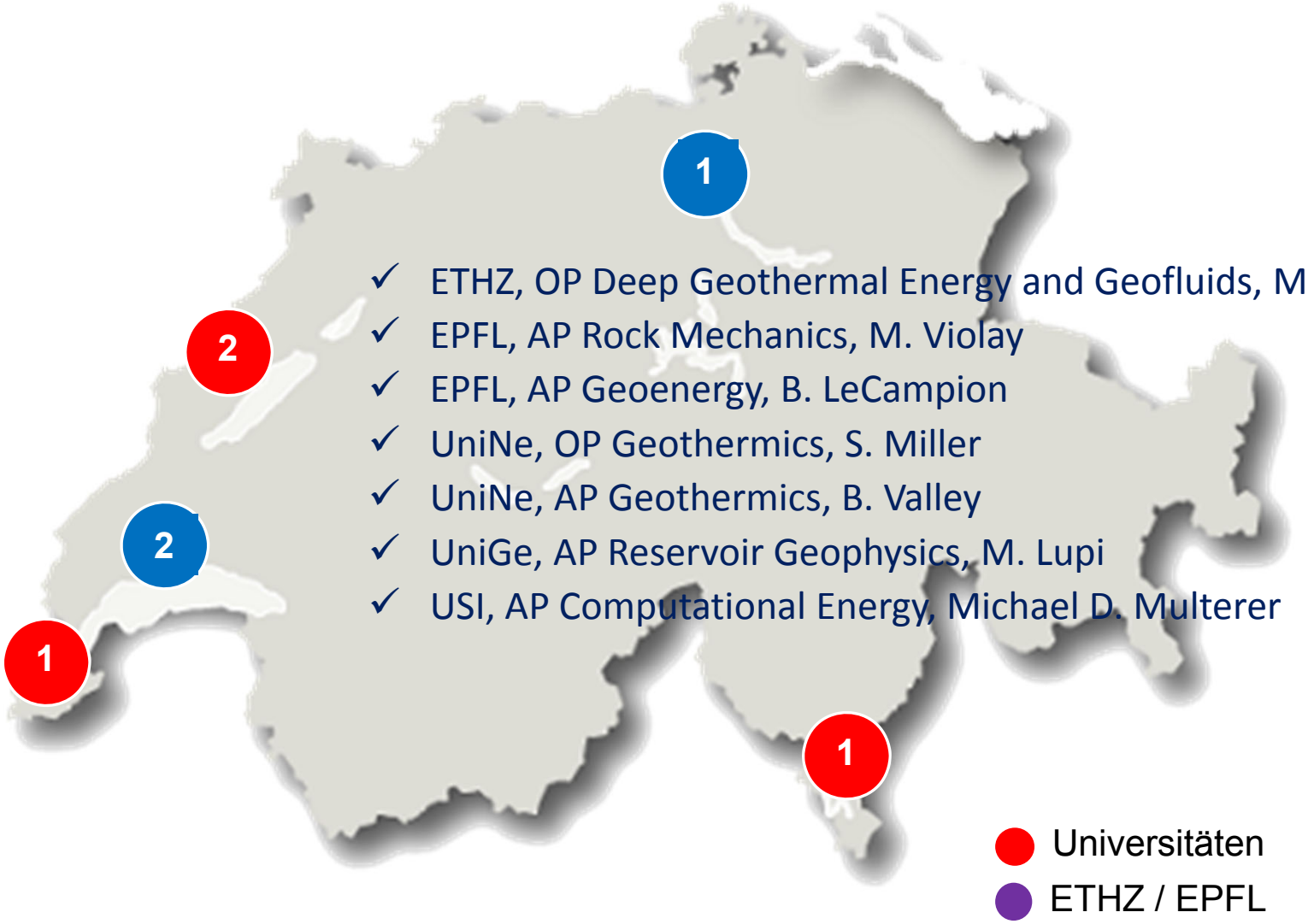
Publications & PhD students



Financial status 2018



SCCER-SoE: 7 new AP and OP in Geo-Energies



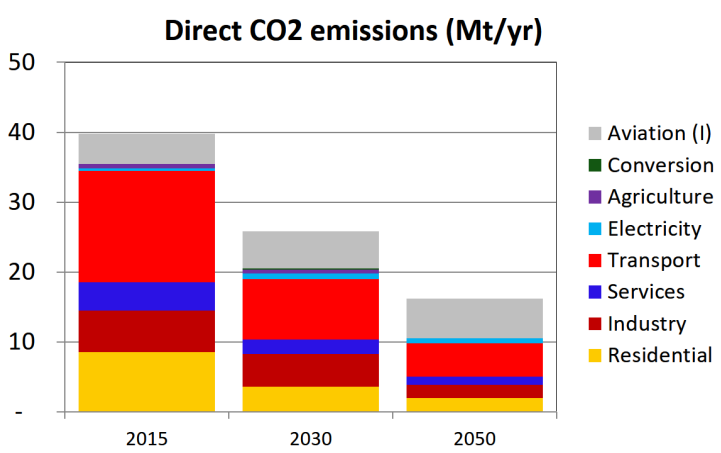
- ✓ ETHZ, OP Deep Geothermal Energy and Geofluids, M. Saar
- ✓ EPFL, AP Rock Mechanics, M. Violay
- ✓ EPFL, AP Geoenergy, B. LeCampion
- ✓ UniNe, OP Geothermics, S. Miller
- ✓ UniNe, AP Geothermics, B. Valley
- ✓ UniGe, AP Reservoir Geophysics, M. Lupi
- ✓ USI, AP Computational Energy, Michael D. Multerer

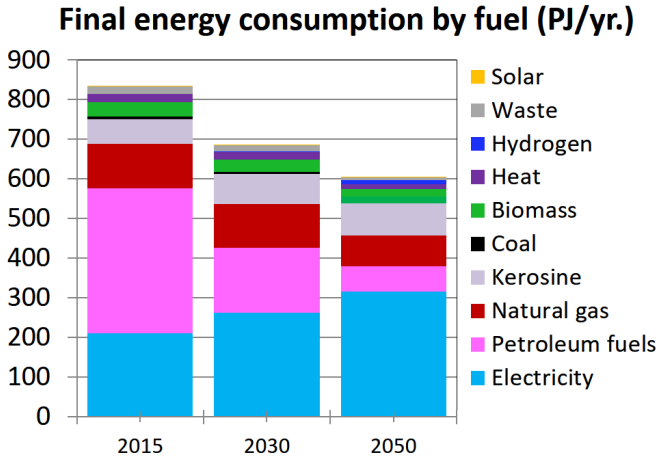
Milestone status Phase II (2018)

Code	Description
M.T11.1	Conventional data analysis and interpretation of Grimsel analogue site completed
M.T11.2	Prototype methodological framework for geophysical estimation of fracture transmissivity and for constraining fracture connectivity
M.T11.3a	Finalize analyses of drill core, borehole geophysical logs and seismic surveys of deep aquifers beneath the Swiss Plateau for geothermal an
M.T11.3b	Complete case studies of advanced data analysis and interpretation based on these newly developed methodologies
M.T11.4	3D models of the aquifers available, start integration into Task 1.4 infrastructure and models
M.T12.1	New inter-institutional work-group on hydraulic stimulation established, joins/integrates theoretical studies and experimental rock mecha
M.T12.2	Numerical analysis of hydraulic stimulation and circulation data at Grimsel test site completed; concerted with Task 1.3: translate analysis
M.T12.3	Next generation of THM numerical simulation tool prototypes for hydraulic stimulation processes operational; milestone will be reached a
M.T12.4	Numerical studies of optimal heat extraction protocols from complexly fractured reservoirs completed
M.T12.5	Prototype integration of THM numerical simulation tools with industry software for geometric/geologic reservoir model building complete
M.T13.1	Completion of reconnaissance prospecting phase and begin of detailed prospecting phase in Greater Geneva Basin
M.T13.2	Completion of detailed prospecting phase, transition to specific exploration projects, including drilling and characterization
M.T13.3	Completion of exploration and transition to implementation
M.T14.1	Completion of Swiss Geological Survey “GeoMol” 1:50,000 3D model
M.T14.2	Integration of GeoWatt thermal model into the 1:200,000 3D Framework Model
M.T14.3	Complete harmonization and integration of 1:50,000 regional partner models (e.g., Uni Geneva for Geneva Basin, in the course of Task 1.3
M.T14.4	Begin of development of National Geological Model “NGM” for online data access
M.T21.1	Methodology report for extension/upgrade of existing HPP projects in order that they can be used more efficient for grid regulation and hi
M.T21.2	Final concept of synthesis report on CC impact and workplan is approved by stakeholders and available
M.T21.3	Synthesis report quantifying the change in Swiss mean annual and seasonal (e.g. winter-time) and extreme weather HP production for 203
M.T22.1	Computation manual how to assess landslide-generated impulse waves in reservoirs is available
M.T22.2	Methodology report for robust and flexible design of hydropower projects is available
M.T22.3	Report on successful sediment flushing procedures in reservoir cascades is available
M.T24.1	Report on re-optimized HP role in different portfolios of electricity production sources is available
M.T31.Aa	Mapping of requirements and recommendations to operate HPP – large or small – from 0% to 100% is available
M.T31.Ab	RenovHydro tool allowing to assess scenarios and optimize HPP renovation scheme reach TRL 6
M.T31.Ac	Method to assess the remaining lifetime of ageing hydraulic component for maintenance optimisation
M.T31.B	Smart Operation Strategy for Pools of Small HPP reach TRL 5 (ready to implement in Demo 5)
M.T31.C	Innovative technologies for energy harvesting in existing infrastructure (both open channels and pressurized networks, total Swiss potentia
M.T31.D	Modelling tools developed to calculate near real time the reservoir while stimulating
M.T31.E	Improve the measurement performance and high pressure/high temperature compatibility of deep borehole seismometer demonstrator, i
M.T31.F	Development of 3-D constitutive relationships for rocks at high temperatures and high in situ stresses corresponding to borehole depths d
M.T32.Aa	Computational performance of FVPM simulation increased by a factor 8 compared to 2015
M.T32.Ab	Physical modelling of silt laden flow considers arbitrary silt shape and advanced material damage models
M.T32.Ba	Cavitation physics is implemented in FVPM code and validated with respect to lab benchmarks (TRL 4)
M.T32.Bb	Validation of new cavitation models with lab benchmark (TRL4)
M.T32.C	Development of new codes to model thermo-hydro-mechanical process during reservoir stimulation
M.T32.D	Software basis for near-real time risk assessment and reservoir characterization during reservoir stimulation
M.T41.1	Validation of the adaptive traffic light system for risk mitigation of induced seismicity for at least one geothermal P&D sites
M.T41.2	Improved best practice guidelines for risk governance in GeoEnergy application in CH
M.T41.3	Improved tools and methodology for risk assesment of hydro-dams (earthquake safety, landslides/impulse waves and the coupling betwee
M.T42.1	White paper reviewing and evaluating the contributions and actual implementation status of individual technologies compared to the goa
M.T42.2	Interactive Multi-Criteria Decision Analysis (MCDA) software tool for integrated sustainability assessment.
M.T42.3	Working version of (i) oligopolistic market model of Switzerland and the surrounding countries 12/2018 (ii) an algorithm on dispatch optin
M.T42.4	Evaluation of numerical results based on (i) market model with 24 hours’ time resolution and stochasticity 6/2020 (ii) multistage stochasti
M.T51	Completion of first stimulation experiment, DUGLab@GTS, Demo-1,
M.T52	Completion of drilling and EGS in Haute Sorne, Demo-2,
M.T53	Proven capability of hydrothermal heat extraction and storage, Geneva basin, Demo-3,
M.T54	Site identification, drilling and test injection for CO2 geological sequestration, Demo-4,
M.T55	Implementation of demonstrator "Small Hydropower Plant", Demo-5,
M.T56	Successful operation of demonstrator "Controlled fine sediment release from a reservoir by a hydrodynamic mixing device", Demo-6,
M.T57	Completion of demonstrator "Complex large hydropower scheme FLEXSTOR”, Demo-7,

SCCER JA: Scenario & Modeling

- First round of scenario completed
- Revision of input assumption ongoing
- Second round of scenarios presented at the 1st scenario benchmarking workshop on 17 Jan 2019 in Zurich





Preliminary results obtained with the STEM model (PSI) underline the importance of electrification of the heating and transport sector.

Energiewende
Nationales Forschungsprogramm NFP 70

SCCER SoE

NFP70 started in November 2014 and ingended in 2019, support PhDs for the SCCER-SoE implementation. Three cluster projects were 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)

Communication & Outreach

Additional activities:

- ✓ Web site with highlights, news, events
- ✓ Blog, 6/y, 1’500 readers
- ✓ Internal newsletter, 3/yr
- ✓ External newsletter, 3/yr, 400 recipients
- ✓ Brochure
- ✓ Media events
- ✓ Media releases

Thank you for the great support!

Evaluation 2018

(quotes from the evaluation report)

Evaluation 2018 very positive for SCCER-SoE:

→ The project develops in an incredible way. The number of personnel outperforms drastically the initially planned number and remains constant on rather high level since several years

→ Impressive number of peer-reviewed publications

→ The outstanding performance of the management on assembling major groups of international reputation in SCCER-SoE is a major key in the success of the project

→ The collaboration within the SCCER-SoE within the hydropower sector is efficient and well organized through official projects but also on a personal level.

→ The communication activities carried out during the reporting period are very good.

→ All over, SCCER-SoE has transformed the landscape of geothermal and hydropower energy re-search and innovation in Switzerland during the last 5 years.

Key points raised:

- Take care that the monitoring report is complete, e.g. thoroughly list all new projects that were acquired in the reporting period
- Focus on the real highlights in the monitoring report
- There is room for improvement when it comes to the approaches to conceptual risk governance particularly for the geothermal side
- SCCER-SoE could be more visible by participating at industry driven conferences

Requirements

Requirement	Due date	Status
Revision of KTT concept	01.10.2018	The main action for spreading the knowledge gained with the SCCER [illegible] organize targeted events with interested partners fr[illegible]es. This concept proved to [illegible]. Another effective means [illegible]national partners in joint research and demon[illegible]ation projects.
Strengthen the technology portfolio in WP3	In Phase II	After a clarification with the review team we understood that this is mostly a communication issue: Reporting should not focus too much on items with limited impact on the ES2050 goals.
Chart that links WPs to the goals of the SCCER	In Phase II	We believe that the link of the major projects in SCCER-SoE to the goals of the Energy Strategy 2050 is well described in the conclusions of the monitoring report. The hydro power project address the challenges of increased generation and flexibility (SmallFlex, Flexstor, Sedmix, Renovhydro), whereas the geothermal project address the full width of geoenergy options, i.e. electricity generation (soft hydraulic stimulation in Grimsel & Bedretto), heat storage & extraction (Geothermie2020, Heatstore), and CO2 storage (Elegancy).
Top innovation chart as a communication tool	In Phase II	We recognize the importance of communication, especially the proper identification of the target audience and the right means of conveying information. Therefore, SCCER-SoE is developing a concept for a public communication event linked to the 2019 annual conference.
More emphasize on social impact.	In Phase II	This subject is at the heart of the Joint Activity IDEA-HDG (Integrated Development of Renewable Energy and Acceptance: the Case of Hydropower and Deep Geothermal energy). Research groups of SCCER-SoE and SCCER-CREST are collaborating closely.

New KTT concept was accepted by Innosuisse

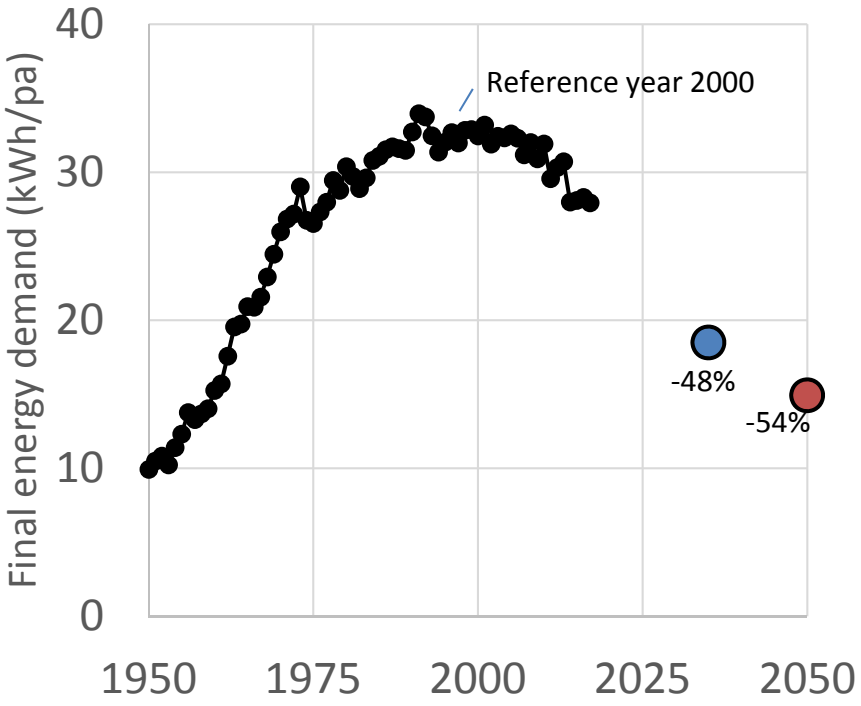
SCCER-SoE 2018

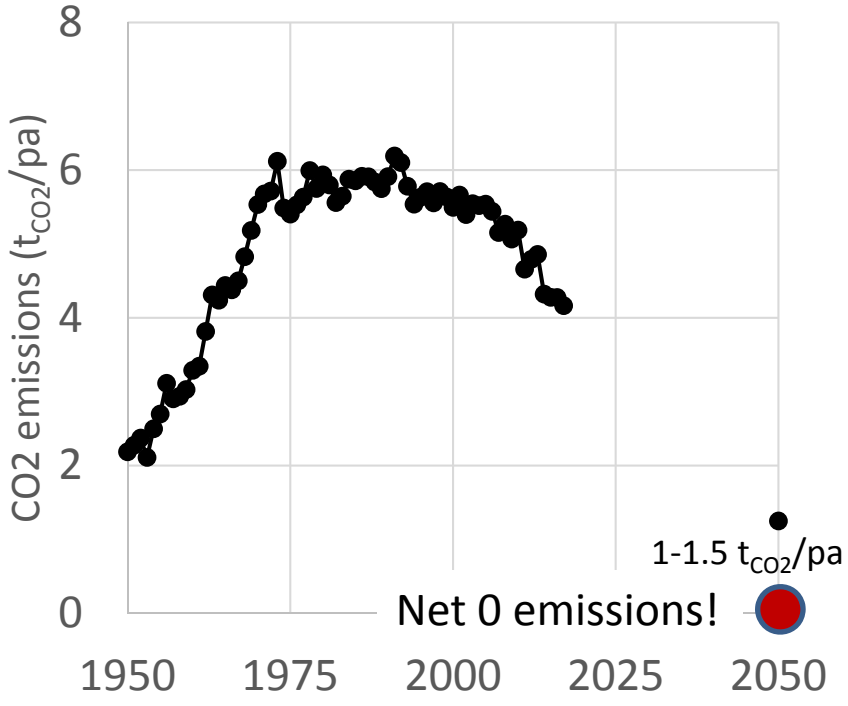
- ✓ Three battles we are loosing
  1. Switzerland is not meeting the ES2050 supply target trajectories
  2. Global warming and global energy transition
  3. Post-2020 continuation of the SCCER program uncertain

Decreasing energy consumption and CO2 emissions in Switzerland

Energy demand and CO2 emissions per person are decreasing with a positive trend visible since the late nineties, owing largely to

- increased efficiency in building sector (lower energy demand due to better isolations, heat pumps, etc)
- reduced emissions from industrial sector (de-industrialization?)
- some (small) progress on road transportation

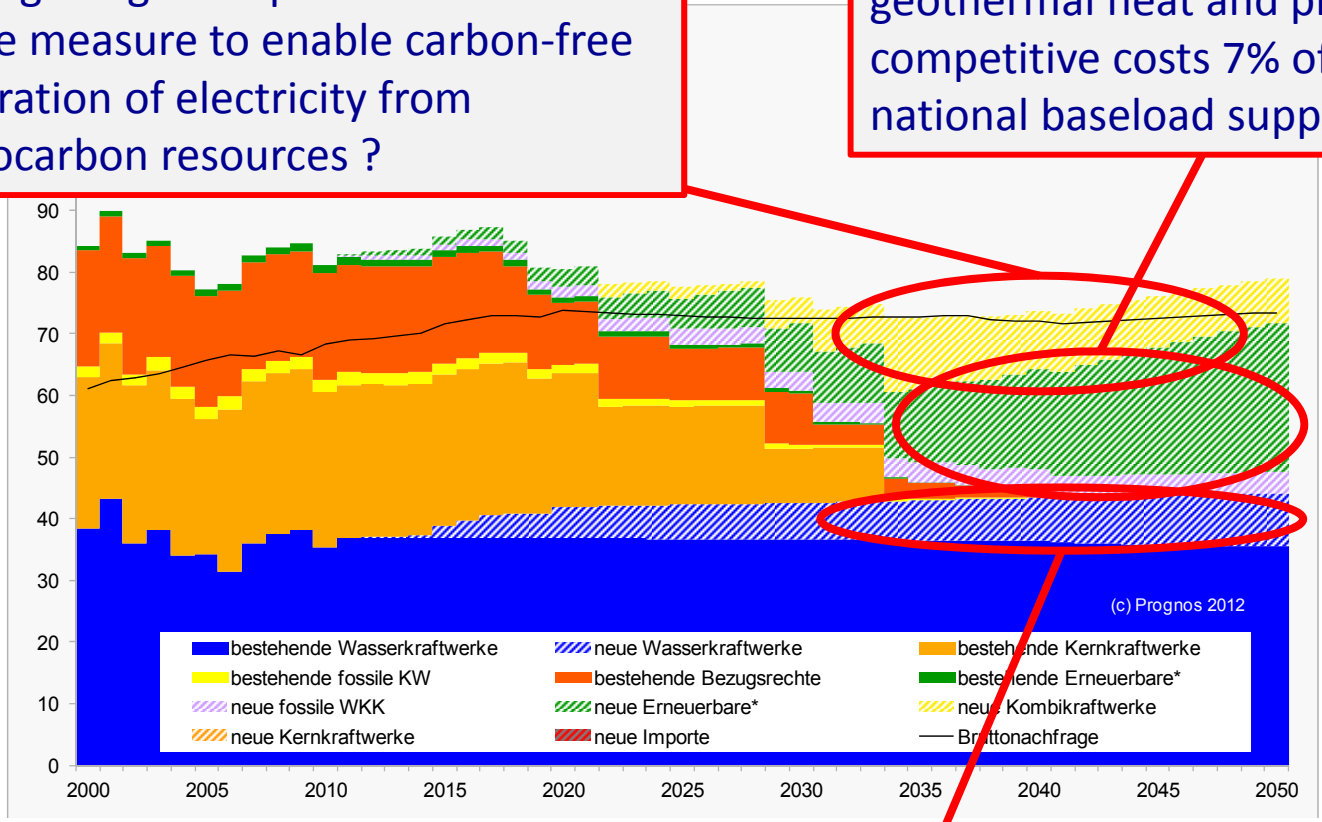




ES 2050: Targets for supply of electricity

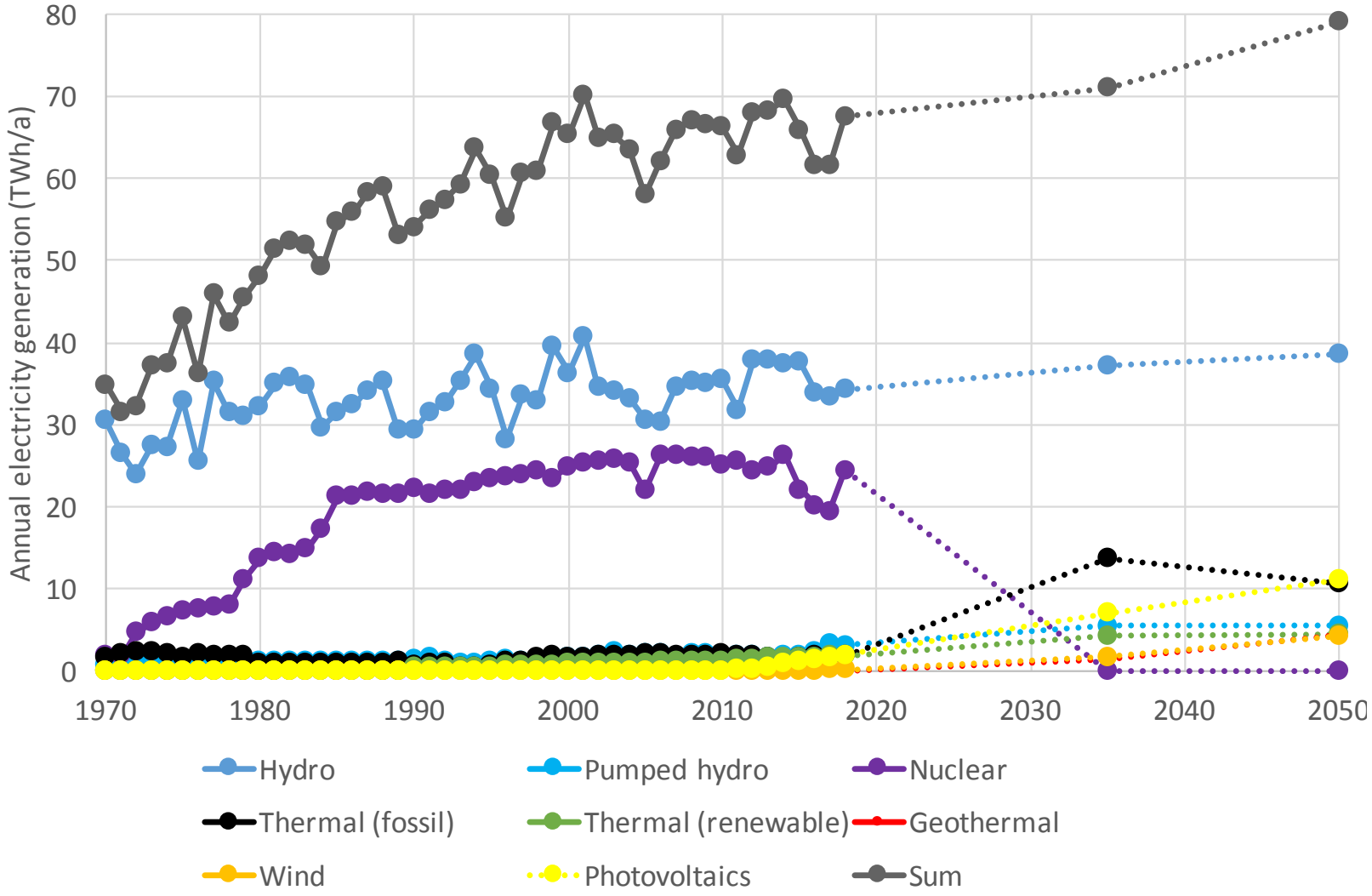
Is the geological capture of CO2 a viable measure to enable carbon-free generation of electricity from hydrocarbon resources ?

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



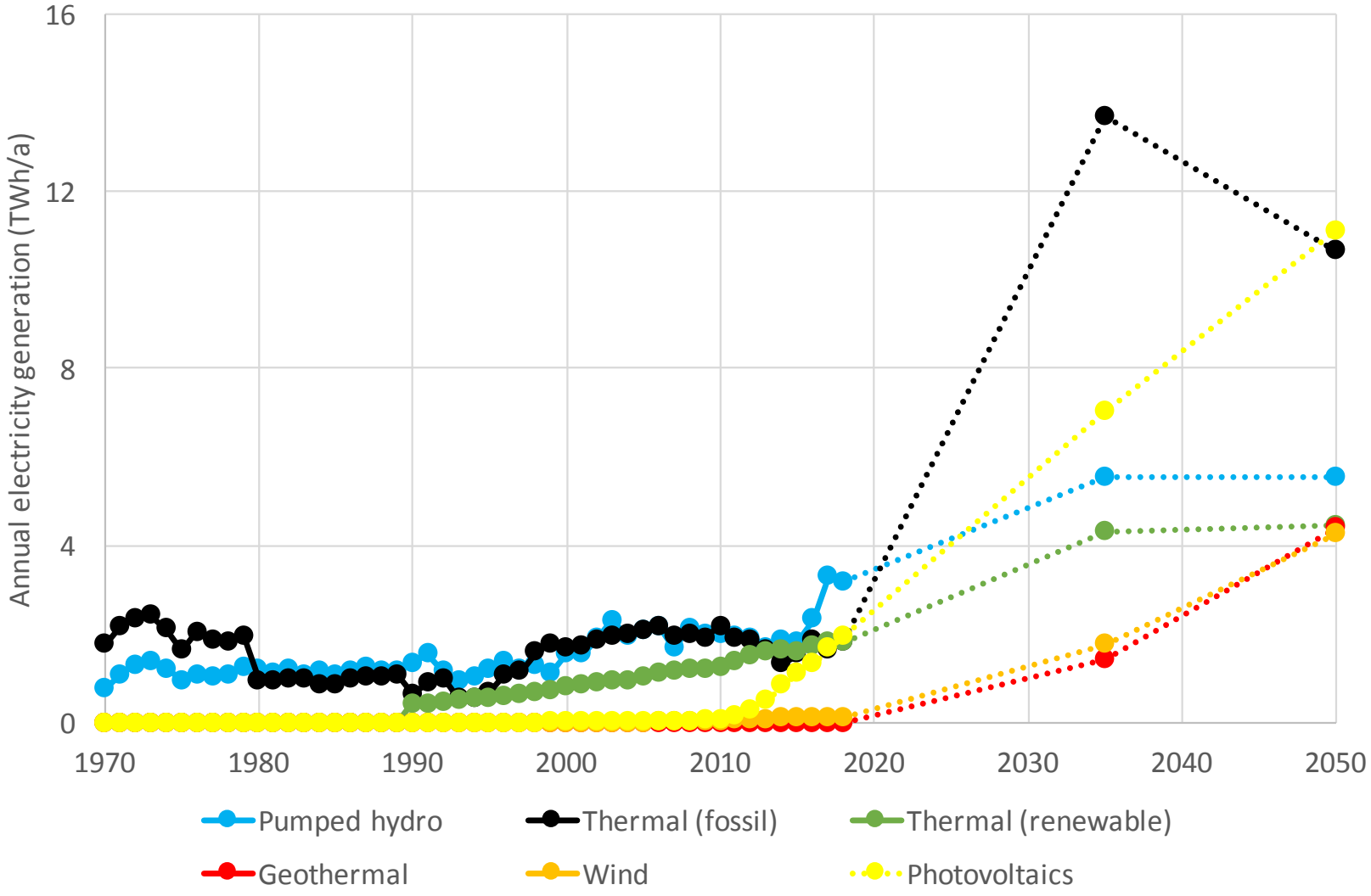
Can we increase (i.e. by 10%) the present hydropower electricity production under changing demand, climate and operating conditions ?

ES2050: are we meeting the targets?



Data from SFOE, 2019

ES2050: are we meeting the targets ?



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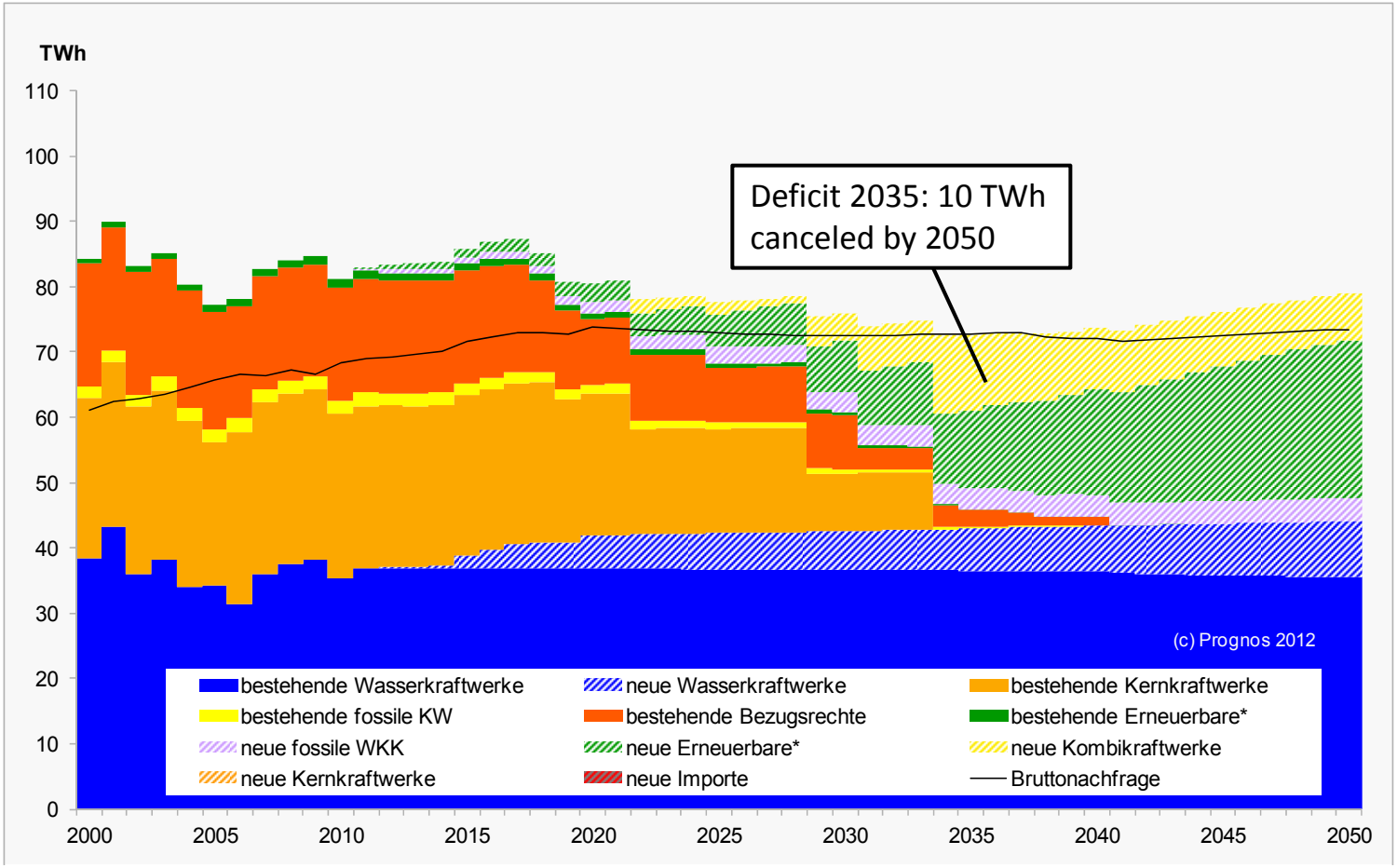
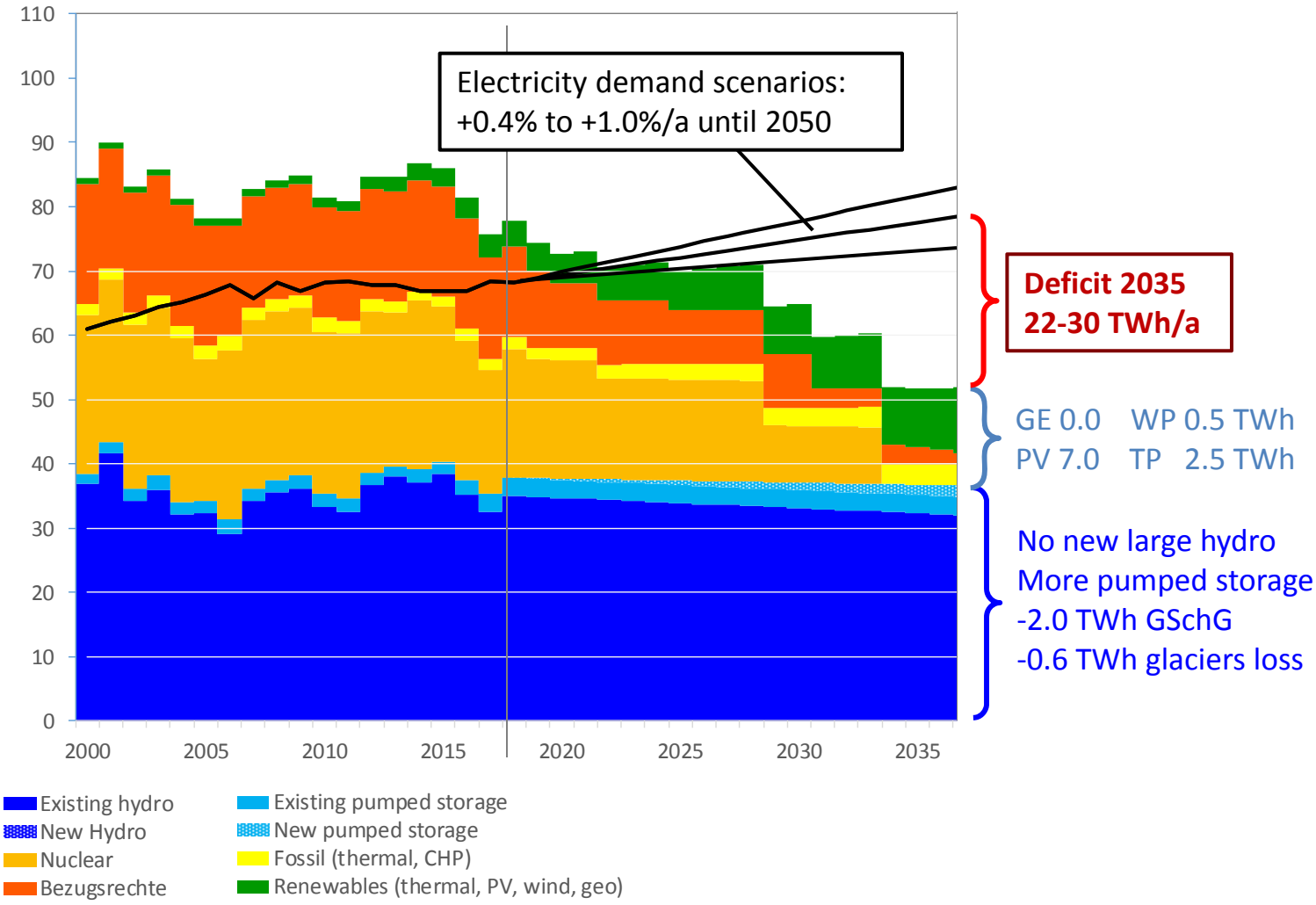
ES2050: are we meeting the targets ?

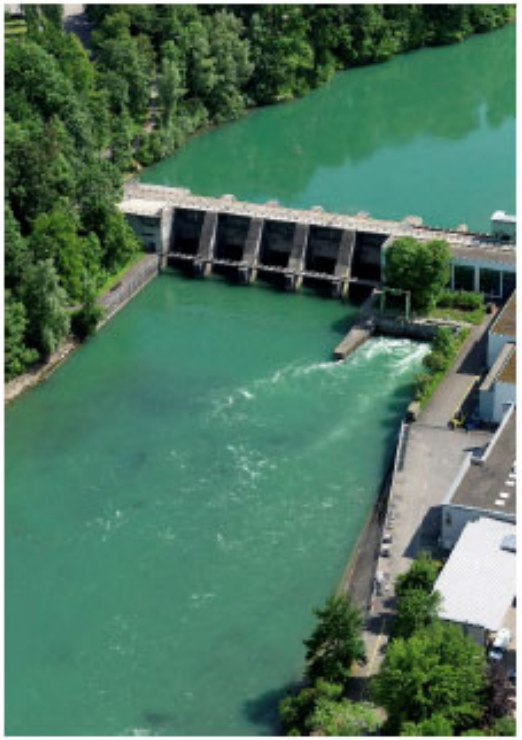


ES2050: are we meeting the targets ?



How large is a 26 TWh/a deficit ?

260 medium-size RoR dams

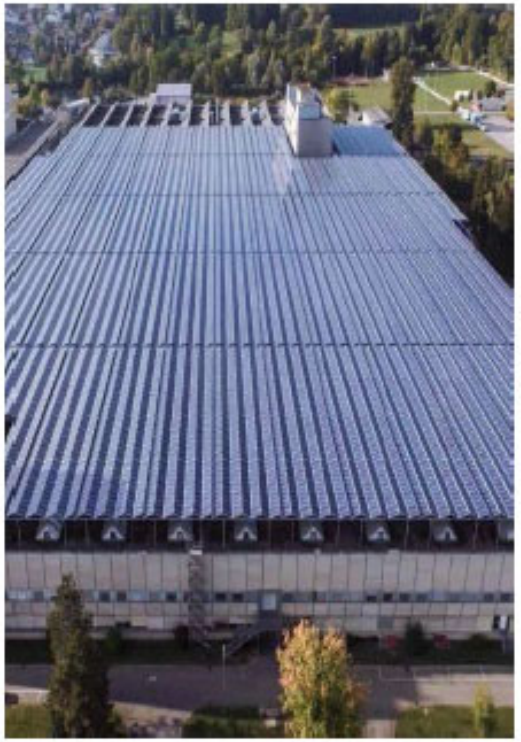


20 MW RoR, 100 GWh/a
KW Bremgarten-Zufikon, 1894

5'200 wind turbines

2 MW wind turbine, 5 GWh/a
RhoneEole Martigny, 2008

26'000 football field PV plants



36'000 m2 (5 football fields), 5 GWh/a
Riverside in Zuchwil, 2015

modified from Schweizerischer Wasserwirtschaftsverband
Association suisse pour l'aménagement des eaux
Associazione svizzera di economia delle acque

How are we progressing with the ES2050 targets?

- ✓ Energy demand and CO2 emissions are decreasing with a positive trend visible since the late nineties, but
  - Low hanging fruits collected so far
  - Increased electricity demand can be expected (increased GDP and population, transition in heating and mobility, increased pumped hydro)
- ✓ The transition to new renewable sources for the supply of electricity is slower than foreseen in the ES2050, with PV increasing according to the expected trend but other sources (WP, GE, TP) showing little/no growth
- ✓ The required increase in HP capacity, flexibility and seasonal storage will be delayed, for the lack of new large projects in the next decade
- ✓ Carbon sequestration unlikely to be installed in Switzerland

- ➢ **We are not meeting the ES2050 target trajectories**
- ➢ **We may expect a deficit of up to 26 TWh/a of primary electricity supply by 2035, not compensated by 2050**

SCCER-SoE 2019

- ✓ Three battles we are loosing
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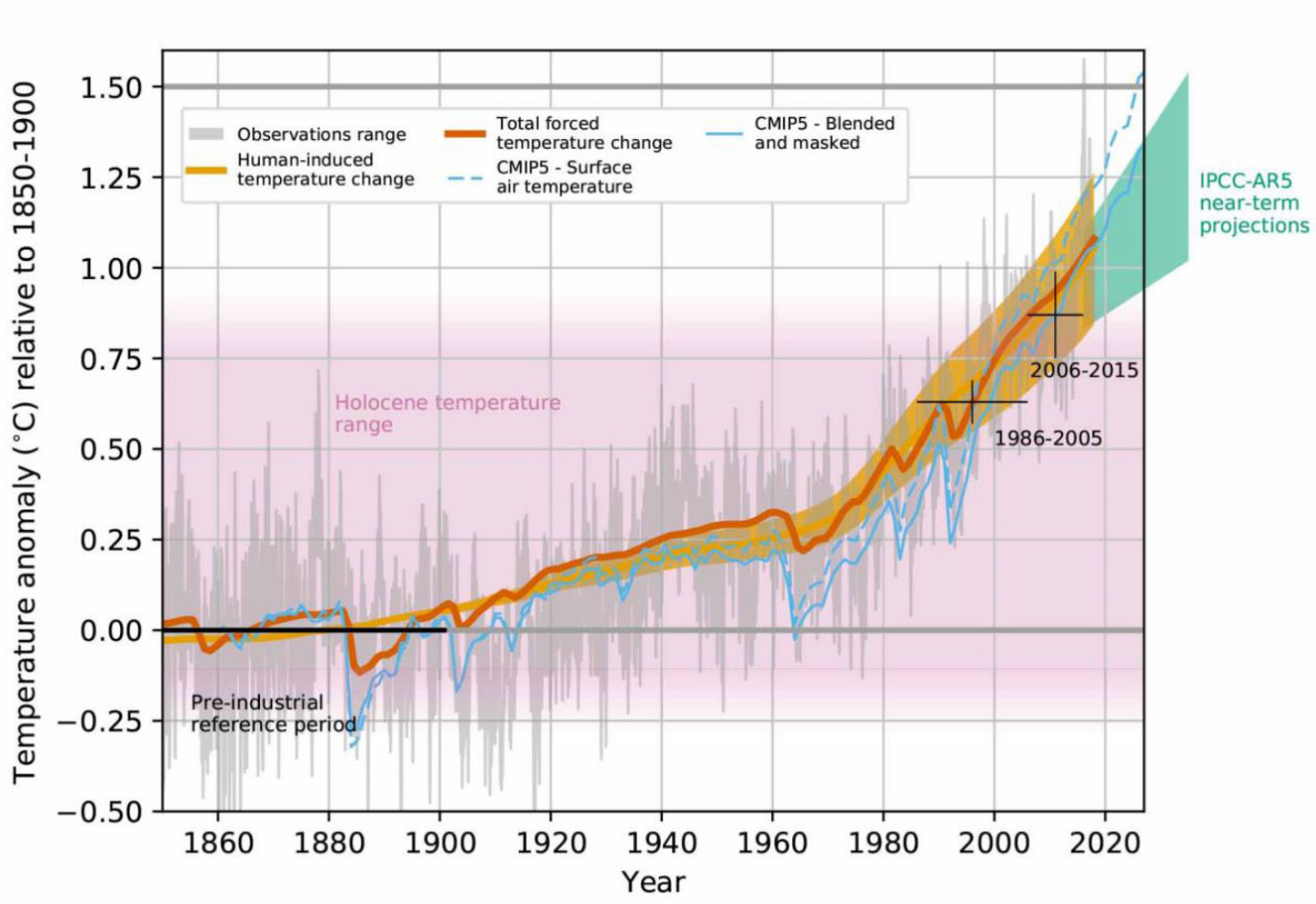
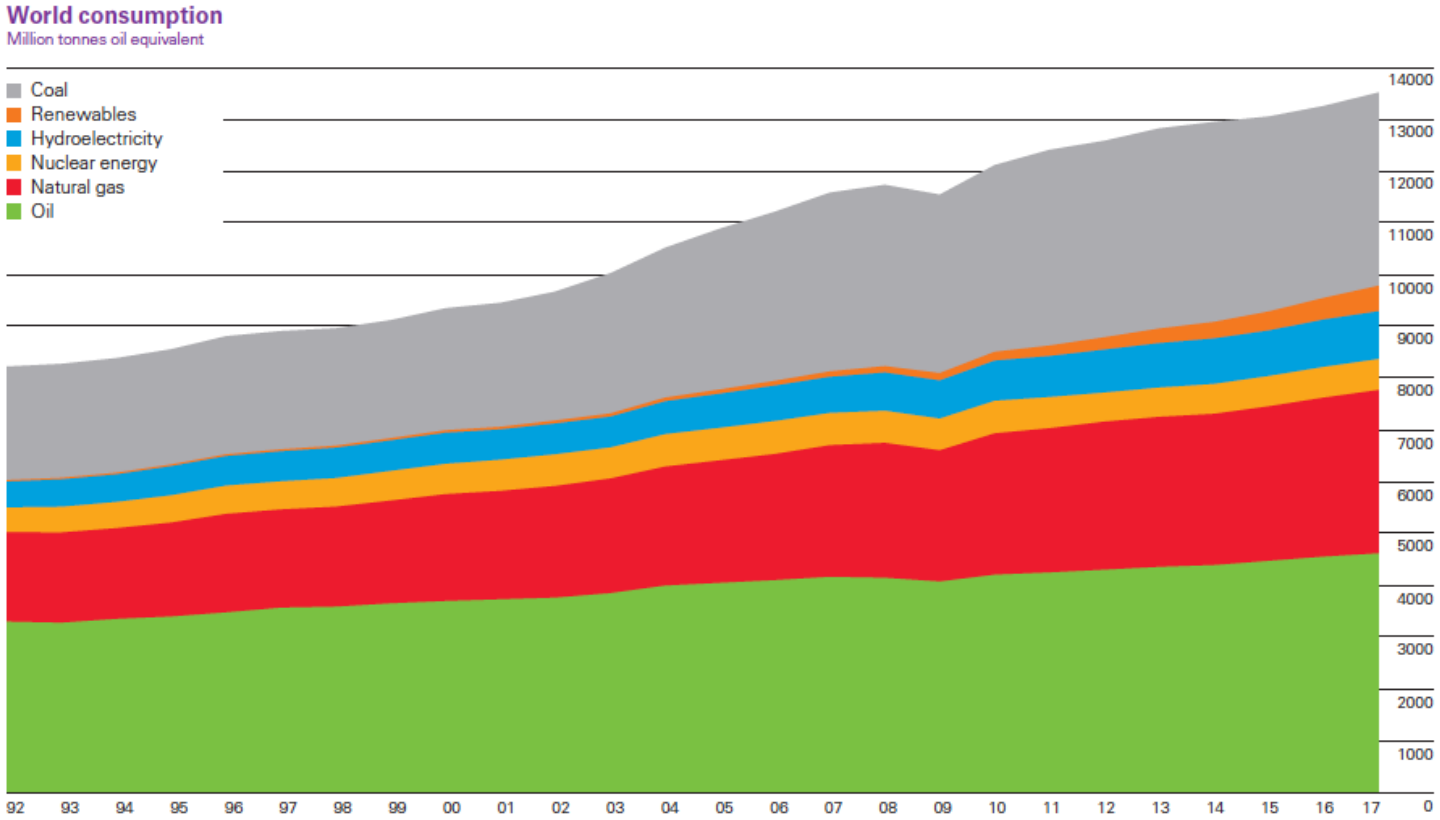
Global warming



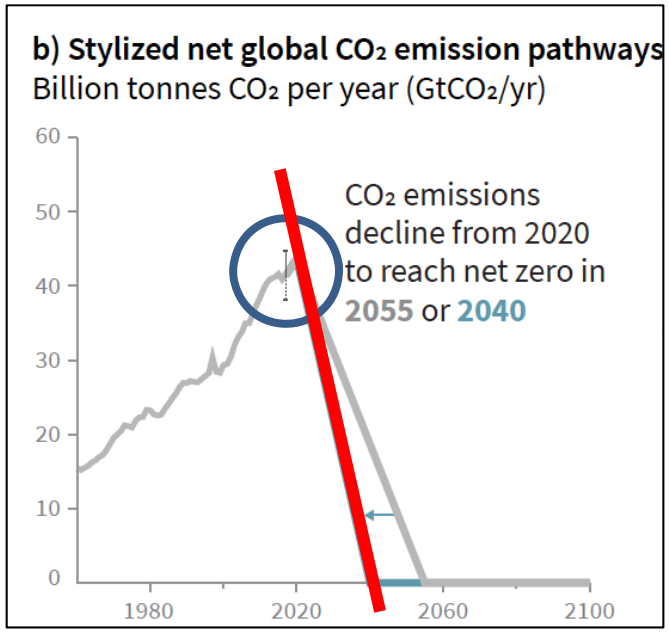
- ✓ 1°C global temperature increase reached in 2017
- ✓ With the present trend (and large uncertainties) +1.5°C will be reached in 2040, +2°C in 2065

World primary energy consumption



World primary energy consumption grew by 2.2% in 2017, up from 1.2% in 2016 and the highest since 2013. Growth was below average in Asia Pacific, the Middle East and S. & Cent. America but above average in other regions. All fuels except coal and hydroelectricity grew at above-average rates. Natural gas provided the largest increment to energy consumption at 83 million tonnes of oil equivalent (mtoe), followed by renewable power (69 mtoe) and oil (65 mtoe).

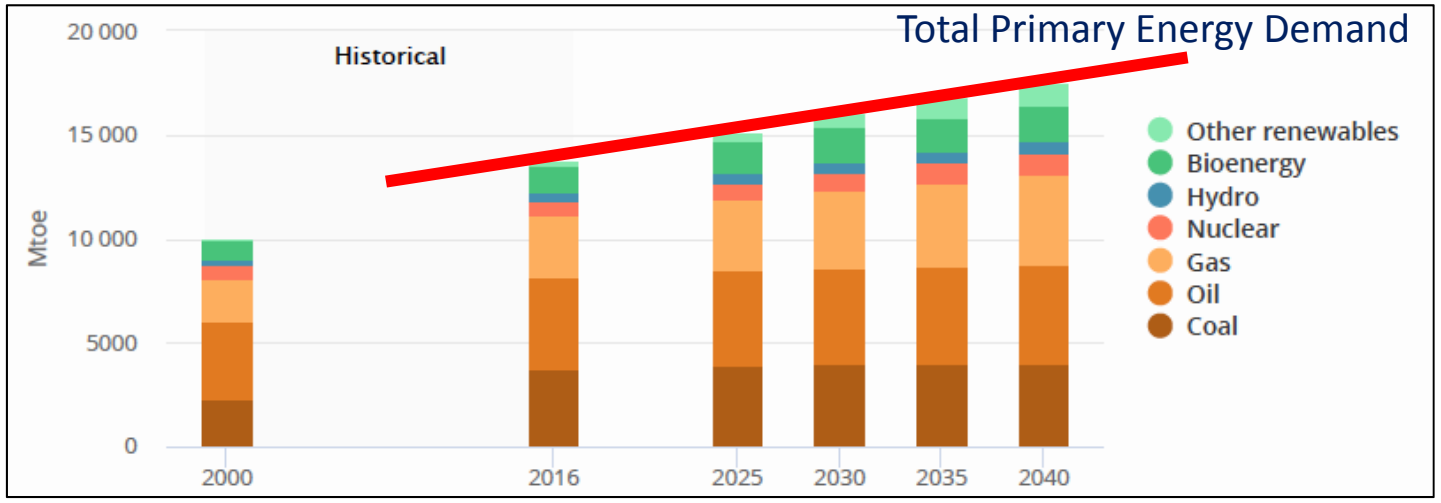
Global warming vs energy transition



IPCC Special Report on global warming of 1.5°C, 2018

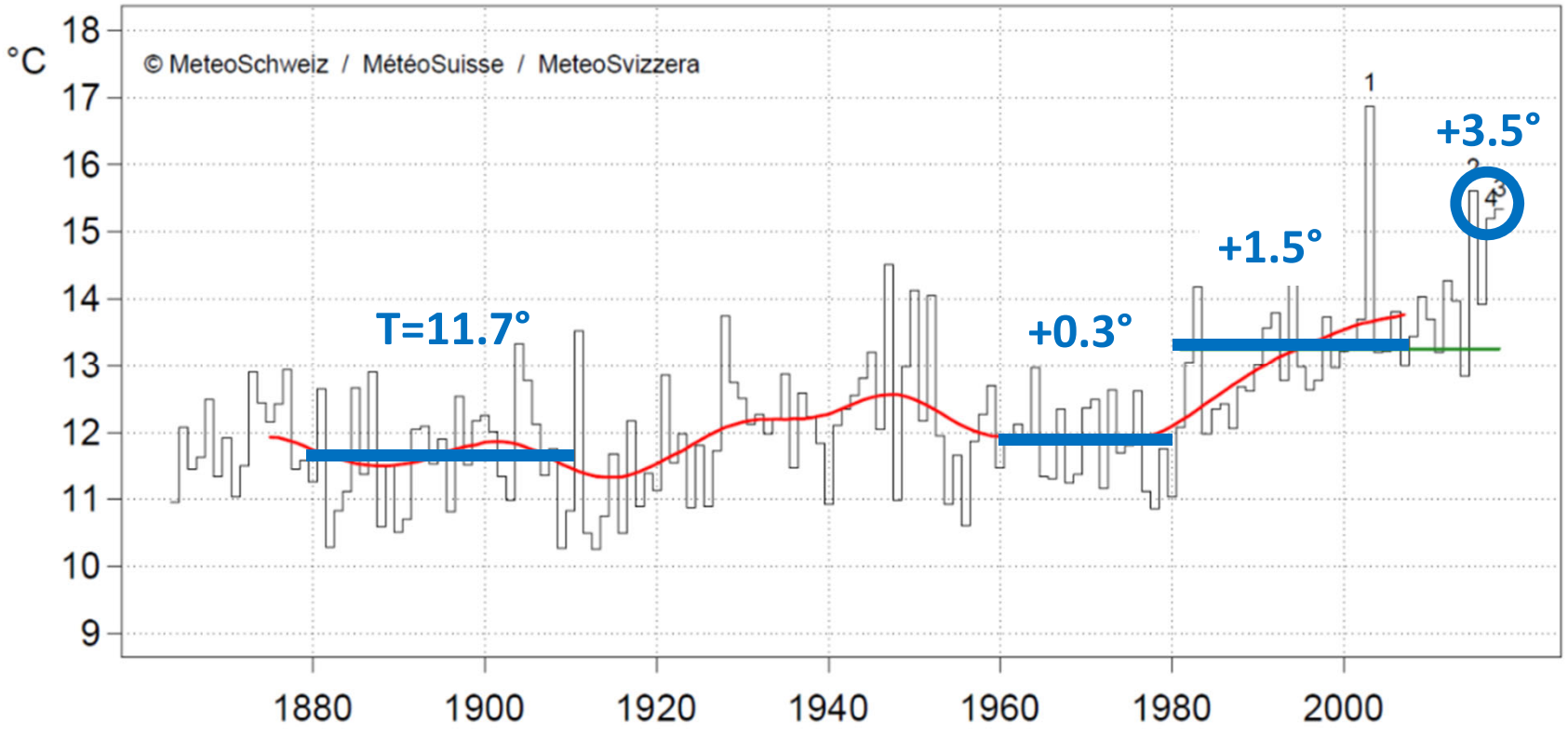
- ✓ Net global CO2 emissions more than doubled in the past 50 yrs
- ✓ All pathways identified by IPCC to maintain global increase to 1.5°C, require curbing CO2 emissions starting in 2020, to reach net zero by 2040-2055 and remain negative afterwards

- ➢ IEA projections for total primary energy demand foresee a significant increase in the use of fossil fuels until and beyond 2040 → the energy transition is too slow!
- ➢ We have no chance to limit global warming to 1.5°C



New Policies Scenario, IEA 2017

Global warming:
Average summer temperatures in Switzerland, 1870-2018



- ✓ Observed temperature increase can be regionally much higher than global average
- ✓ In Switzerland, average summer temperatures of past 4 years increased over 3°C

SCCER-SoE 2019

- ✓ Three battles we are loosing
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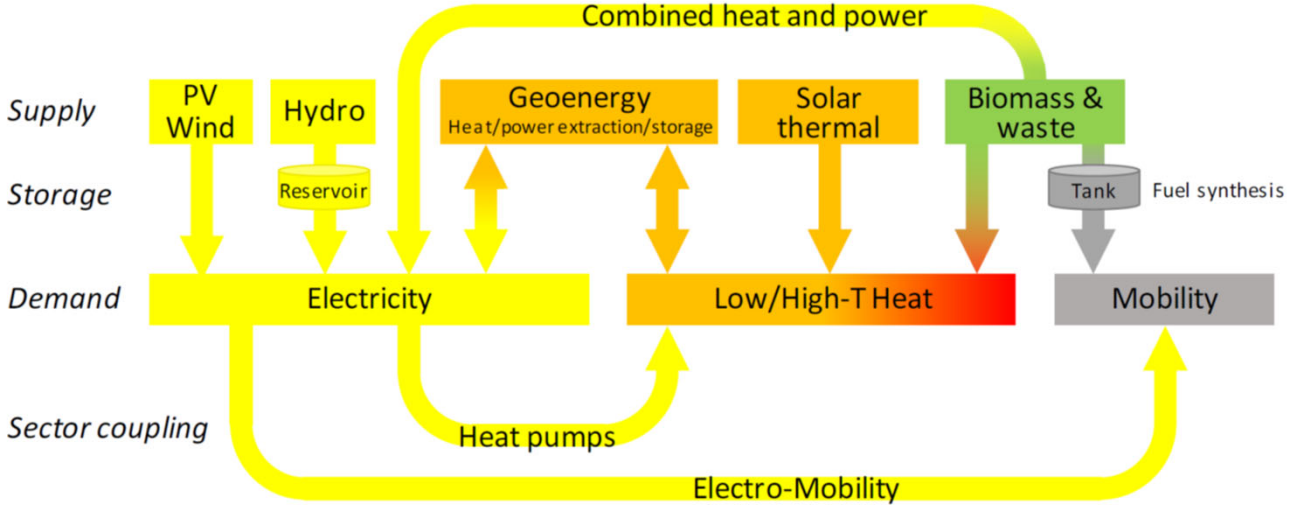
Outlook post-2020

In the past two years:

- ✓ Numerous meetings and documents
- ✓ Consensus that a new program must be established to replace/continue beyond SCCER, considering a systemic approach
- ✓ CORE Energy Research Masterplan
- ✓ Plans for dedicated, targeted, competitive funding for energy research presented by SFOE, ETH Rat, Innosuisse
- ✓ On going discussion for inclusion in the BFI-Botschaft 2021-2024
- ✓ "La confusione regna sotto i cieli"



Annual Conference 2018, Horw