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Switzerland's national emissions mitigation pathways: towards net-zero CO2 emissions in 2050

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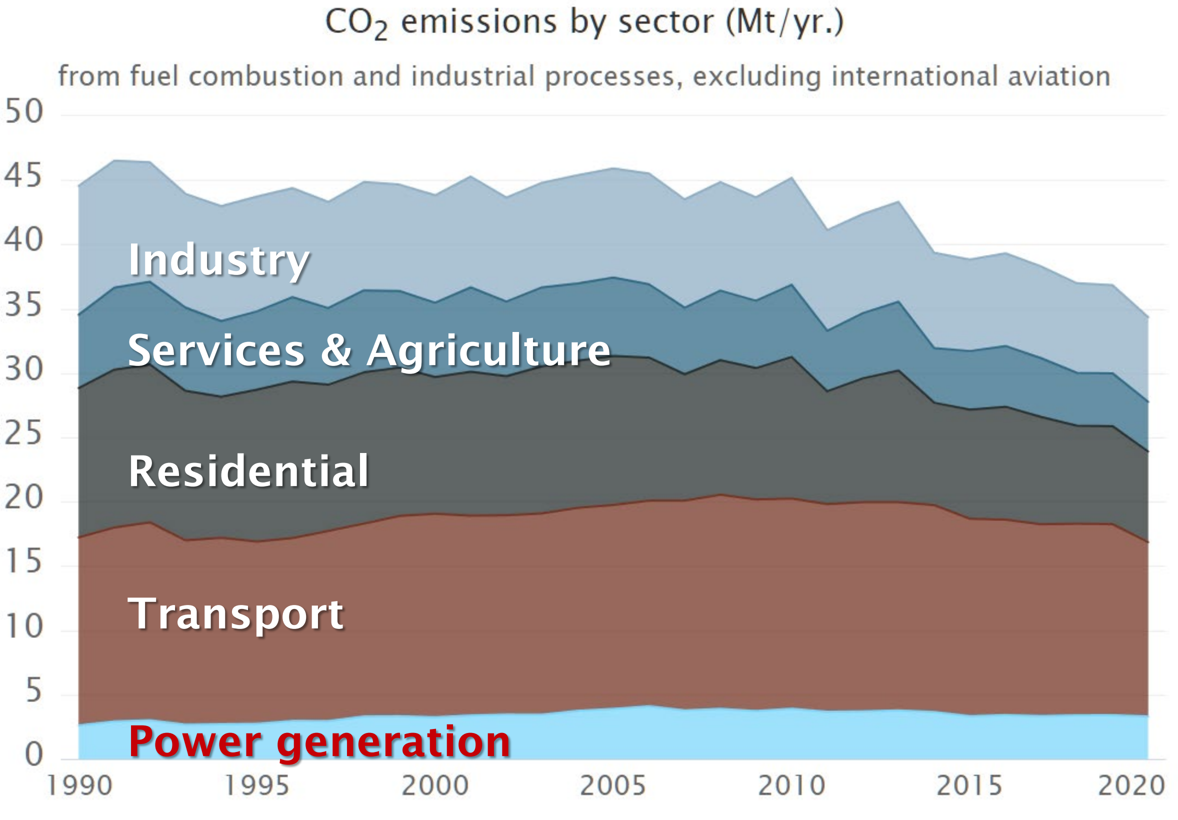
CO_2 emissions in Switzerland: -23% in 2020 from 1990

Challenges in the Swiss transition to net-zero CO_2 emissions in 2050:

- Limited renewable sources
- Seasonal and daily balancing
- CO_2 storage
- Population increase
- Energy security



Source: Swiss Federal Office for Environment

Milestones in the Swiss energy & climate policy

2010

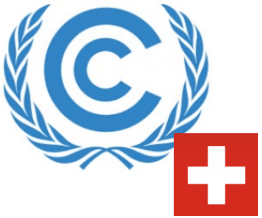
Introduction of the CO_2 levy for heating fuels: 36 CHF/tCO_2 (*Jan 2010*)

(*in 2020, 120 CHF/tCo2*)

2011

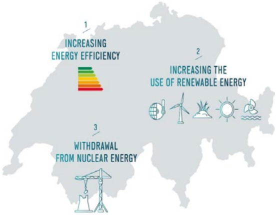
Negotiations for linking Swiss and EU ETS

The linking entered into force in Jan 2020



2015

Switzerland is the first country submitting its climate action plan ahead of Paris Agreement (*Feb 2015*)



2018

New Energy Act comes into force:

1. Increase energy efficiency
2. Increase use of renewables
3. Withdrawal from nuclear

(*Jan 2018*)

2019-2020

The Swiss Federal Council commits to Net-Zero emissions in 2050 (*Sep 2019*)

The Swiss parliament votes the revision of the CO_2 Law (*Sep 2020*)

2021

The Swiss Federal Council adopts the long term climate strategy (*Jan 2021*)

The Swiss voters rejected the revision of the CO_2 Law (*Jun 2021*)

Research project SCCER JASM to assess the Swiss energy transition

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Innosuisse – Swiss Innovation Agency

The Swiss Competence Centres for Energy Research (SCCERs) programme:

- 250 MCHF for 2013-2020 to 8 challenges of transition (biomass, storage, industry, buildings, transport, electricity, grids, society)

SCCER JASM (~5.6 MCHF) is a **cross-SCCER joint activity** assessing **net-zero pathways**

Scenarios*	**Energy trade availability**	**Renewables and CCS deployment**	**Society and lifestyles**	**Policies**
CLI: core scenario	good	cost optimal	cost optimal	technology and building standards
ANTI: fragmented solutions	moderate	moderate	fragmentation	local markets
SECUR: energy security	low	cost optimal	pay for security	zero net imports

*a subset of the STEM JASM scenarios is shown here, focusing on those discussed in this presentation

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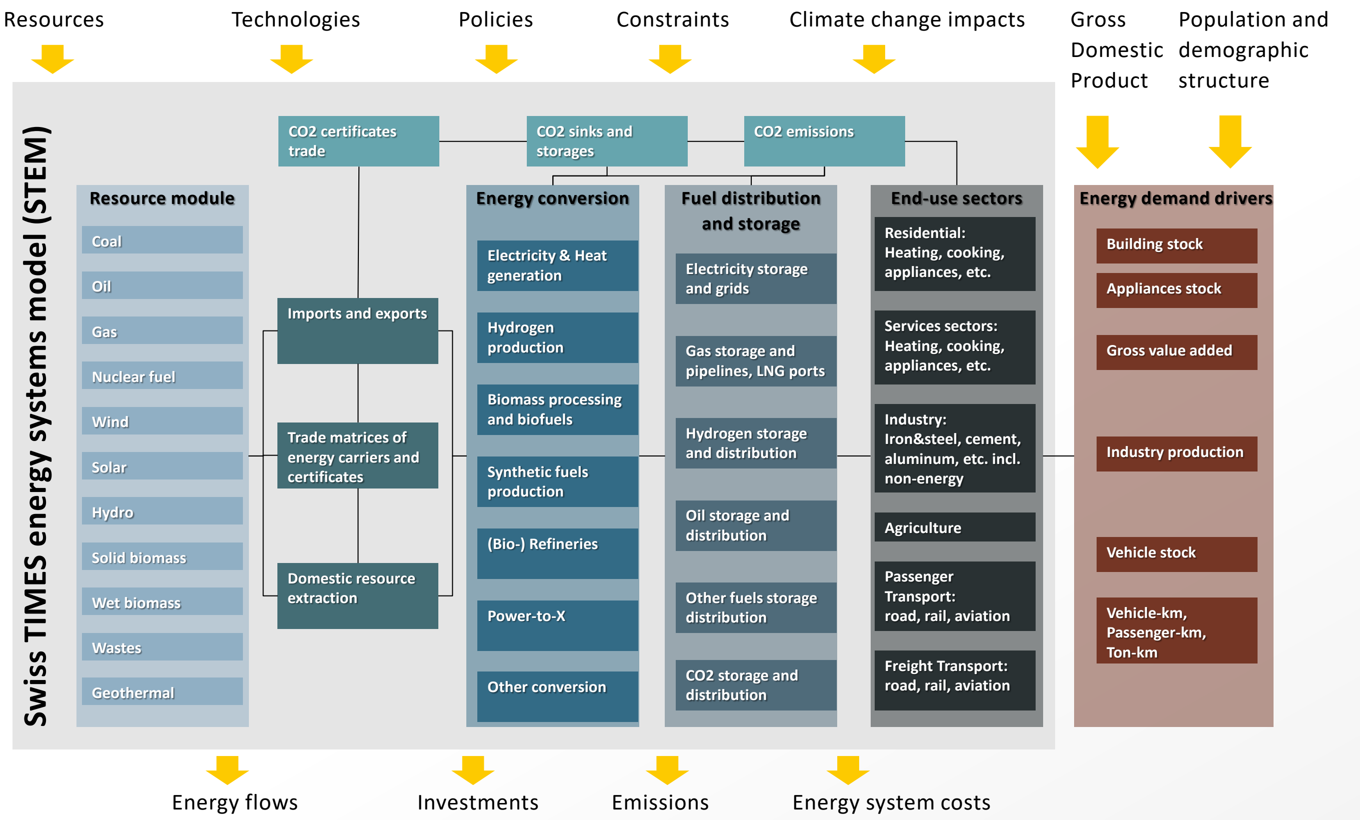
SCCER JASM website https://sccer-jasm.ch

Swiss TIMES energy systems model (STEM)

- Entire energy system
- Transition pathways
- Long term horizon
- 288 hourly time steps
  - Seasons
  - Days
- Age structure of assets
- Unit commitment
- Ancillary markets
- Grid topology
- Endogenous RES variability
- Endogenous load profiles
- Demand side management



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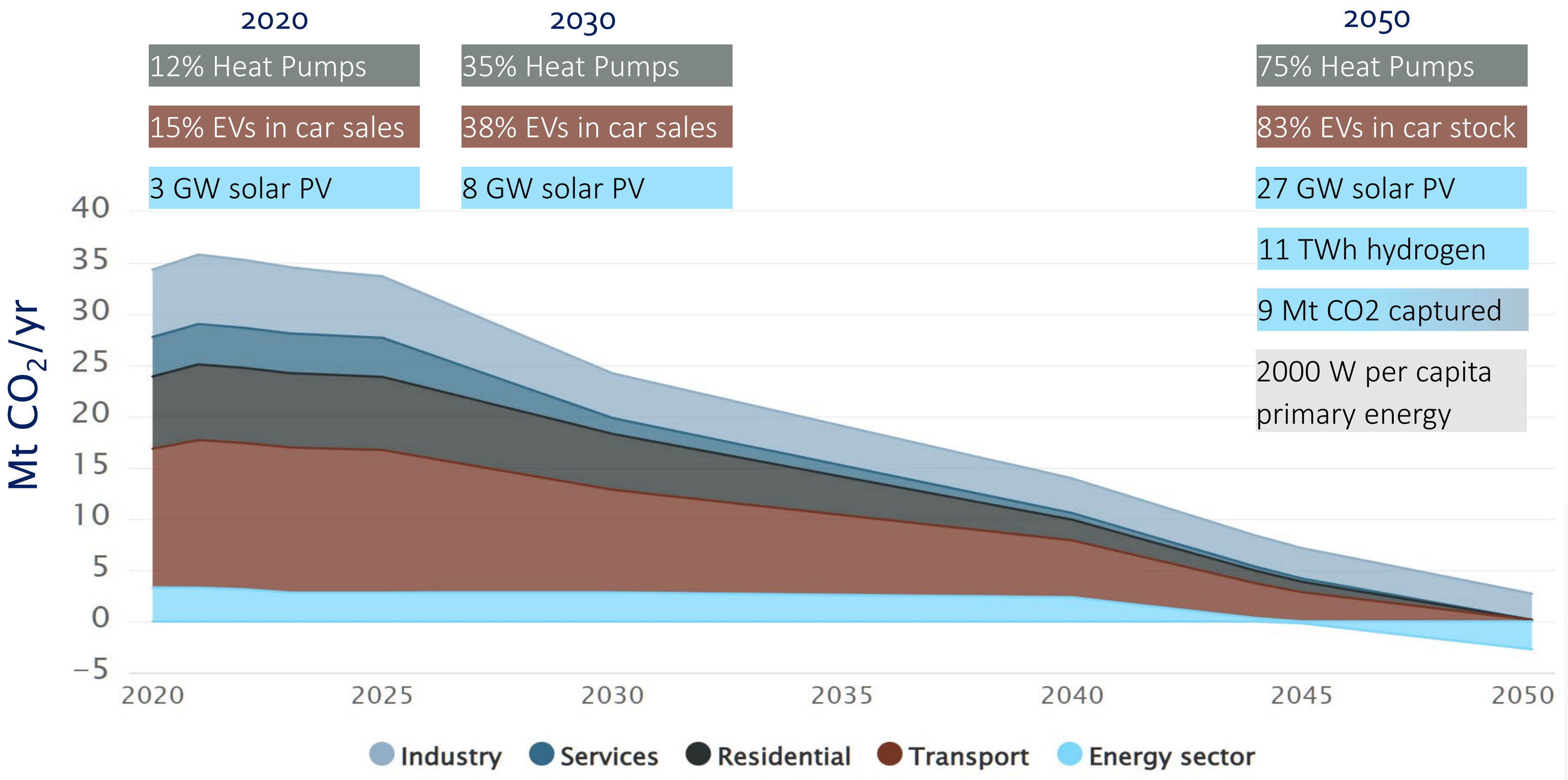
Milestones to net-zero CO2 emissions in 2050

CLI SCENARIO



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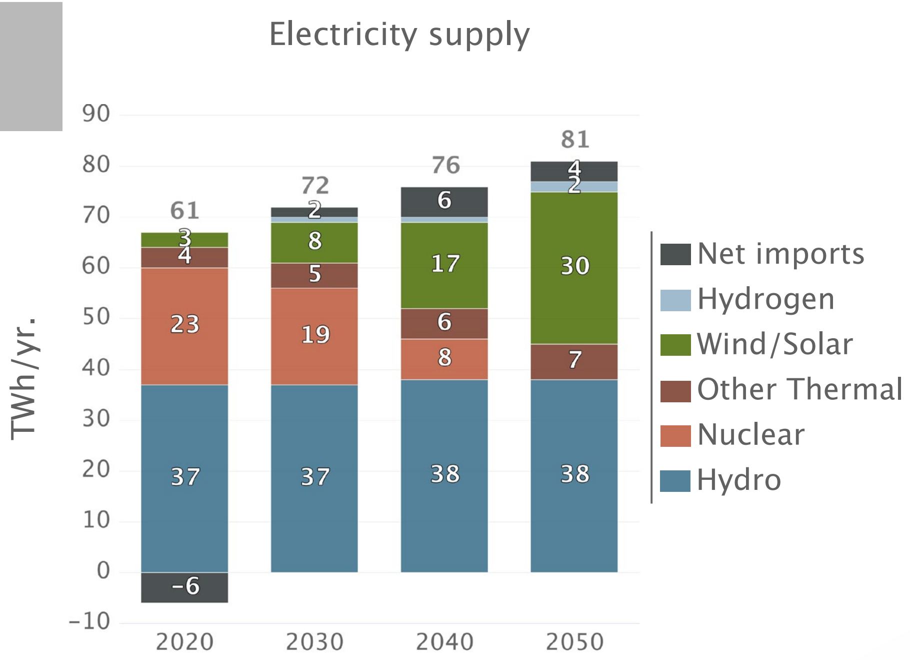
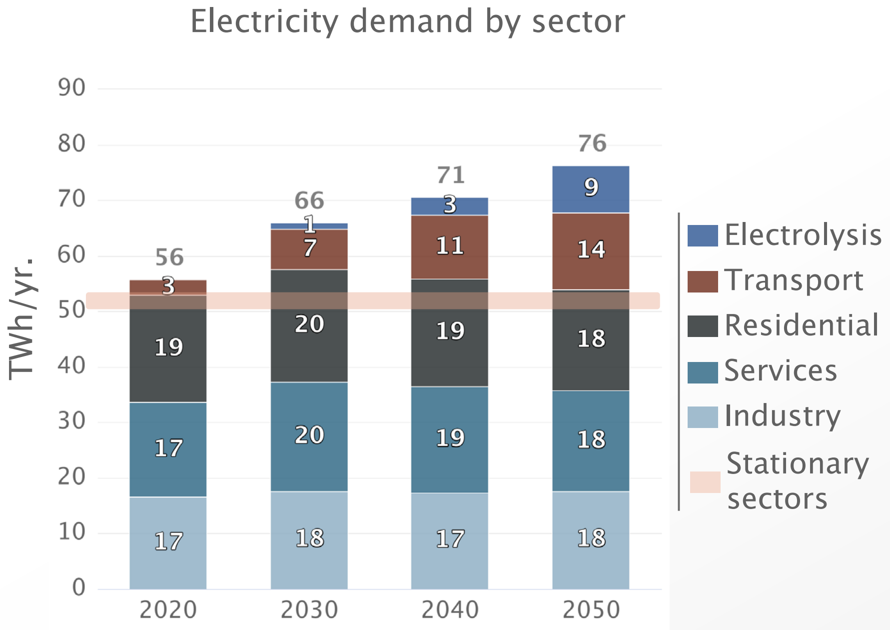
Electricity becomes more weather dependent while new demand comes from transport and electrolysis

CLI SCENARIO





Electric cars: 8 TWh, 6 GWp, for charging in 2050

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CLI SCENARIO

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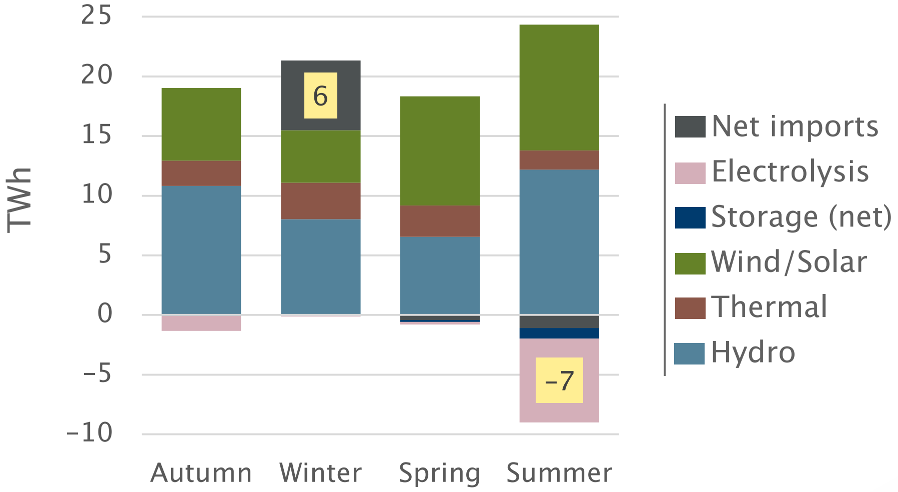
A net-zero energy system calls for flexibility from all actors & sectors, and at different time scales

Seasonal imbalances in electricity in 2050



Deployment of flexibility options in 2050

Flexibility option	Deployment (capacity)
Pump storage	4.5 GW , 520 GWh
Stationary batteries	2.1 GW , 11.5 GWh
Thermal storage	5.8 GW , 35 GWh
Thermal storage (seasonal)	1.4 TWh
H2 storage (seasonal)	1.6 TWh
Vehicle-to-Grid (V2G)	output 0.5 TWh (from 13% of the electric cars)
FCR+ reserve demand	+ 45% from 2020 (624 MW)
Electricity shifts (DSM) in industry, services, residential	10% of demand (5.5 TWh)

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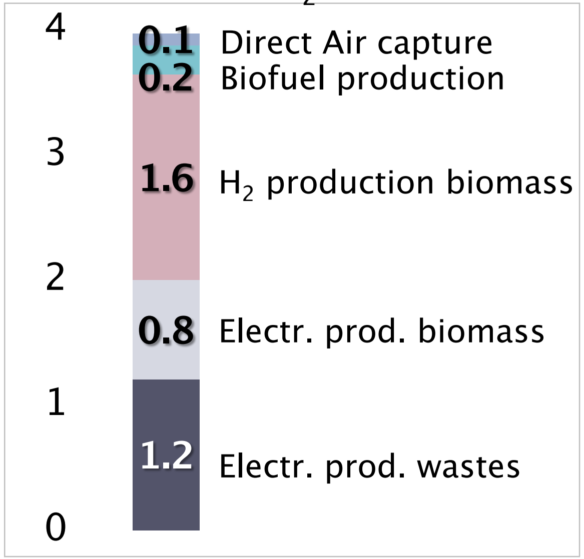
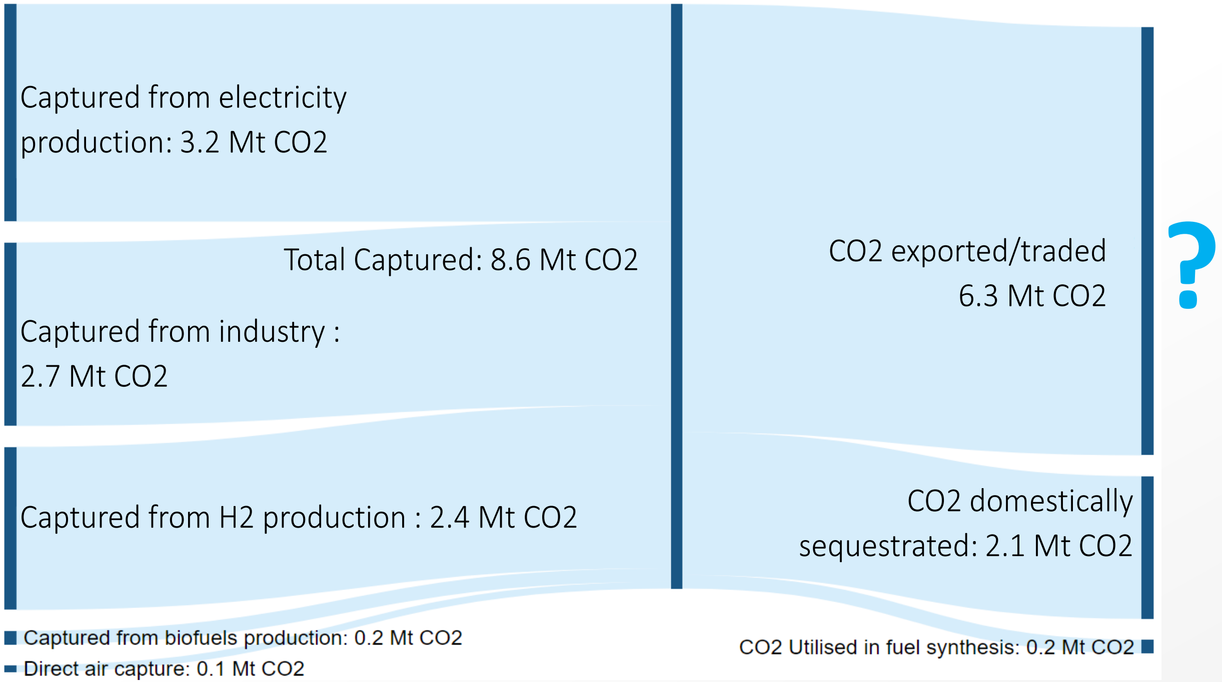
CC(US) needs to be developed and links to international CO2 storage sites need to be secured

CLI SCENARIO

Negative Emissions $MtCO_2$ in 2050



Carbon capture, utilisation, and storage in 2050



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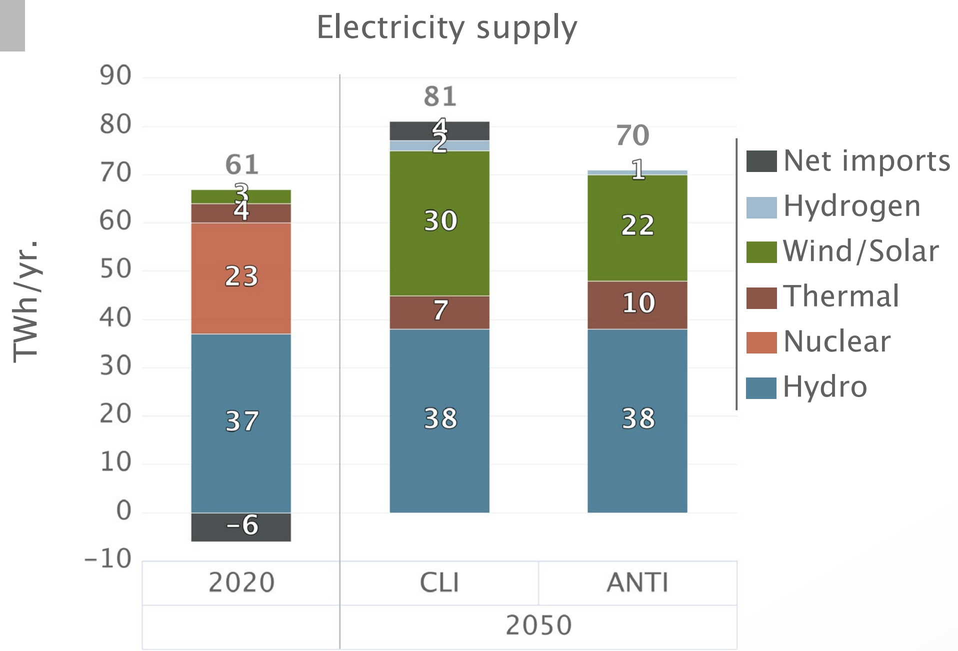
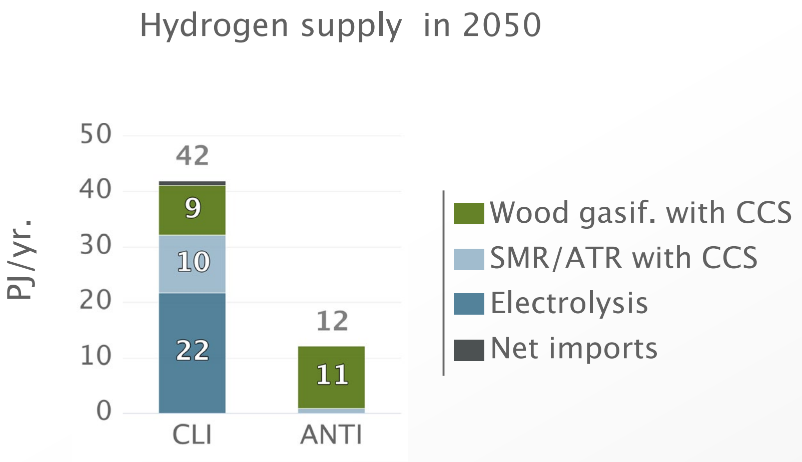
What if renewable energy uptake is slow?

ANTI SCENARIO

Electricity supply gap of 11 TWh in 2050 hinders decarbonisation of the end-uses



Domestic H2 production is limited and H2 use is prioritised to industry and transport



BECCS to deliver negative emissions to offset emissions from buildings sector

In general: Strong shift of bioenergy to supply side

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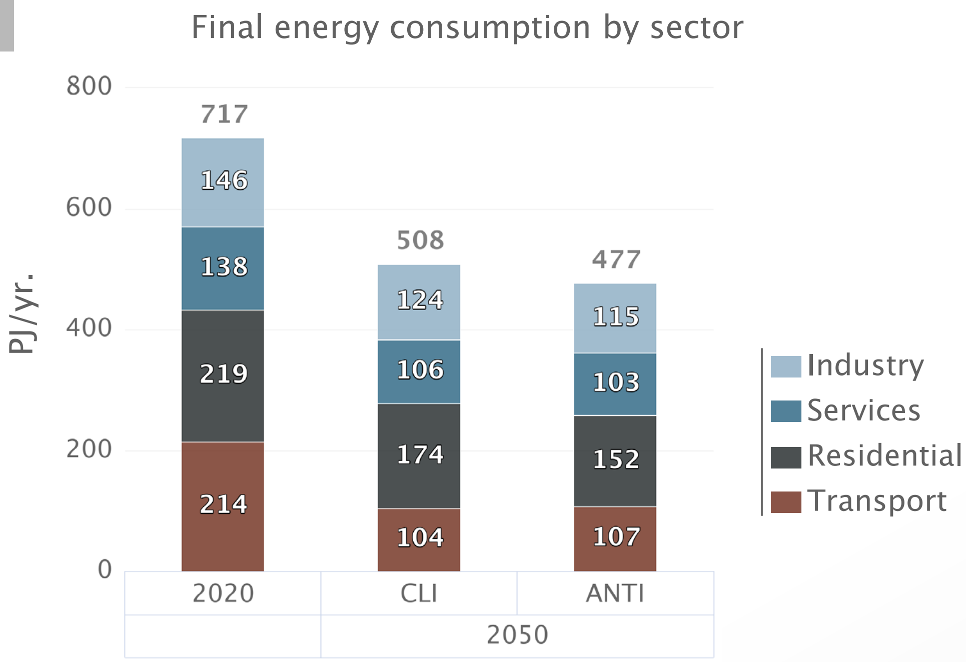
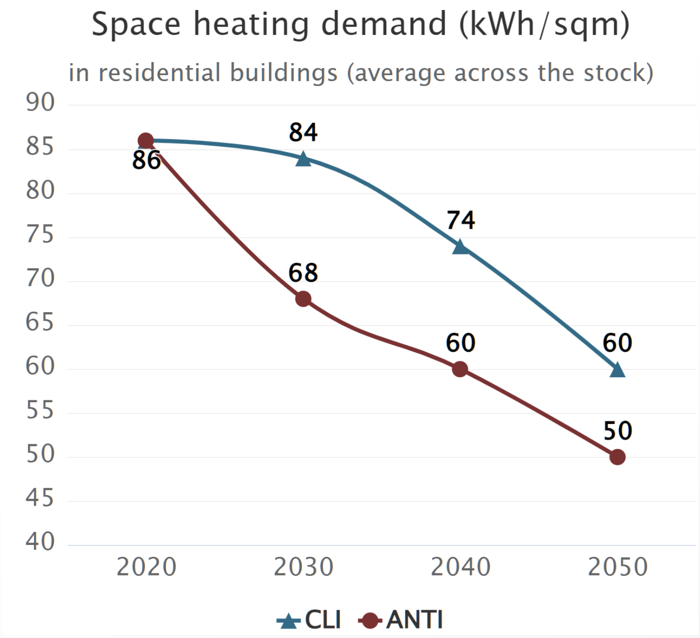
What if renewable energy uptake is slow?

ANTI SCENARIO

Extensive energy conservation measures



Building renovations brought forward



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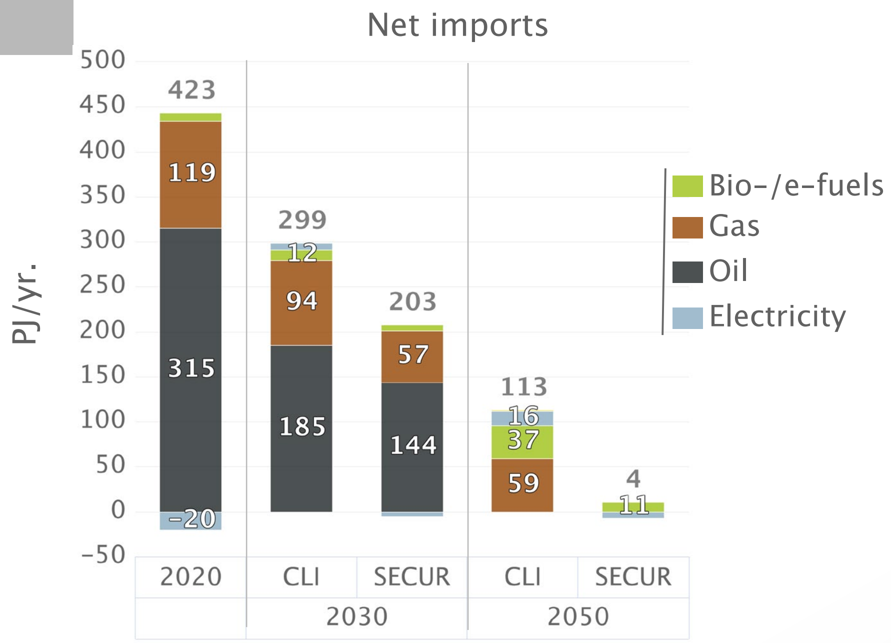
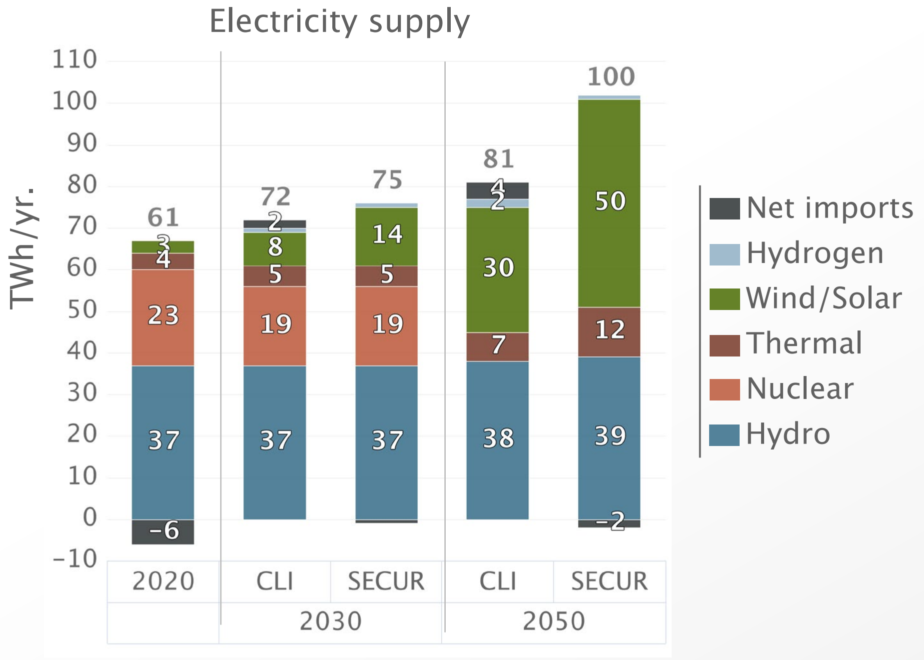
Can achieve net-zero and be self-sufficient?

SECUR SCENARIO

Import independence of fossil fuels is possible but bio/e-fuels imports are needed



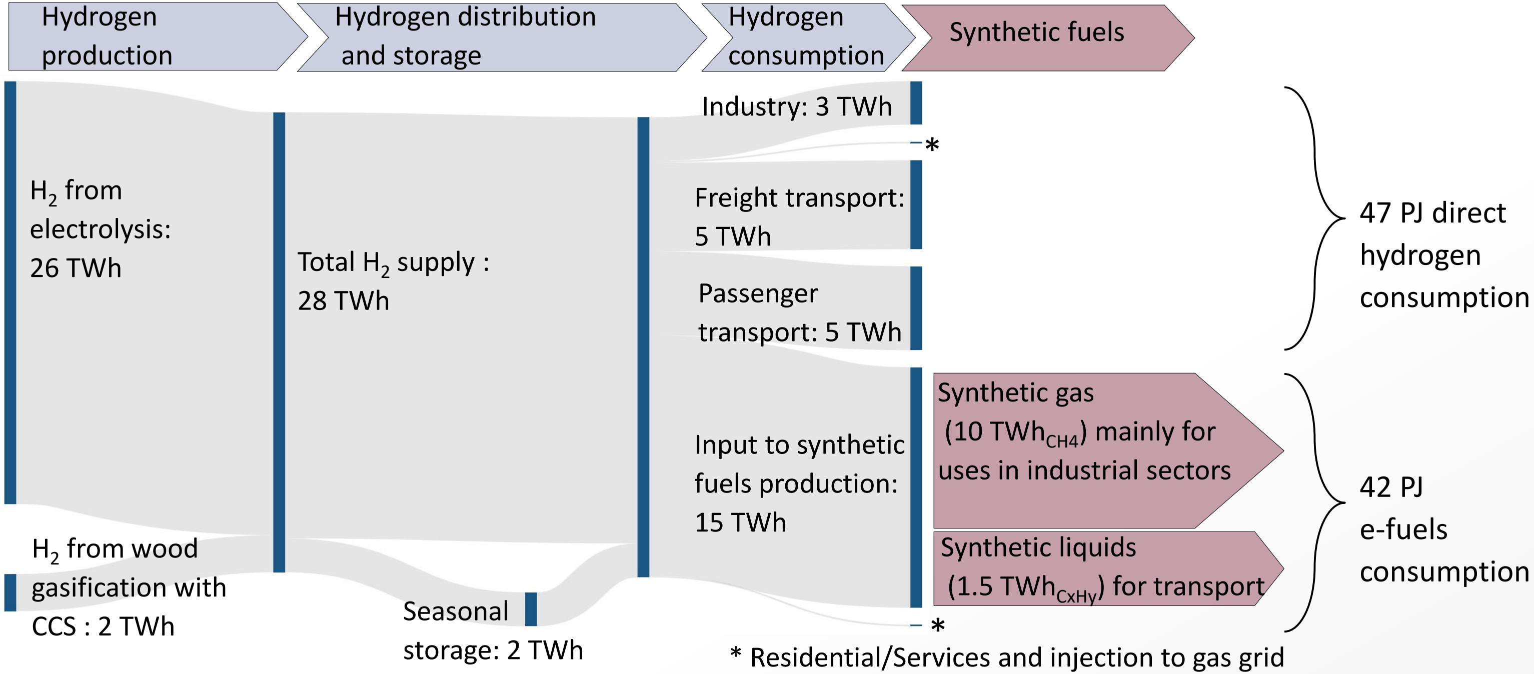
Electricity supply increases by accelerating and fully exploiting solar, wind & geothermal potentials



Can achieve net-zero and be self-sufficient?

SECUR SCENARIO

Direct H2 consumption and e-fuels substitute in SECUR >90% of the CLI imports in 2050



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“Price Tags” of the Swiss transition to net-zero in 2050

compared to “Baseline” that achieves -40% CO2 emissions reductions in 2050 from 1990

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Average annual per-capita energy system cost 2020-2050 to achieve net-zero emissions (CHF/yr)

Scenario	Cost (CHF/yr)
Limited deployment of renewables and weak market integration	1390
Net-zero core scenario (CLI)	530
Technical innovation and strong market integration	320

↑ expensive energy saving measures and production of domestic clean fuels

↓ lower capital costs and balanced deployment of low-carbon options

07.03.21

01.09.21

Tages-Anzeiger

Das braucht es für eine klimaneutrale Schweiz ohne AKW

Bis 2050 sollen nur noch E-Autos fahren und alle Kernkraftwerke abgeschaltet sein. Das bedeutet vor allem eines: Wir brauchen mehr Strom. Woher soll der kommen?

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Conclusions

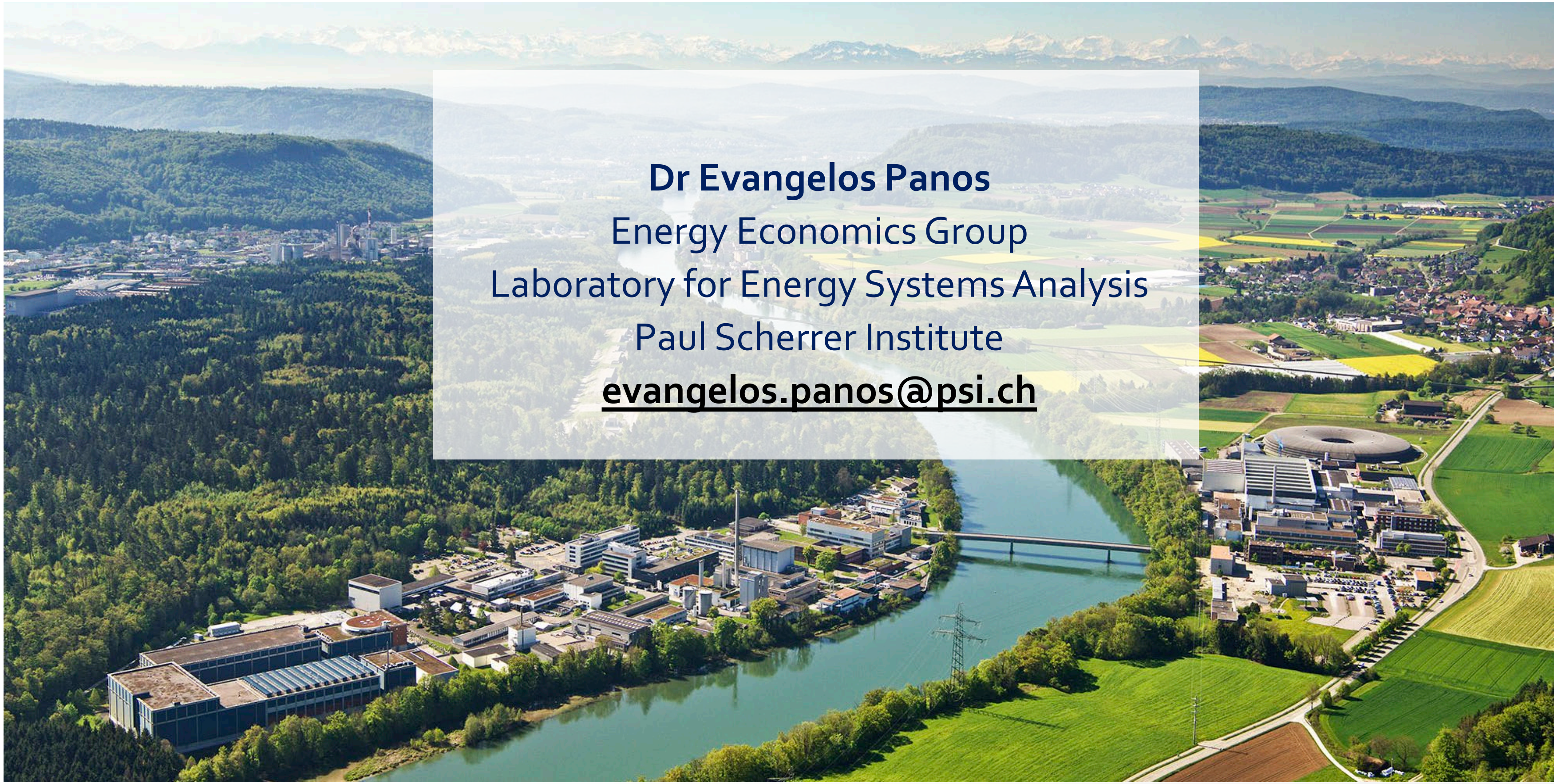
- Achieving net-zero is technically feasible, under:
  - coordinated sectoral policies accounting for systemic interdependencies
  - accelerated deployment of domestic renewable resources : ***doubling RES capacity every 10 years***
  - higher energy efficiency in buildings : ***saving 7 - 11 TWh of heat per year, keep stable electricity demand***
  - bioenergy remaining potential to energy supply with CCS: ***+ 32 PJ/yr., or 2/3 of the total consumption***

- Net-zero systems require flexibility options provided by all actors
  - thermal storage of equal importance with electricity storage, for demand side management

- Hydrogen makes achievable both net-zero and import independency – but it comes at a cost
  - Large PtX investment needs : (***22 BCHF CAPEX or 1/3 of the energy-system-wide CAPEX in 2040/50***)
  - But, without H2 the net-zero target is not feasible for Switzerland

- When analysing ambitious energy and climate targets at national scales, we need to:
  - to work further to improve the "realism" of the modelled pathways (not only technical, but also societal)
  - to increase modelling details to identify local constraints and best-fit options
  - develop participatory processes in scenario development and communication

Wir schaffen Wissen – heute für morgen



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