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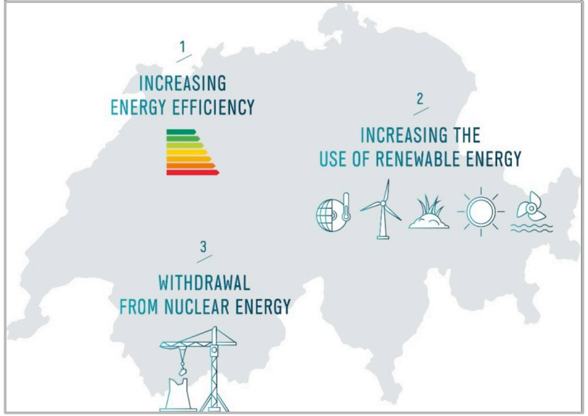
Evangelos Panos , Tom Kober :: Energy Economics Group

Flexibility needs in the energy system for the integration of distributed renewables

38th International Energy Workshop , 3 – 5 June 2019, Paris

The “  Challenge”

Energy policy objectives



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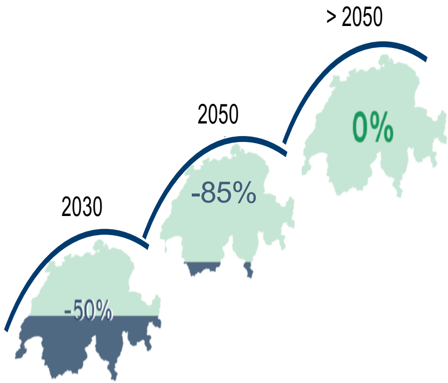
Climate policy objectives



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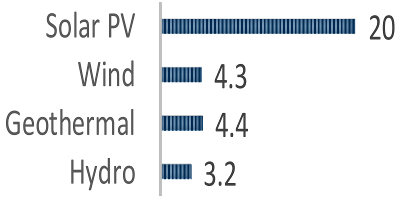
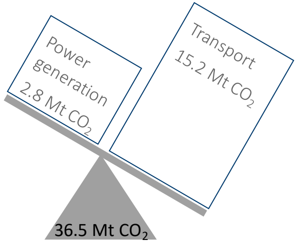
Additional exploitable RES potential mostly solar



“zero-CO_2” power sector



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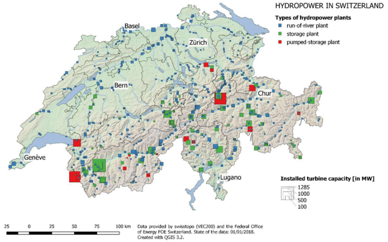
638 hydro power plants



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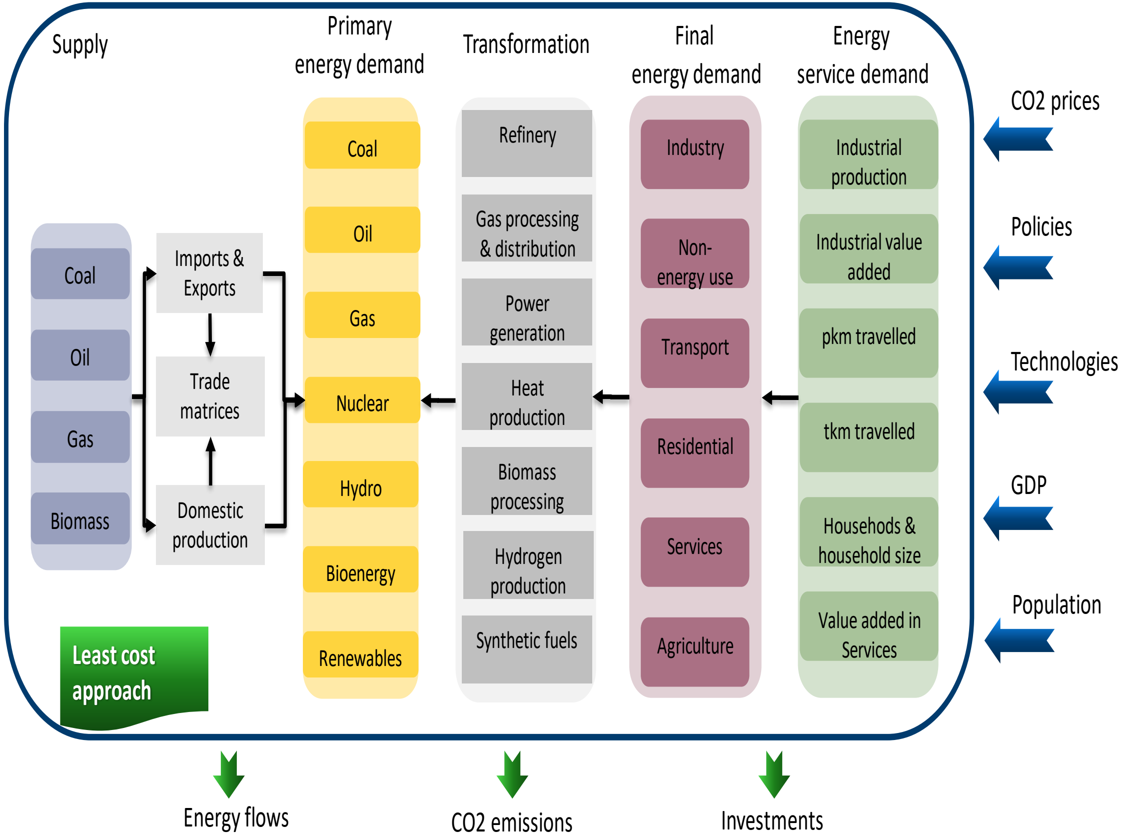
How much flexibility does it need the Swiss Energy System

The Swiss TIMES Energy Systems Model (STEM)

Time	Long term horizon & high intra annual resolution
Grid	Representation of 309 electricity grid transmission lines
RES	Representation of the stochasticity of supply & demand
AS	Technical & market-based flexibility options, incl. VPPs
DSM	Storages, DSM, G2V and V2G



Integrated scenario-based analysis with STEM

Two Long Term Scenarios regarding the future configuration of the Swiss energy system

Baseline	Climate
- GDP growth +1.1% p.a. from 2015 to 2050 - POP growth +2 million in 2050 from 2015 CO_2 price in ETS sectors gradually increases to 60 EUR/t-CO_2 - Nuclear phase out to be completed by 2034 - Emissions standards in transport sector as in the EU from 2025 (95gCO_2/km for cars, 147gCO_2/km for vans); remain constant until 2050 - Modest energy efficiency measures	- All assumptions of the *Baseline* scenario plus CO_2 emissions constraint -30% in 2030, -50% in 2050 from 1990 levels - ETS price increases to 140 EUR/t-CO_2 in 2050 - Intensification of emissions standards in transport to 70gCO_2/km in 2030, 25 in 2050 for cars; 120 in 2030 and 60 in 2050 for vans - Endogenous additional efficiency measures

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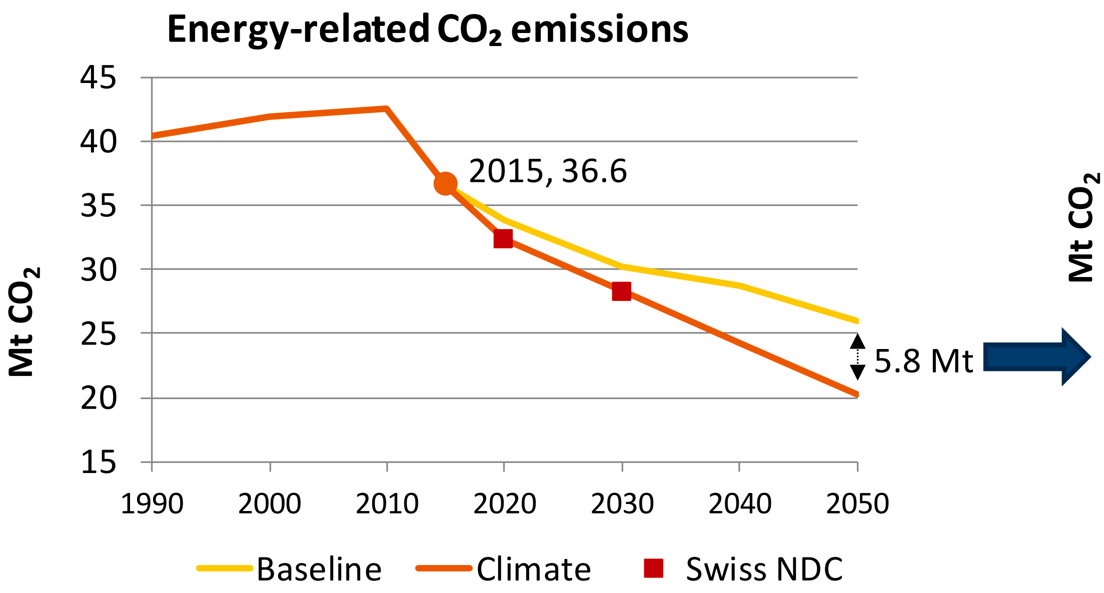
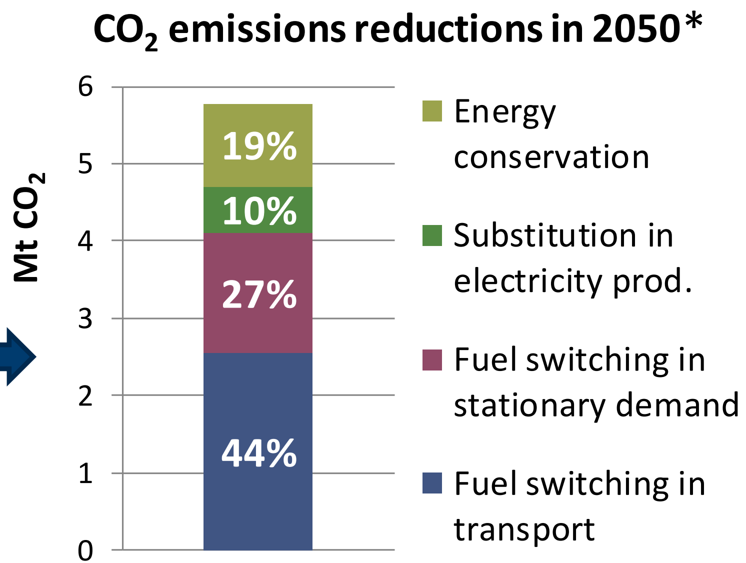
Efficiency and electricity play an essential role in reducing CO2 emissions

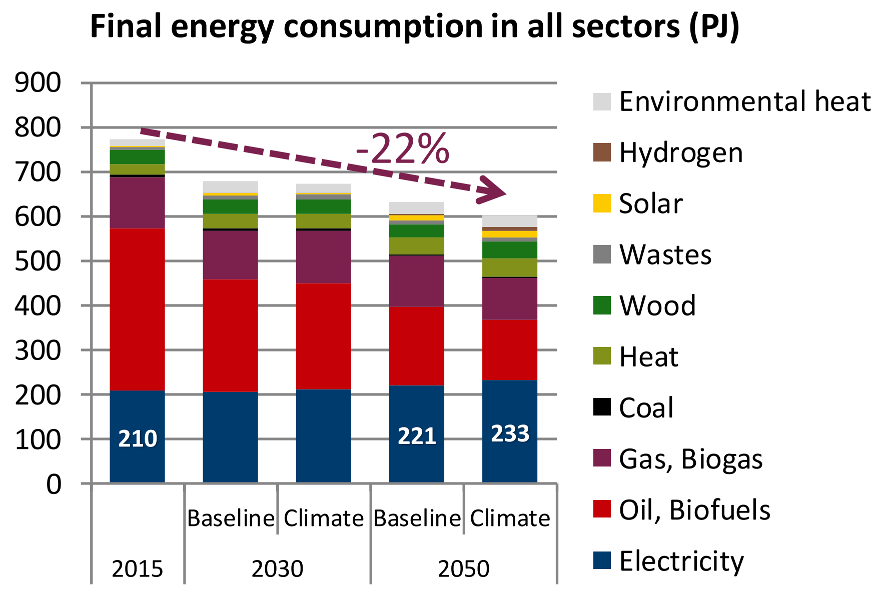


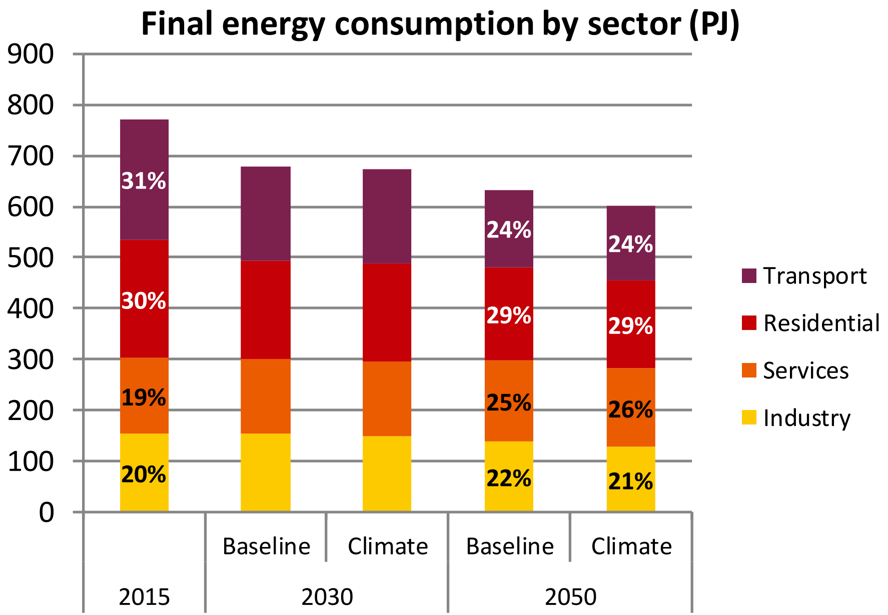


* In Climate scenario from the Baseline levels

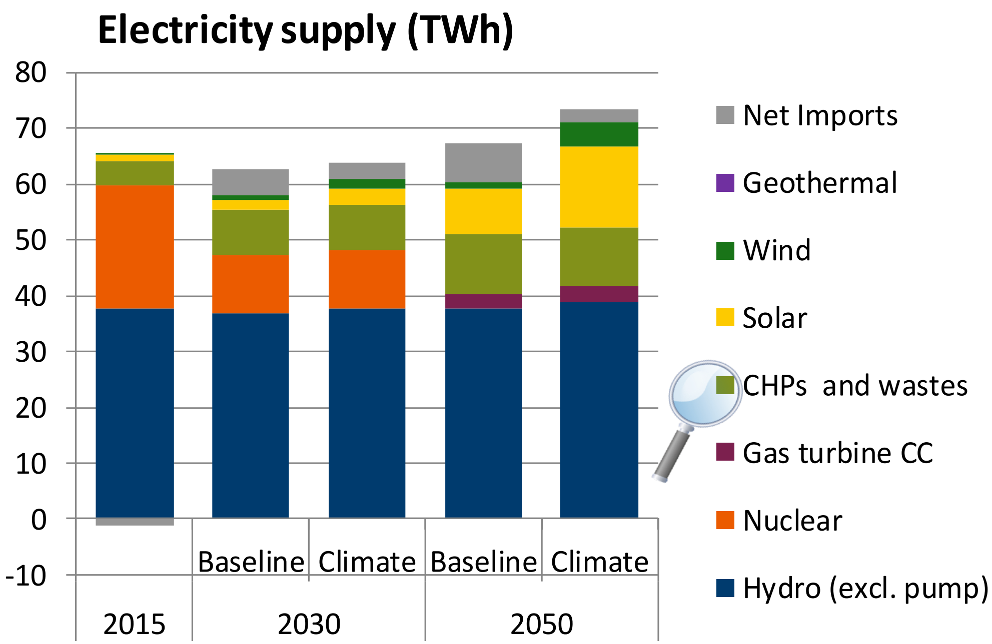
International aviation is excluded from the figures presented in this and next slides

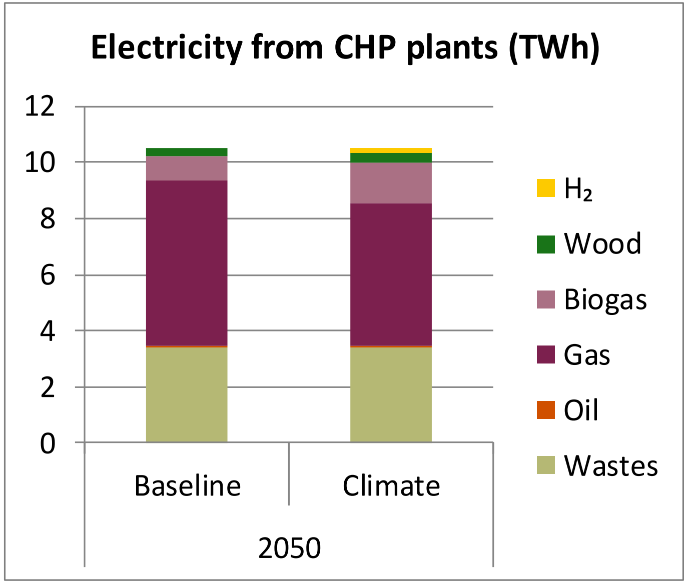
Residential heating shifts away from oil, alternative fuel vehicles emerge, and industry adopts innovative energy and material strategies



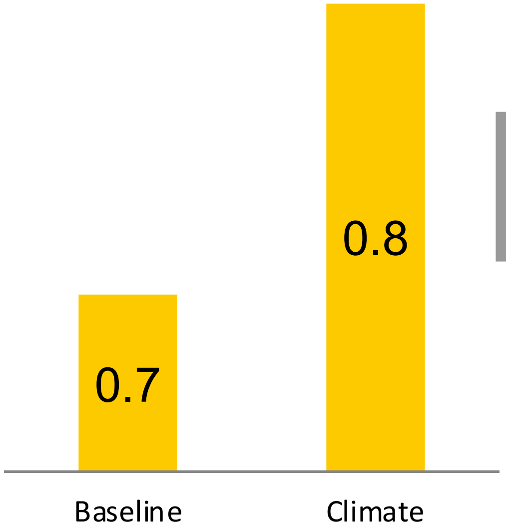


The power generation sector undergoes a profound transformation towards distributed generation and renewables

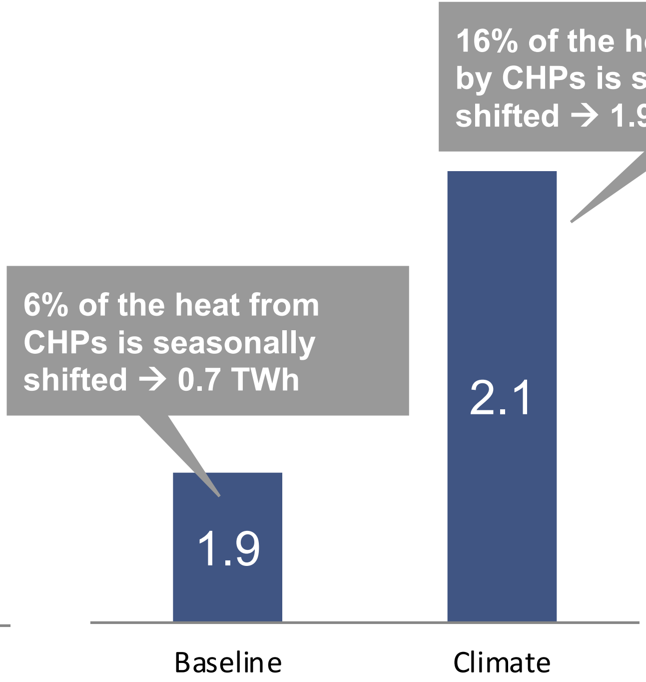




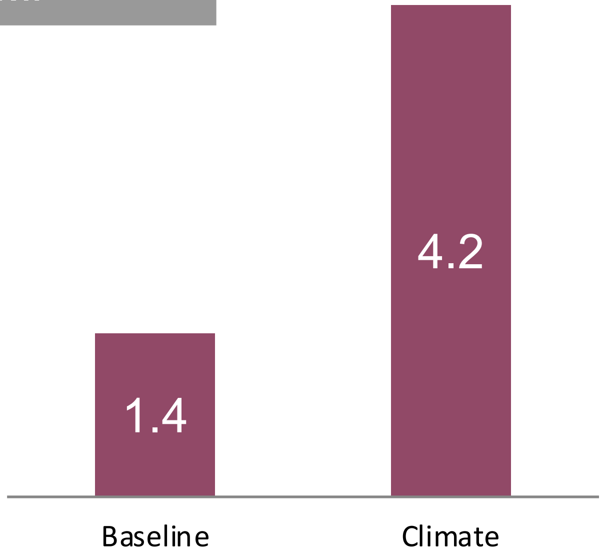
Flexible distributed thermal capacity emerge, back-up with heat storage; centralized flexible capacities need to provide secondary & tertiary reserve



Flexible gas turbines in 2050 (GW_e)



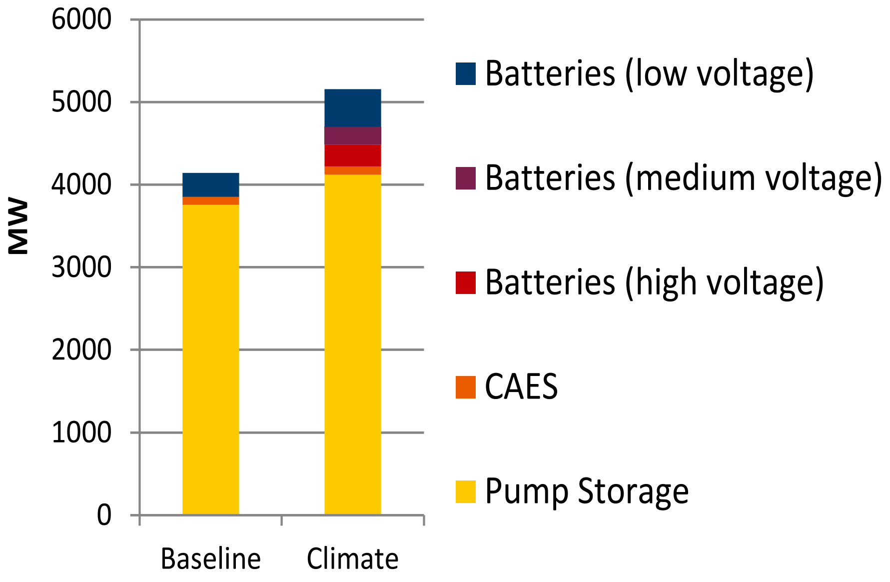
Flexible CHPs in 2050 (GW_e)



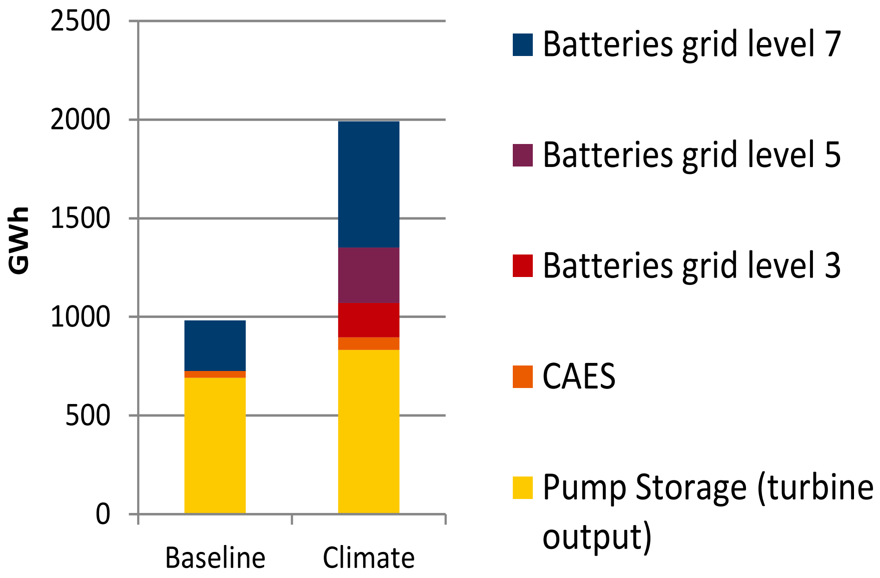
Heat storage to support flexible operation of CHPs in 2050 (GW_{th})

Electricity storage important for VRES integration: batteries used for distributed balancing; pump hydro operation relates to cross-border trade & ancillary markets

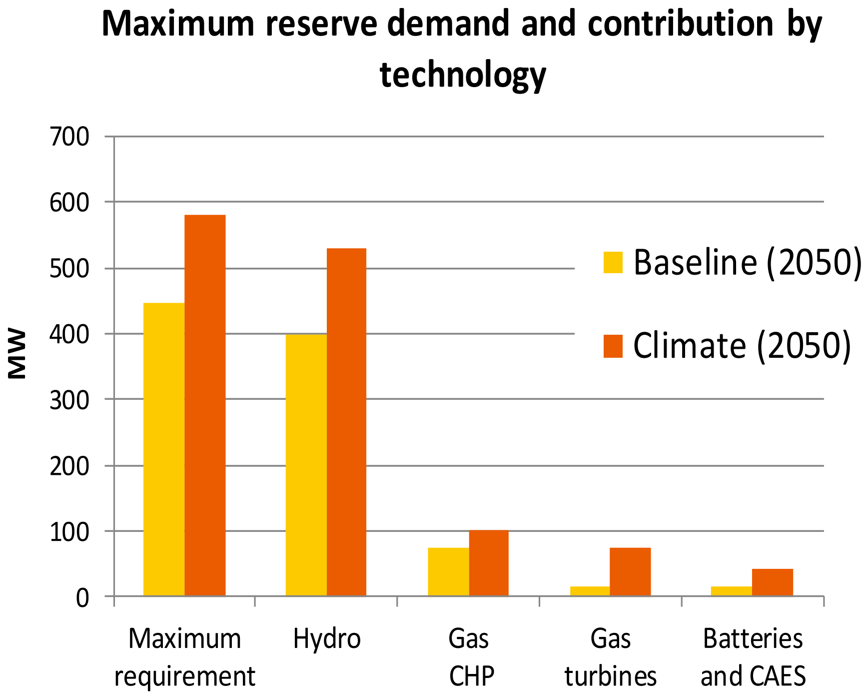
Electricity storage capacity in 2050



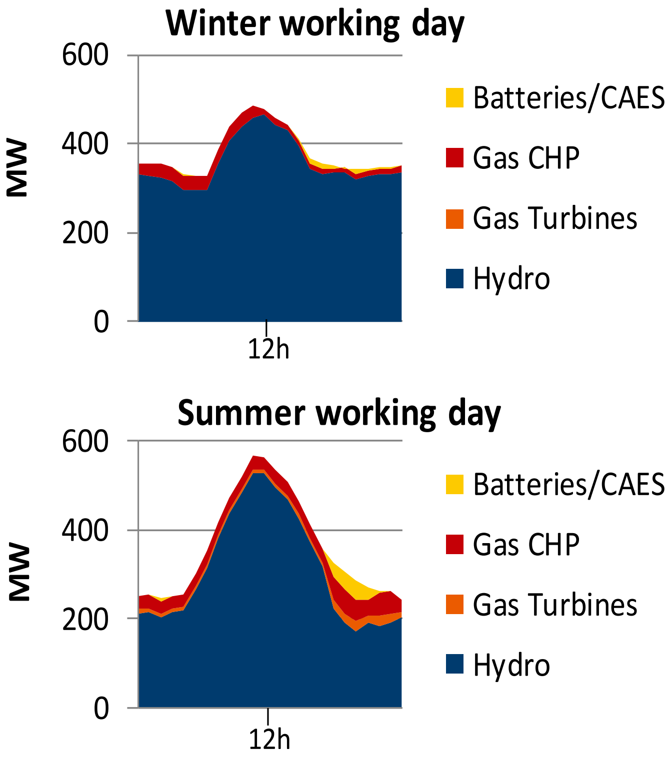
Electricity storage output in 2050



VPPs & gas turbines supply the increased needs in secondary reserve; peak demand shifts from winter to summer

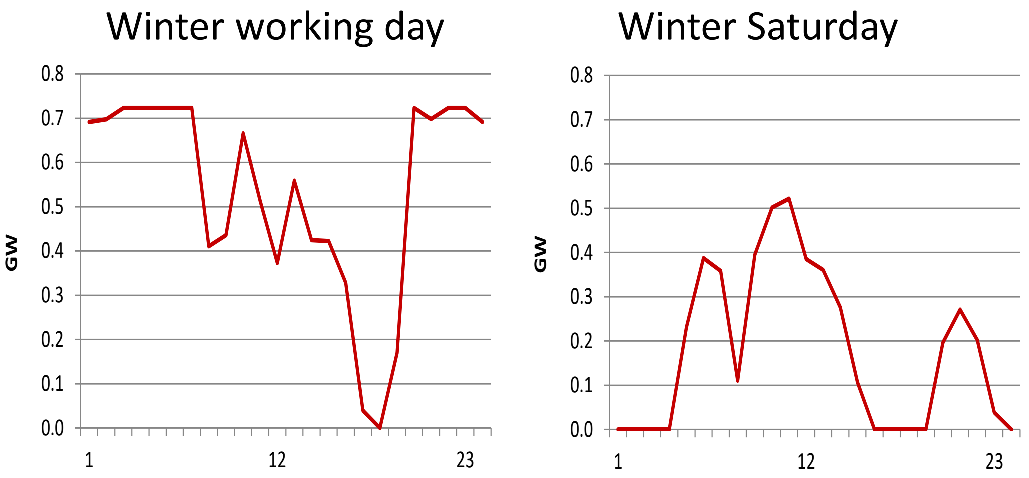


Reserve provision in 2050, Climate scenario

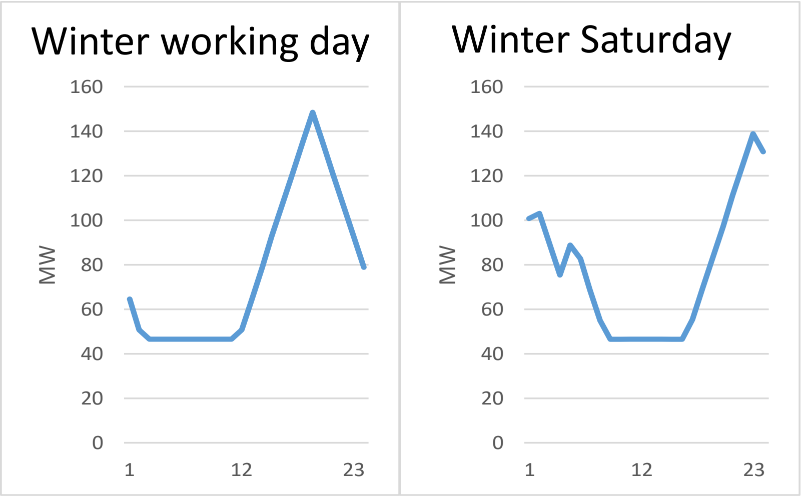


Grid-to-vehicle & vehicle-to-grid provide additional flexibility to the system in *Climate* scenario, via smart two-way communication technologies

3.5 million EVs in 2050 (65% of the fleet) → **4.3 TWh electricity consumption by cars** → **>300 GWh available storage capacity in EVs**



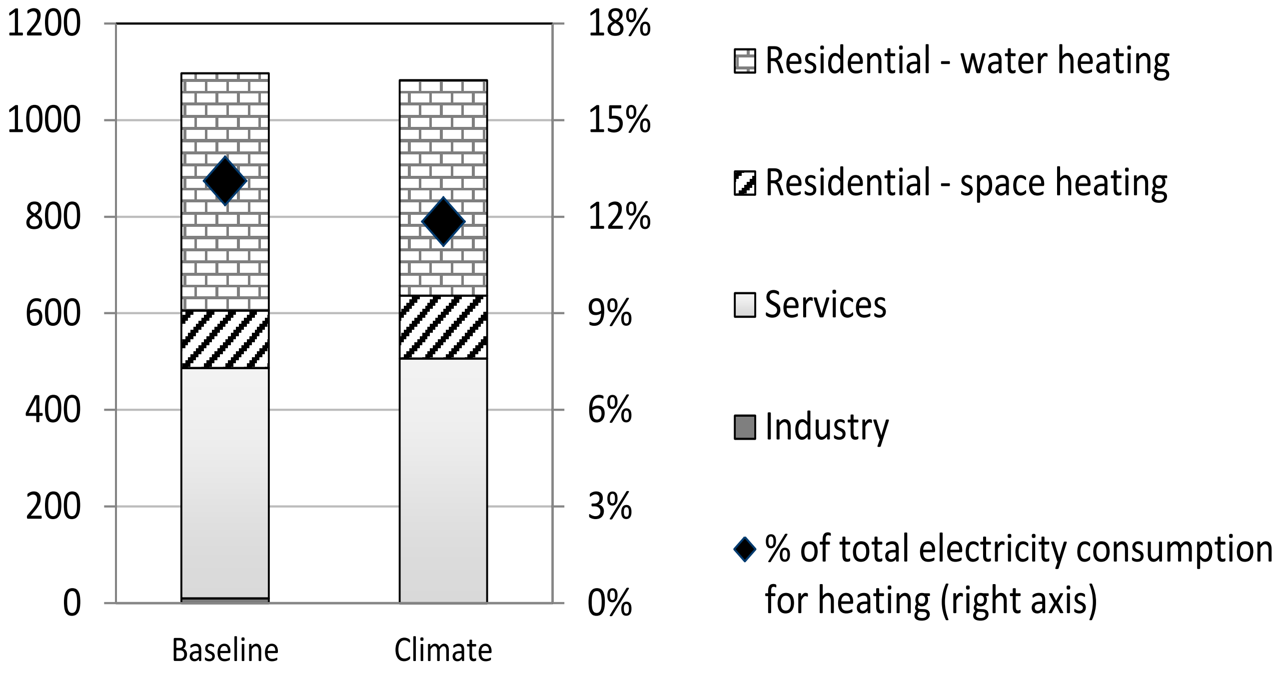
Endogenous G2V profiles in 2050
(note scale is in GW)



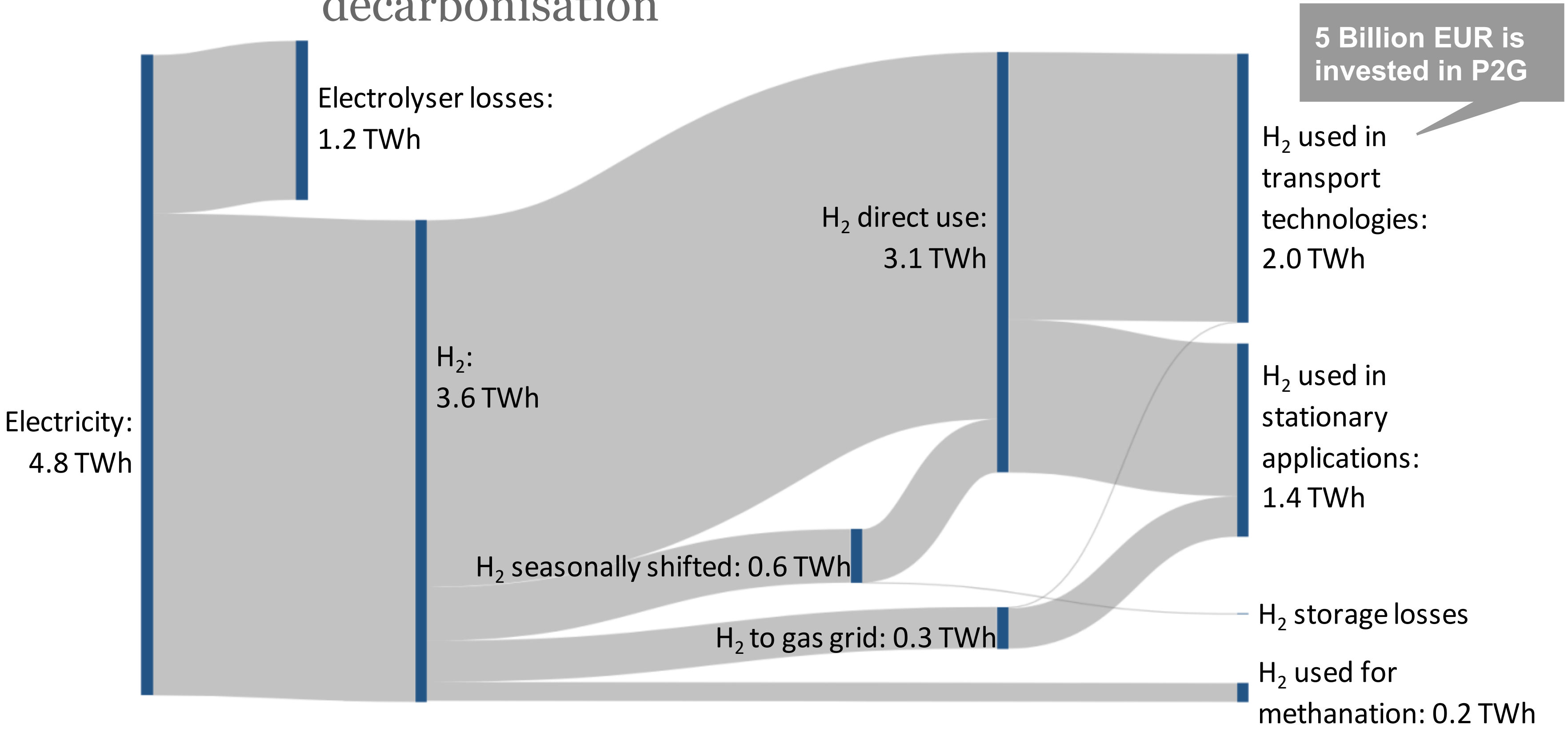
Endogenous optimum V2G profiles in 2050
(note scale is in MW)

Demand side management in buildings sector is a crucial pillar of flexibility; temporal shifts of electricity in electric-based heating systems with storages

Electricity stored in water heaters and heat pump systems in 2050



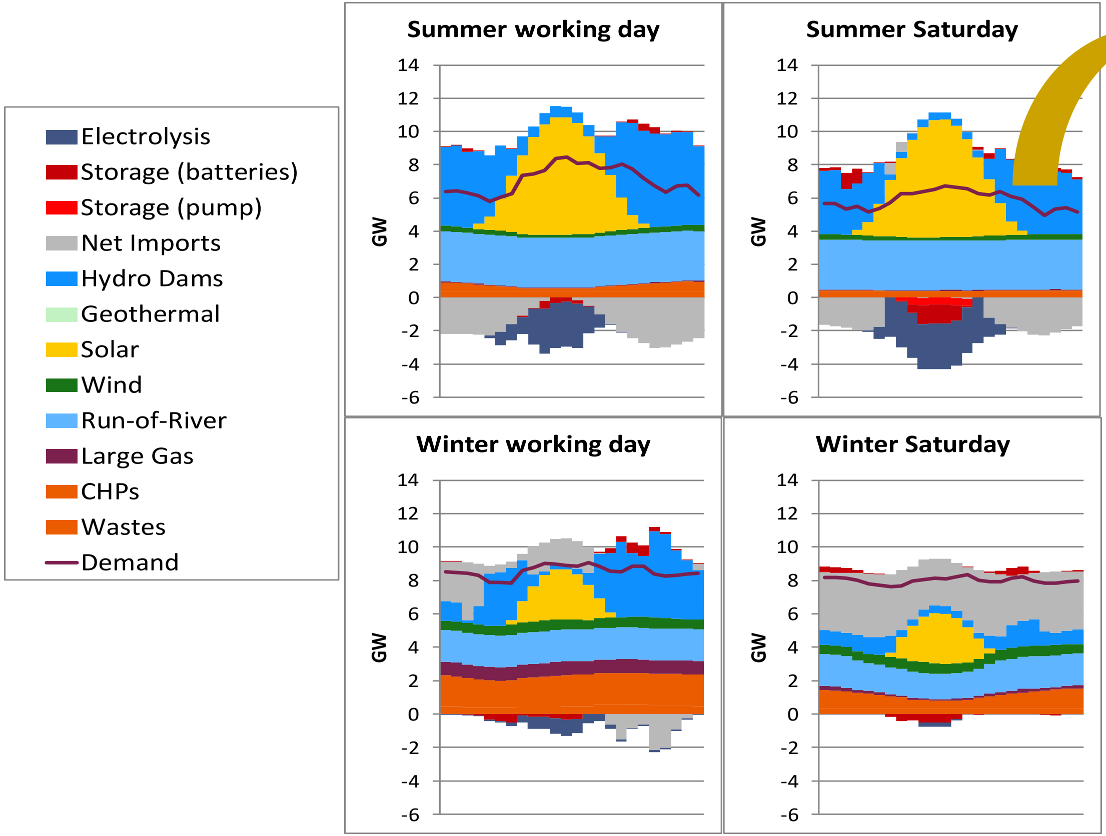
Power-to-gas technologies become commercial, provide seasonal flexibility and generate clean fuels to support decarbonisation

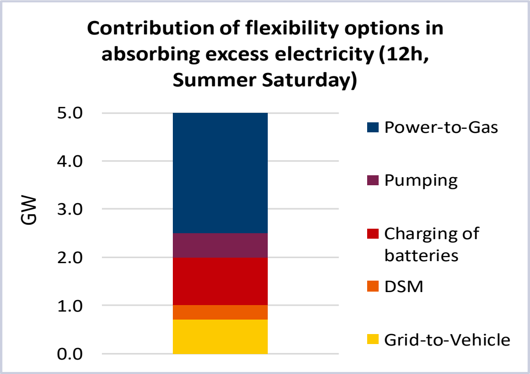


P2X pathway in the *Climate* scenario in 2050

The different flexibility options have complementary and synergistic for a cost effective integration of VRES

Dispatch profile in 2050, Climate scenario

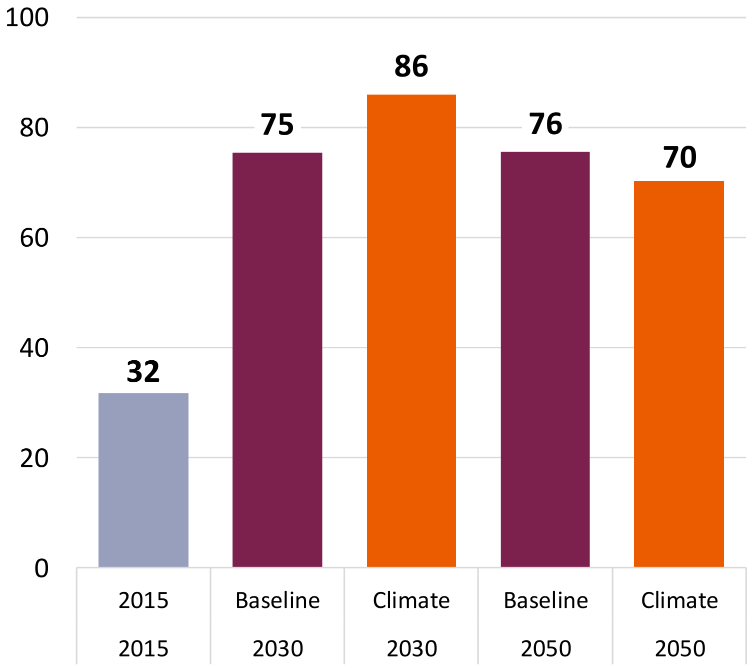




The shape of the load profile in 2050 is much different from today's

The increase in fuel & carbon prices raises the marginal cost of electricity production, but efficient integration of VRES is critical to avoid high price peaks

Marginal cost of electricity production (EUR/MWh)
(median value accros the 288 typical operating hours of the STEM model)



Conclusions

- Flexibility is a crucial parameter for future energy systems worldwide

- Multiple flexibility options need to be synergistically provided, involving multiple actors (energy planners, TSOs, utilities, consumers)

- The type of flexibility options deployed is influenced by uncertainty in energy prices, economic growth, climate policy intensity, technology availability, and market designs

- For the flexibility options to be cost-effective, markets need to be redesigned, new business models to emerge, load forecasting methods to be improved, and consumers need to adopt new flexibility measures

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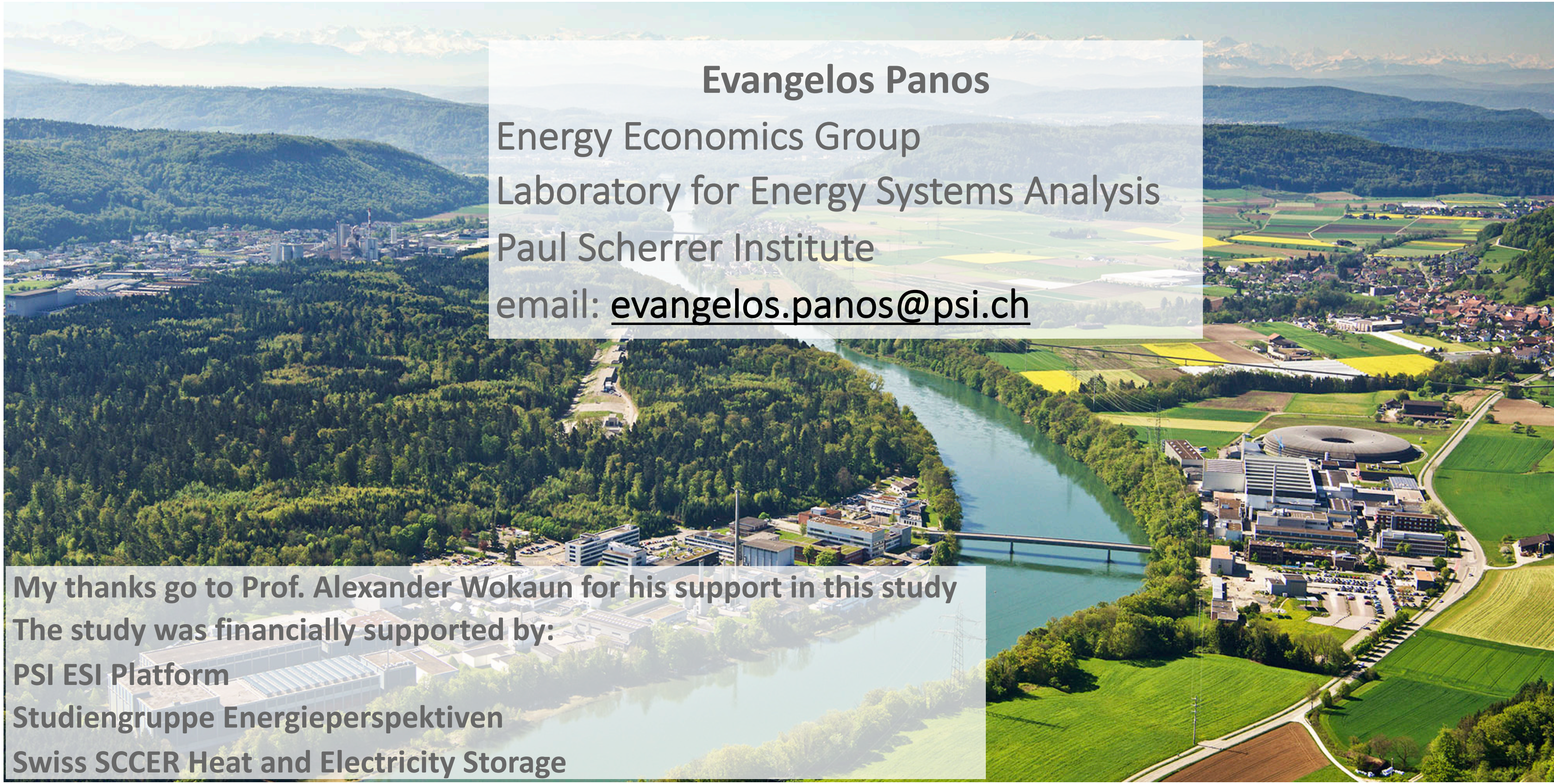
Wir schaffen Wissen – heute für morgen



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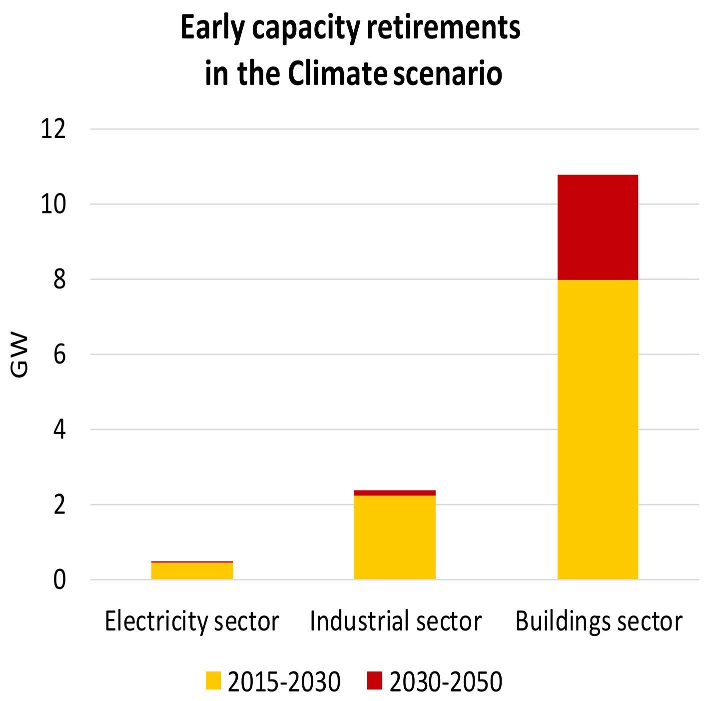
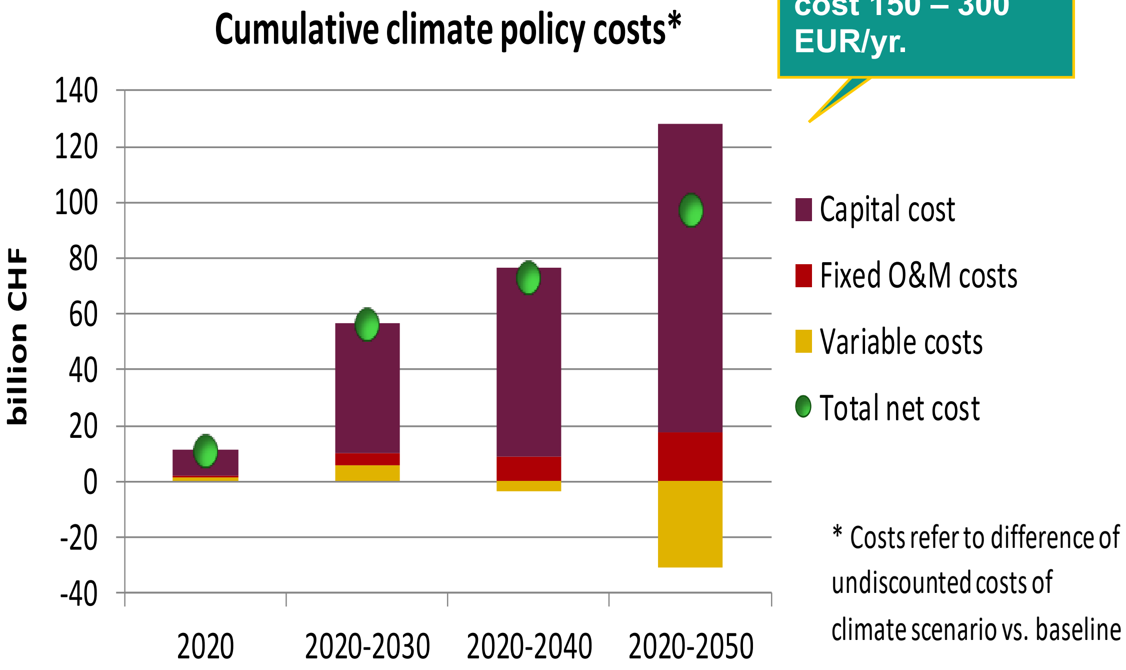
PSI ESI Platform

Studiengruppe Energieperspektiven

Swiss SCCER Heat and Electricity Storage

The transition to a low-carbon system creates stranded assets due to lock in long-lived investments; early action is important to reduce the climate policy costs



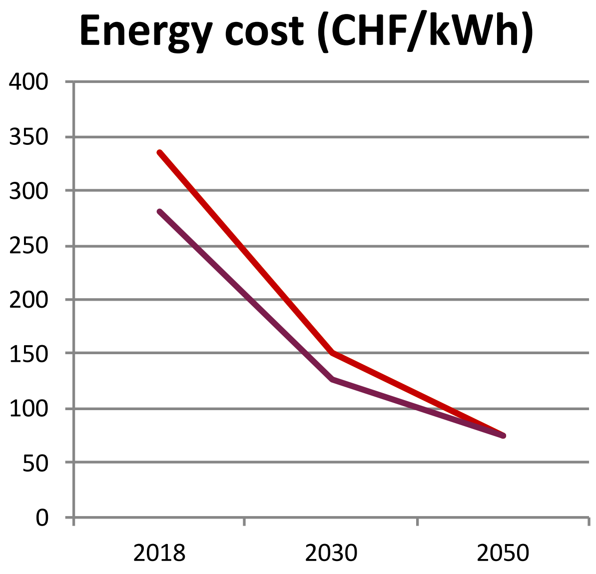


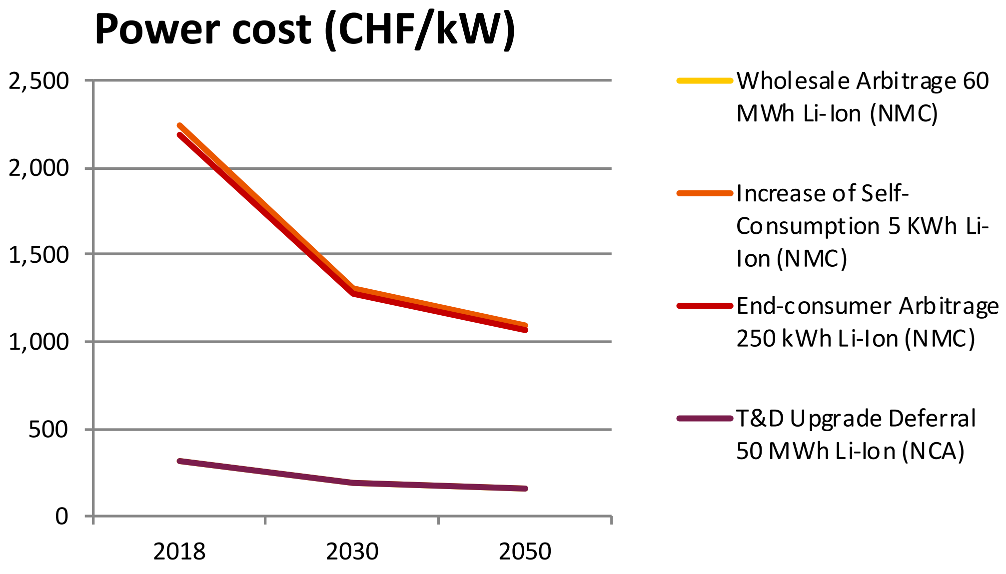
Per capita policy cost 150 – 300 EUR/yr.

* Costs refer to difference of undiscounted costs of climate scenario vs. baseline

Cost assumptions of batteries

- LEA/TA group recent estimates regarding current storage costs from SCCER HAE
- Future projections are based on the developments seen in the IRENA Storage Report 2017





Cost estimates for P2X technologies

	Investment cost		Efficiency	
	Current	2050	Current	2050
Electrolyzer (large scale)	2400 CHF/kW_{H2}	950 CHF/kW_{H2}	63%	75%
H2 Storage (large scale)	900 CHF/kg_{H2}	450 CHF/kg_{H2}	99%	99%
H2 Methanation (large scale)	1500 CHF/kW_{CH4}	800 CHF/kW_{CH4}	70%	85%

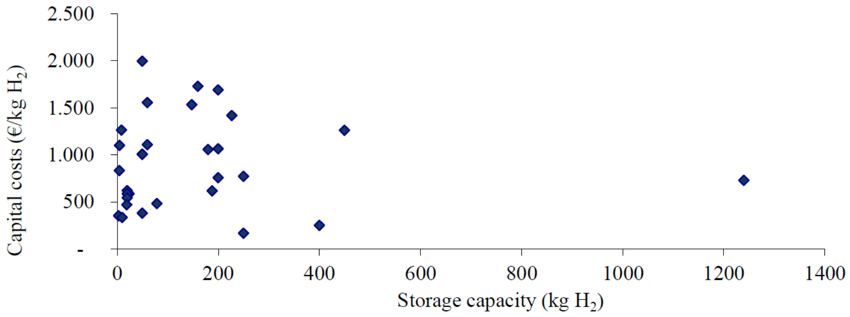


Figure 23: Capital costs for hydrogen storage

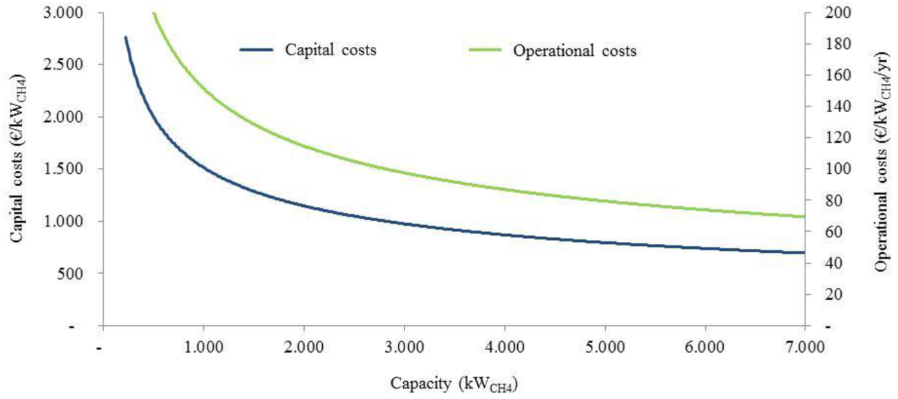
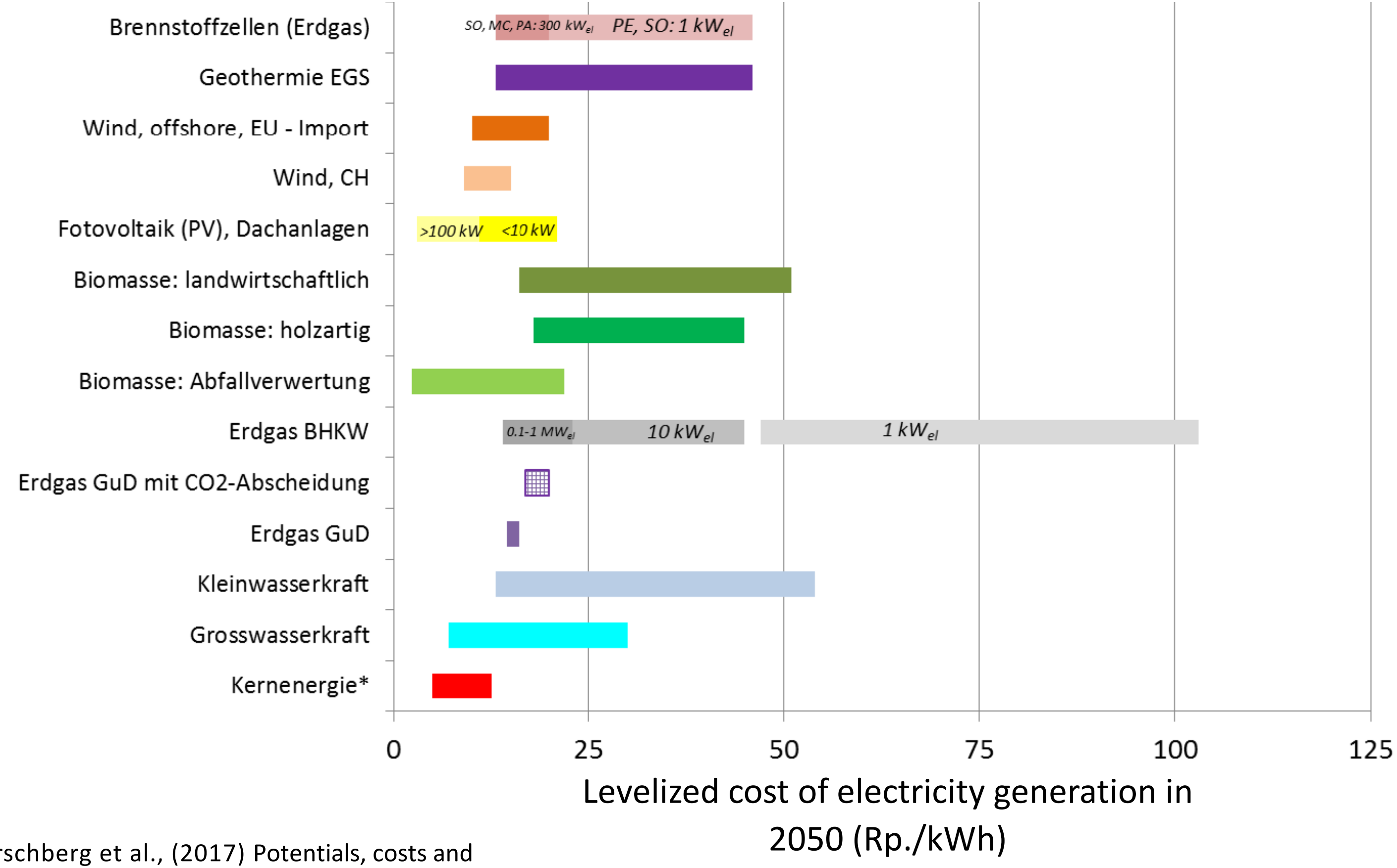


Figure 13: Capital and operational costs of chemical methanation plants.

Source for P2X technologies: KEMA, 2013. Systems analyses Power to Gas
Source for electrolyzers: ISCHESS project, LEA/TA Group estimates

Characteristics of future power technology



Source: Bauer and Hirschberg et al., (2017) Potentials, costs and environmental assessment of electricity generation technologies