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The Contribution of Flexible Sector Coupling to Fully Renewable Electricity Generation in Australia

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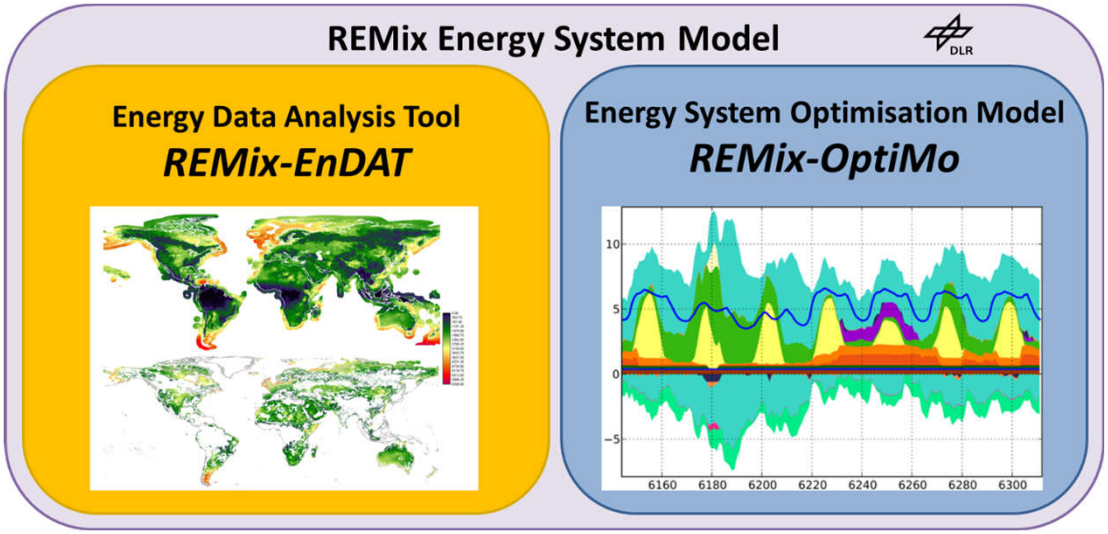
Hans-Christian Gils, Yvonne Scholz, Hedda Gardian

German Aerospace Center (DLR)
Energy Systems Analysis

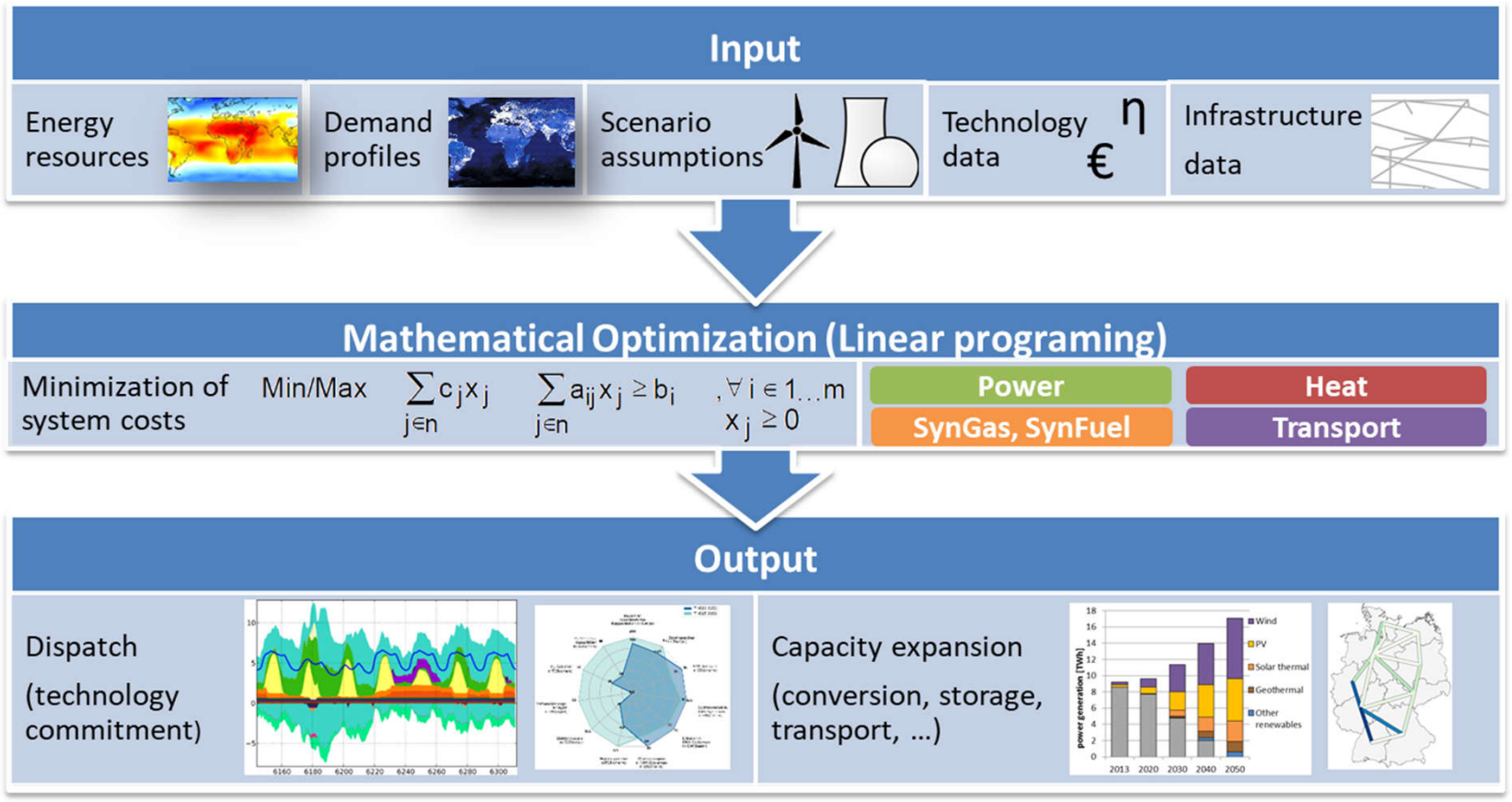
DLR

Research interest

- Evaluation of flexibility in integrated and sustainable energy systems
- In the project
  - Analysis of the energy system transformation in Australia
  - REMix application focused on hydrogen production, sector coupling and infrastructures

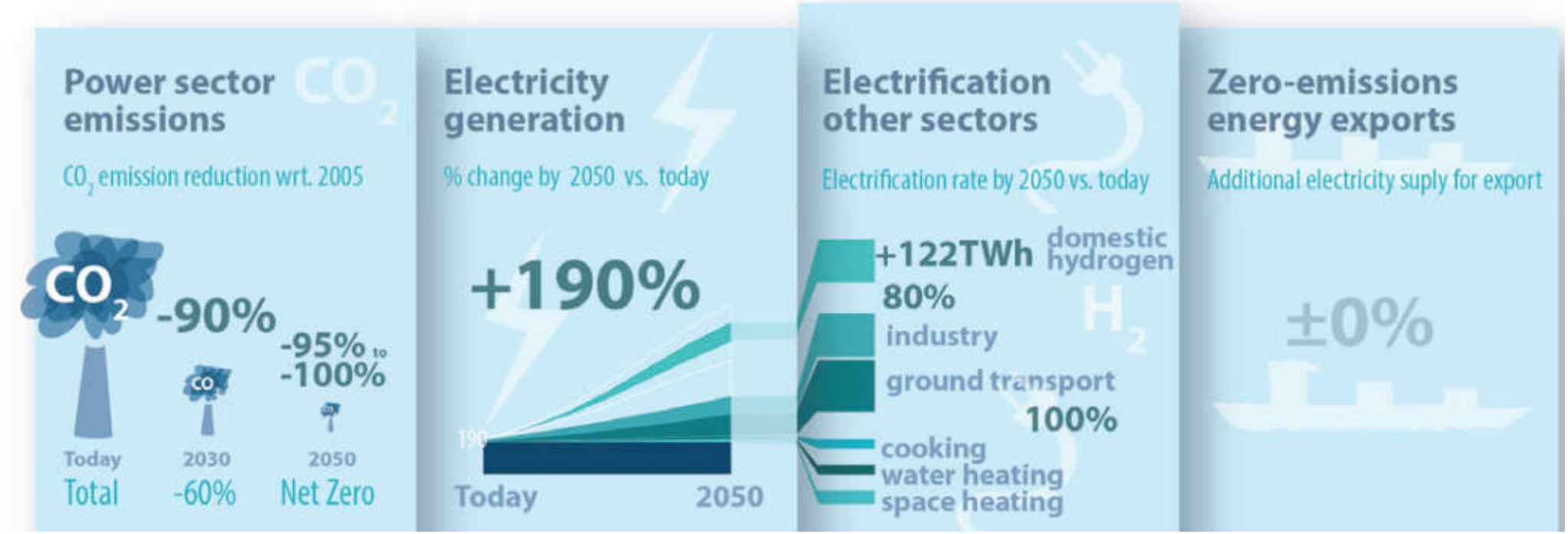


REMix energy system model



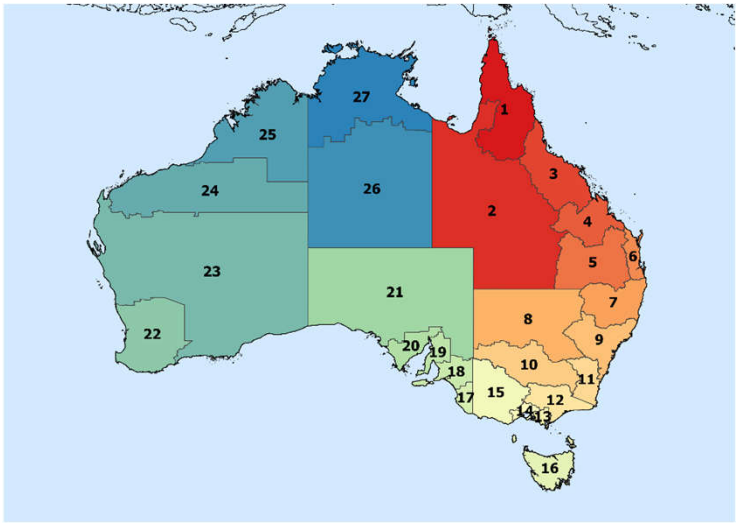
Source: Gils, H.C, Scholz, Y., Pregger, T., Luca de Tena, D., Heide, D. (2017) Integrated modelling of variable renewable energy-based power supply in Europe. Energy, 123: 173-188. http://dx.doi.org/10.1016/j.energy.2017.01.115

Modelled target system for the year 2050



Technologies and regions in the Australian case study

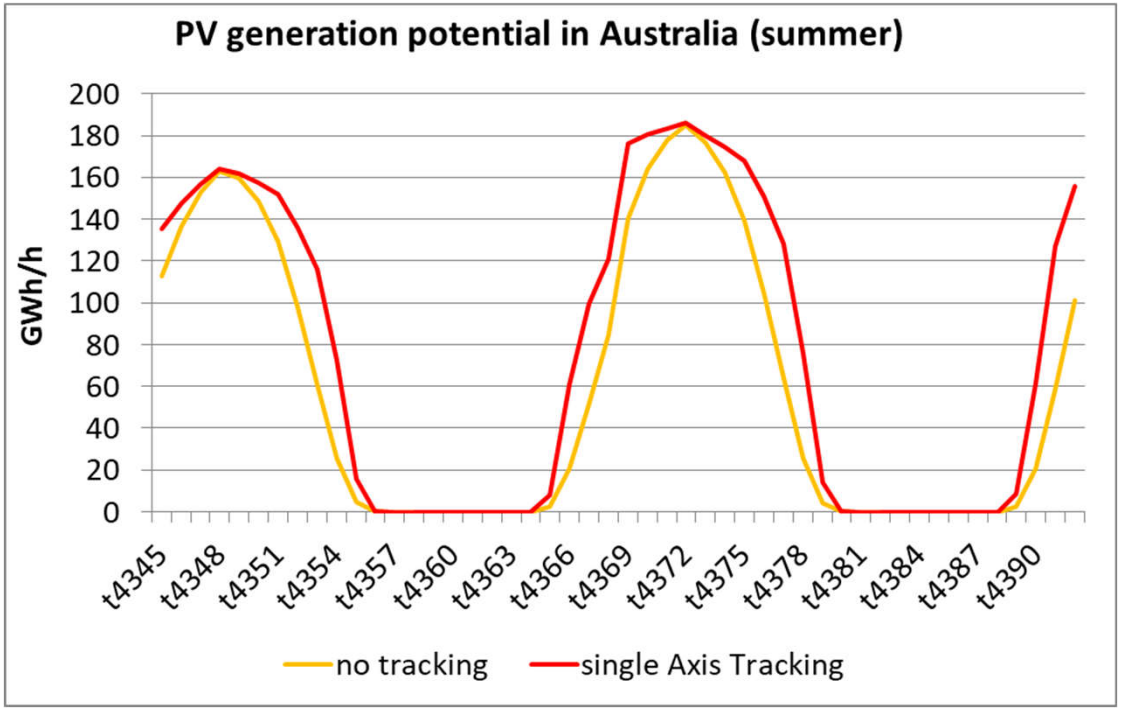
Intermittent power generation	Dispatchable power generation	Conventional balancing options	Energy sector integration	
Roof-top PV	Nuclear fission	Alternating Current grid	CH_4 pipelines	Trans-port
Utility-scale PV	Coal w/ CCS	Direct Current lines	H_2 pipelines	
Onshore wind	Lignite w/ CCS	Pumped hydro storage	Thermal energy storage	Storage
Offshore wind	CH_4-fired SCGT/CCGT	Battery storage	H_2 tank storage	
Run-of-river hydro	H_2-fired SCGT/CCGT		H_2 underground stor.	
Wave	Biomass		CH_4 underground stor.	
	Geothermal		H_2 underground stor.	
	Reservoir hydro	Demand response	H_2 electrolysis	Flexible Loads
	Concentrating solar		Methanation	
	Biomass CHP		Battery electric vehicles	
	CH_4-fired CHP		Electric heating&cooling	
	H_2 fuel cell CHP			



Highlighted are optimized in their capacity

Excursus: new implementation of single axis tracking PV in REMix-EnDAT

- Default: tracking along a north-south axis
- Yield increase: 25% to 29%



Hourly PV generation potential in Australia in 2003,
w/ and w/o single axis tracking

Model configuration: power and gas transport and storage

Power

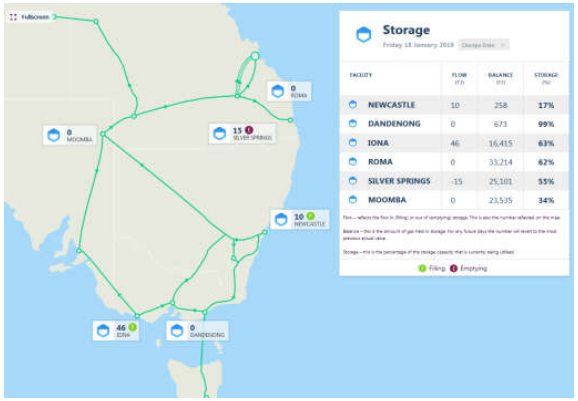
- Existing power grid considered
- AC grid expansion for existing connections and nearby regions, DC grid expansion for longer distances
- Storage expansion: PSH potentials according to ANU*, unlimited expansion of stationary lithium ion batteries

Hydrogen

- Pipeline network can be established endogenously
- Hydrogen underground storage can be built where caverns are available

Methane

- Existing gas pipelines and storage considered
- Endogenous expansion of methanation, pipelines, storage



Screenshot from AEMO gas bulletin board:
https://www.aemo.com.au/energy-systems/gas/gas-bulletin-board-gbb/interactive-map-gbb

*Pumped hydro potentials: http://re100.eng.anu.edu.au/research/phes/

Model configuration: sector coupling in heating , cooling and electric mobility

Heating and cooling

- Consideration of industrial biomass CHP (750 MW)
- Remaining industrial heat supplied by electric boilers (~35%) and heat pumps (~55%)
- Residential/commercial heat supply: ~40% direct electric, ~60% heat pumps
- Consideration of electric air conditioning
- **All technologies can be equipped with thermal storage to provide flexibility**

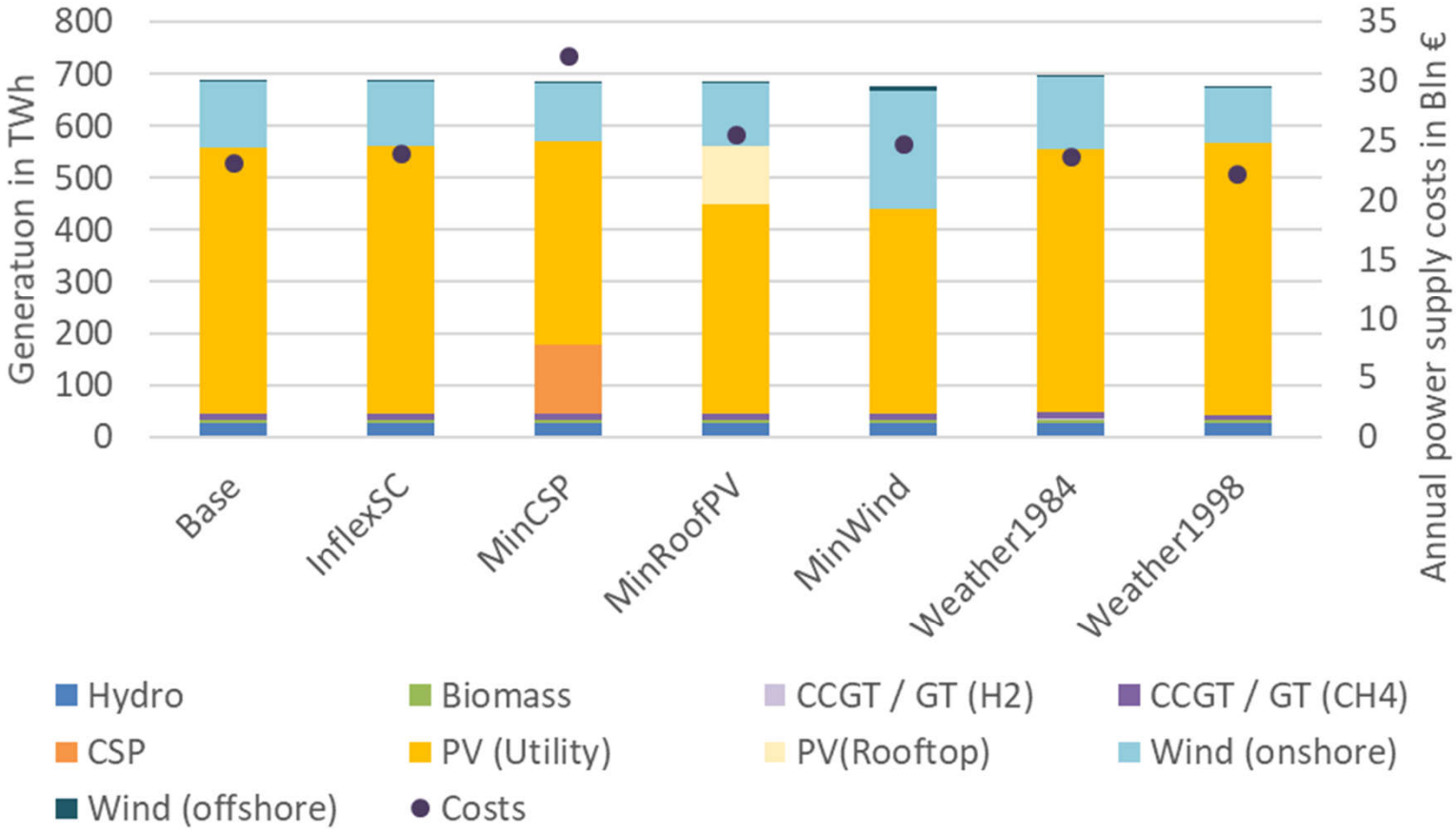
Electric mobility

- Freight transport and electric rail without flexibility
- Passenger cars provide some flexibility in charging

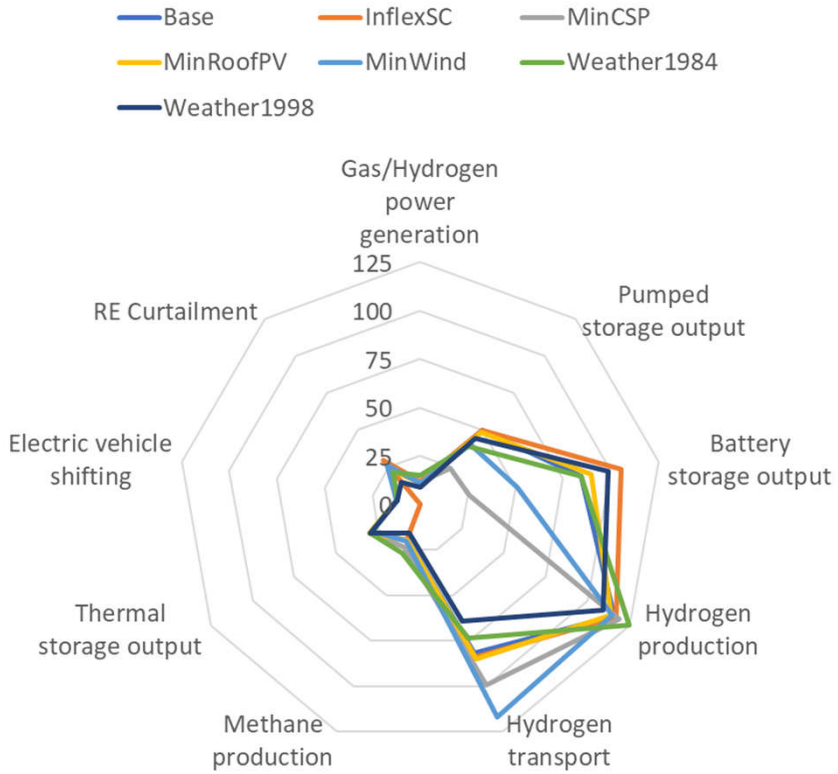
Scenario variations

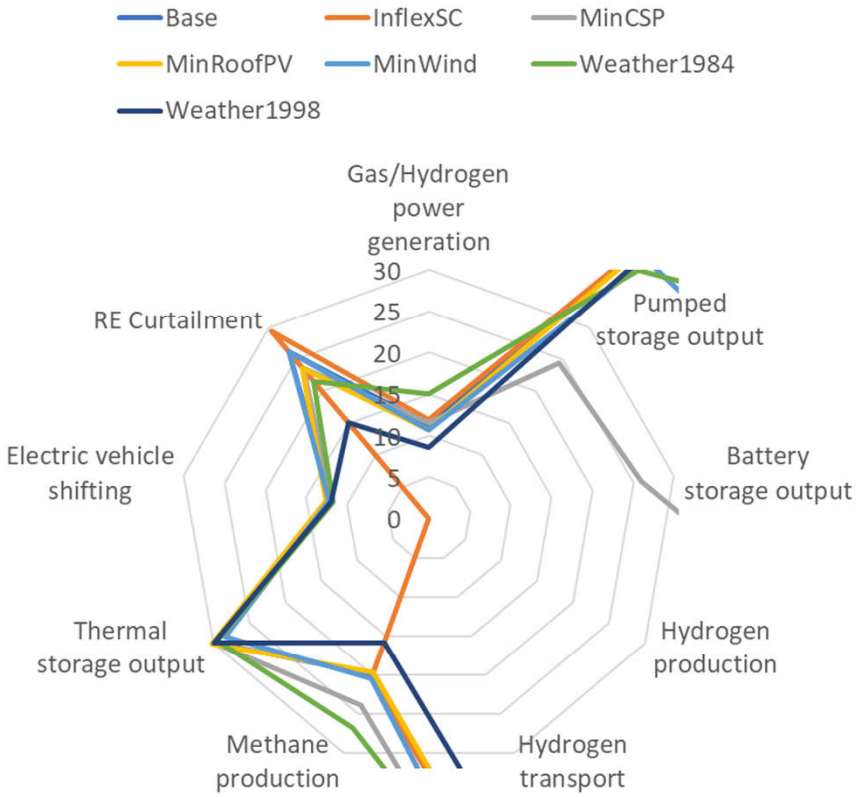
Scenario	Description
Base	With flexible sector coupling,historical weather data of the year 2003
InflexSC	Inflexible sector coupling: no controlled charging and thermal storage
MinCSP	Exogenously defined CSP capacity of 30 GW
MinPV	Exogenously defined rooftop PV capacity of 112 GW
MinWind	Exogenously defined wind supply share of 40%
Weather1984	Historical weather data of the year 1984: higher solar and lower wind availability
Weather1998	Historical weather data of the year 1998: lower wind and solar availability

Resulting power generation structure and power supply costs

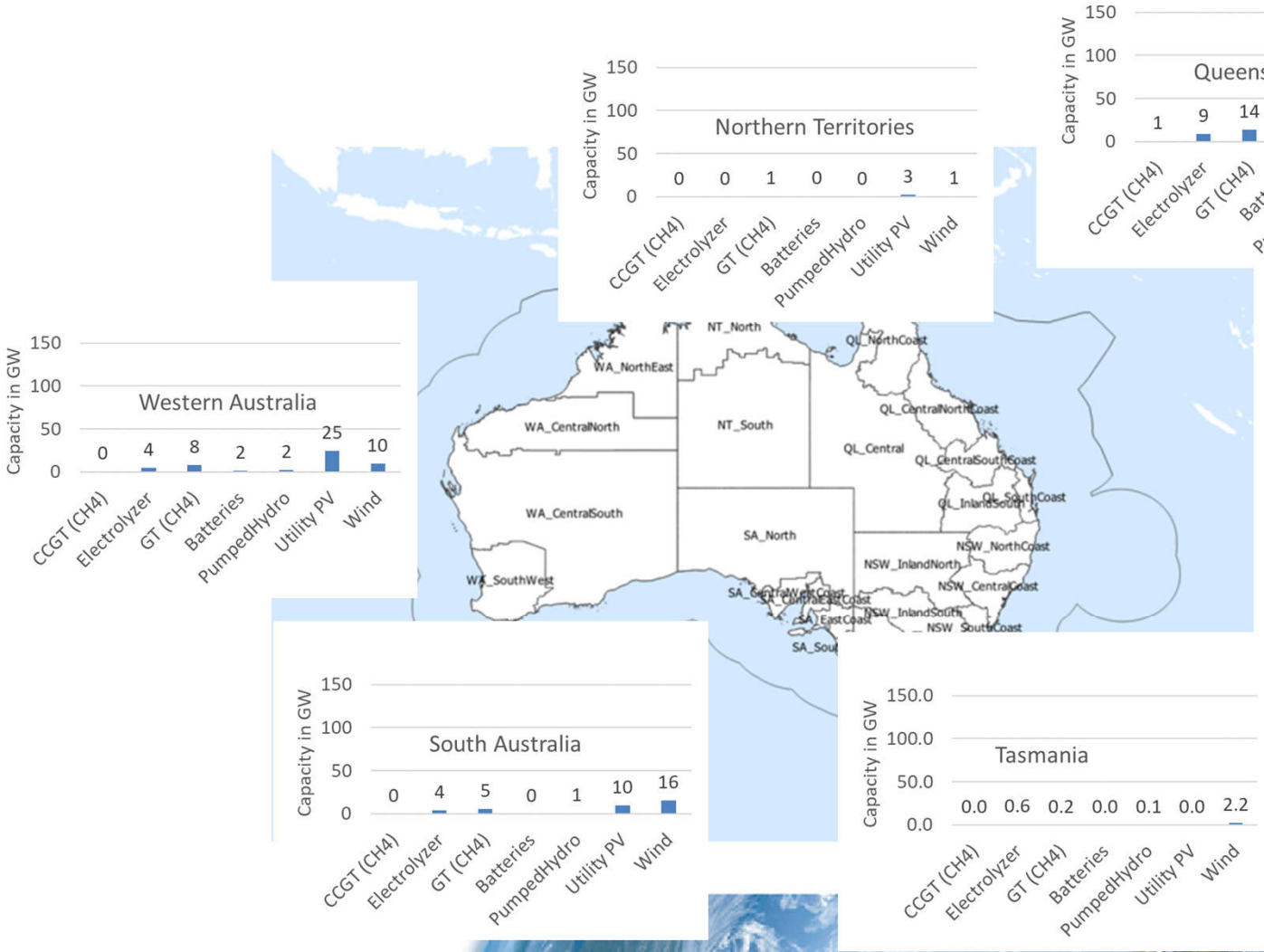


Model results on load balancing

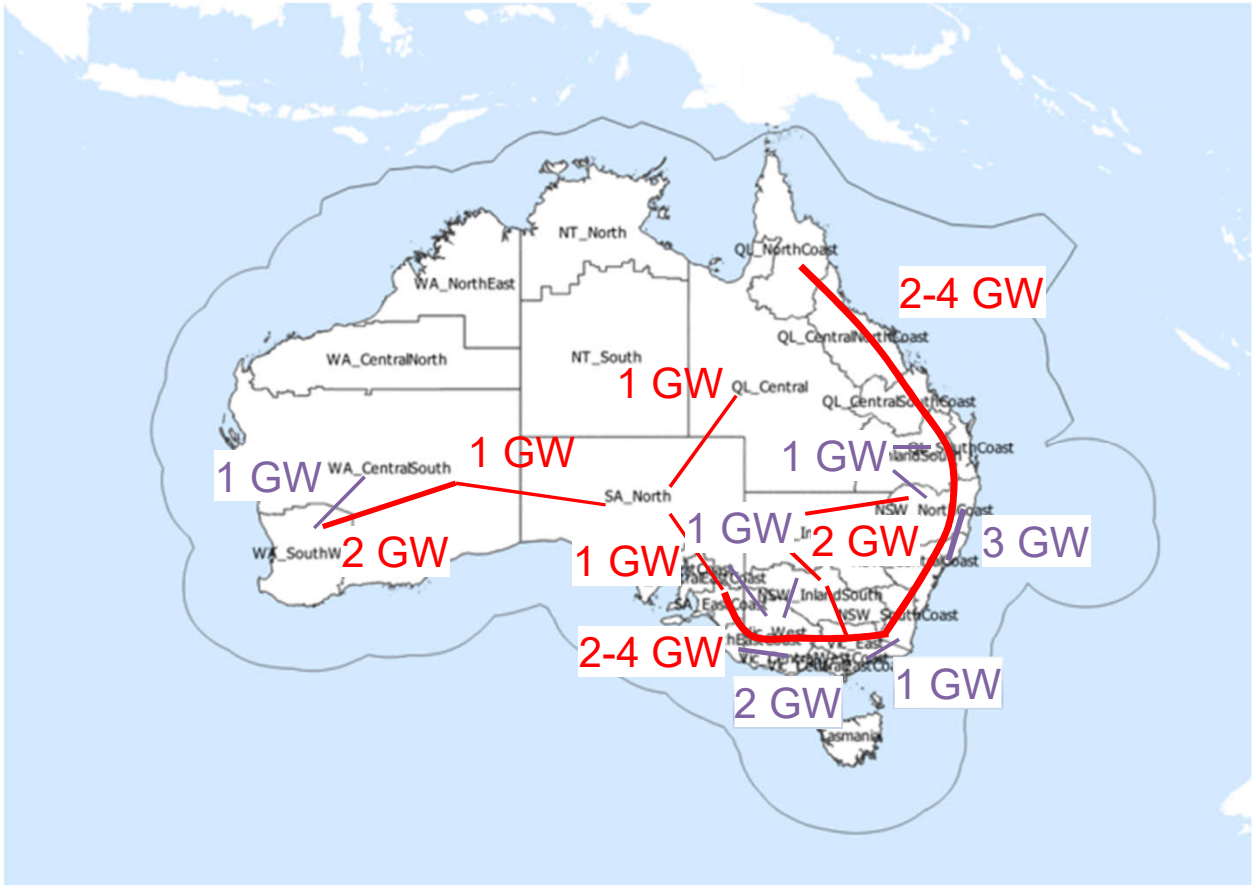




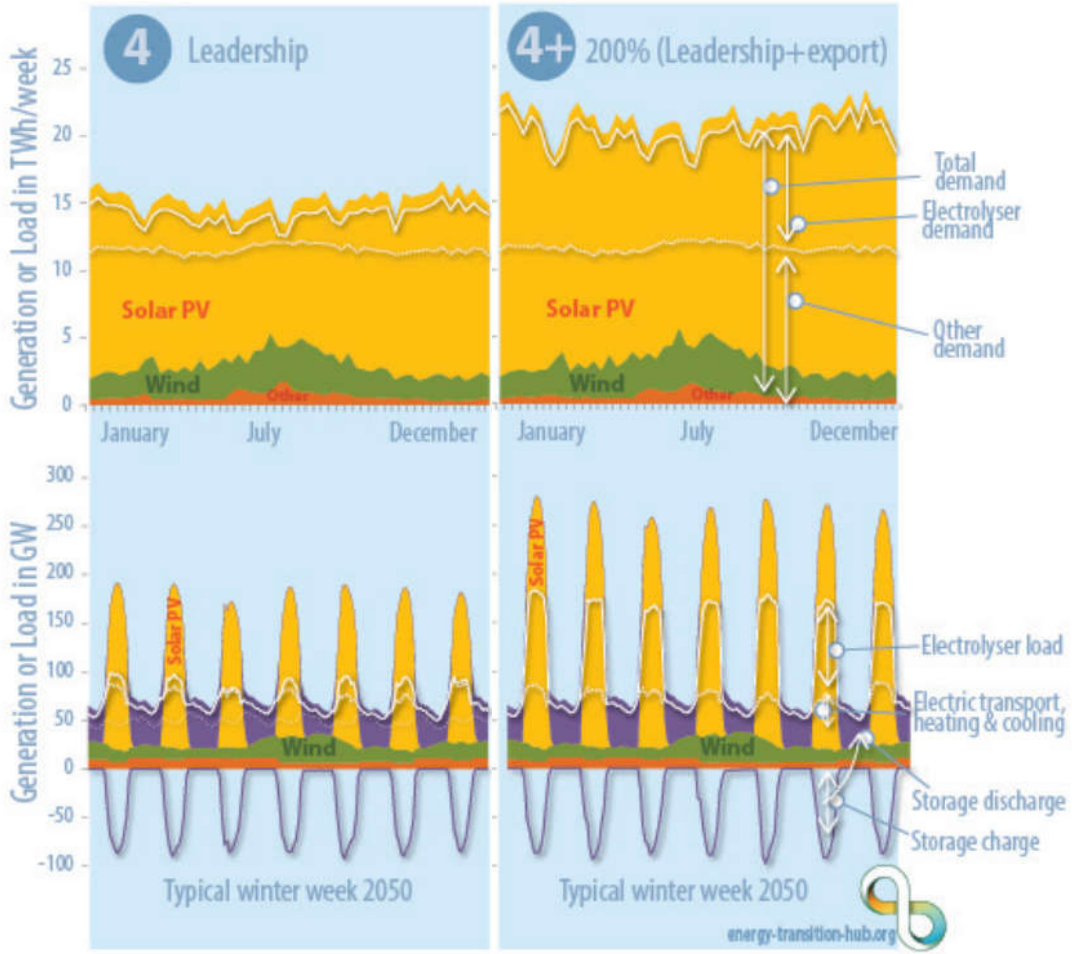
Regional distribution of converters and storage



Expansion of the power grid and hydrogen pipelines



Representative system dispatch in the Base case



Conclusions and outlook

- Least-cost wind supply share strongly depends on assumed historic weather year
- Higher shares of rooftop PV and wind without significant impact of system costs → flat minimum
- Large-scale hydrogen infrastructures built, including transport pipelines in the southwest of the country
- Flexibility mostly provided by electric energy storage and flexible hydrogen production
- Flexibility of heating/cooling and transport is used, but to minor extent and without big impact on system costs

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Contact

Dr. Hans Christian Gils, Head of the Energy Systems Modelling Group

Department of Energy Systems Analysis, Institute of Engineering Thermodynamics, German Aerospace Center (DLR)

Curiestrasse 4| 70563 Stuttgart | Germany

Telefon +49 711 6862-477 | hans-christian.gils@dlr.de | www.DLR.de/tt

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