

WORKSHOP ENERGY & SPACE

**Overcoming the challenge of limited space
to achieve a decarbonised energy system**

Renewables
Grid Initiative 



Co-funded by
the European Union

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Space and Energy Infrastructure Planning

Understanding needs for decarbonisation



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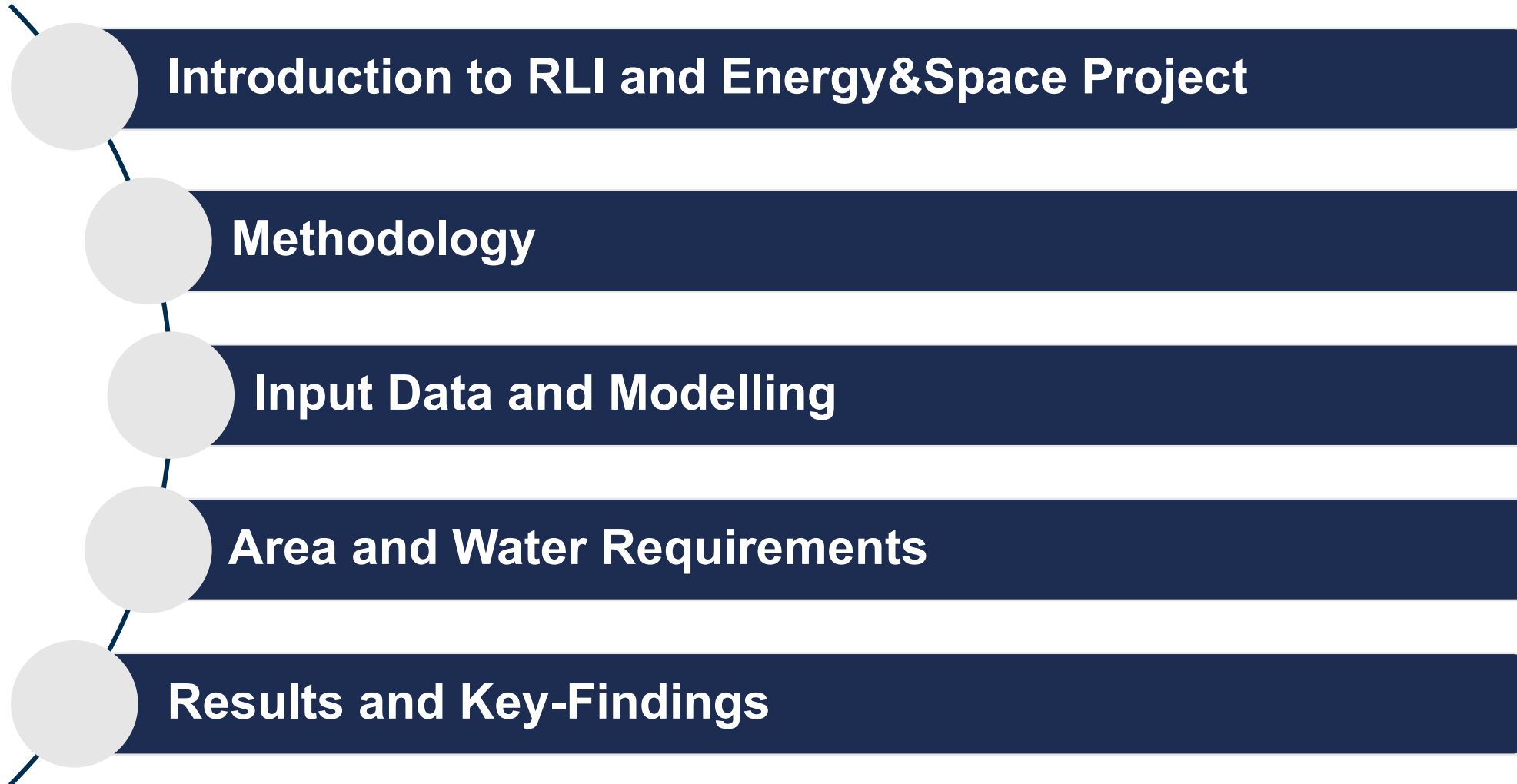


Project Energy&Space

Paul Dubielzig, Birgit Schachler

27th September 2023



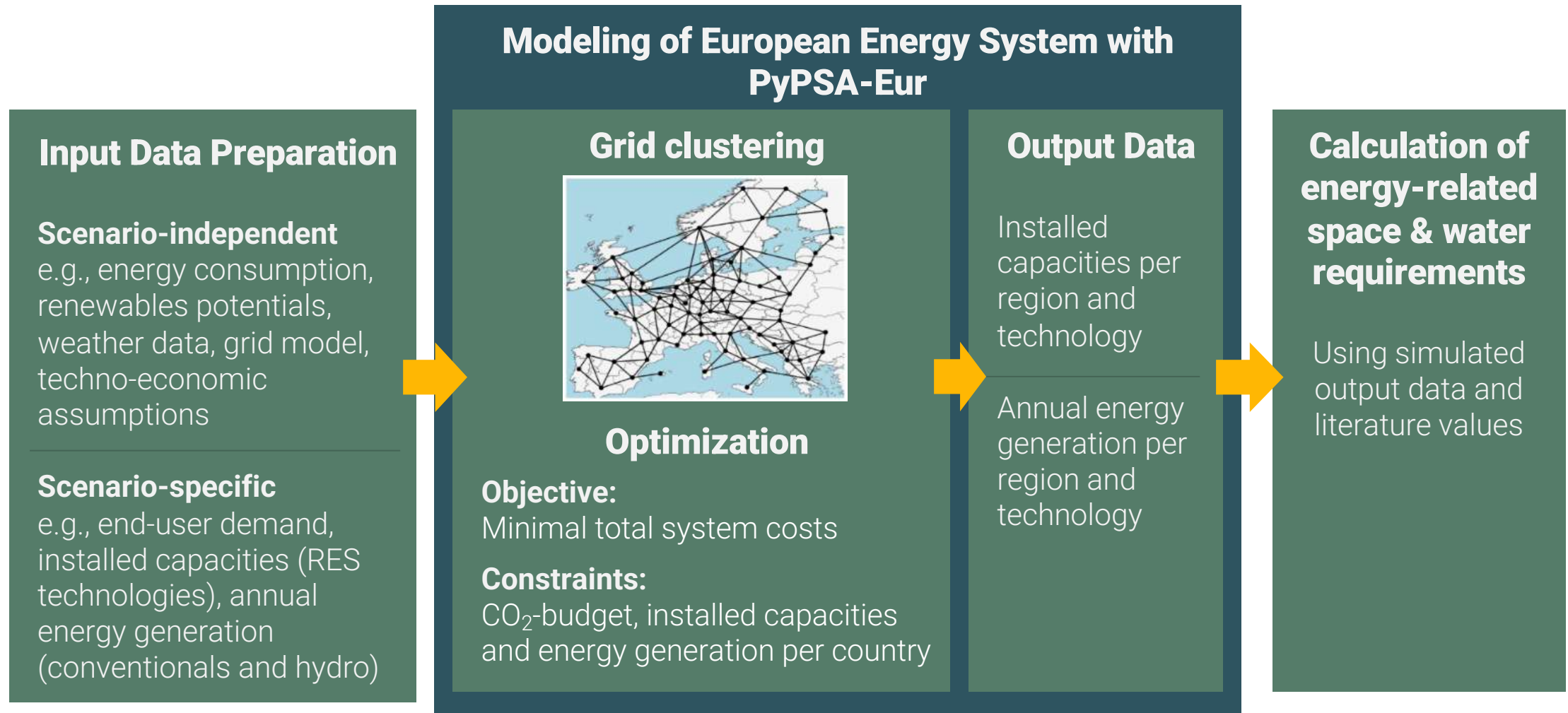


Introduction to RLI

- Independent non-profit **research institution** based & founded in Berlin
- 100% owned by Reiner Lemoine Foundation
- Goal: **energy transition** towards a future with 100 % renewable energy supply
- Around **100 employees**
- **Research units:**
 - Transformation of Energy Systems
 - Mobility with Renewable Energy
 - Off-Grid Systems



Reiner Lemoine
Founder of
Reiner Lemoine Foundation



Input Data: Scenario-specific Data

Demand:

Country-specific annual demand data for buildings, transport, industry and agriculture sector

→ if not available, generated using PyPSA-EUR

Supply:

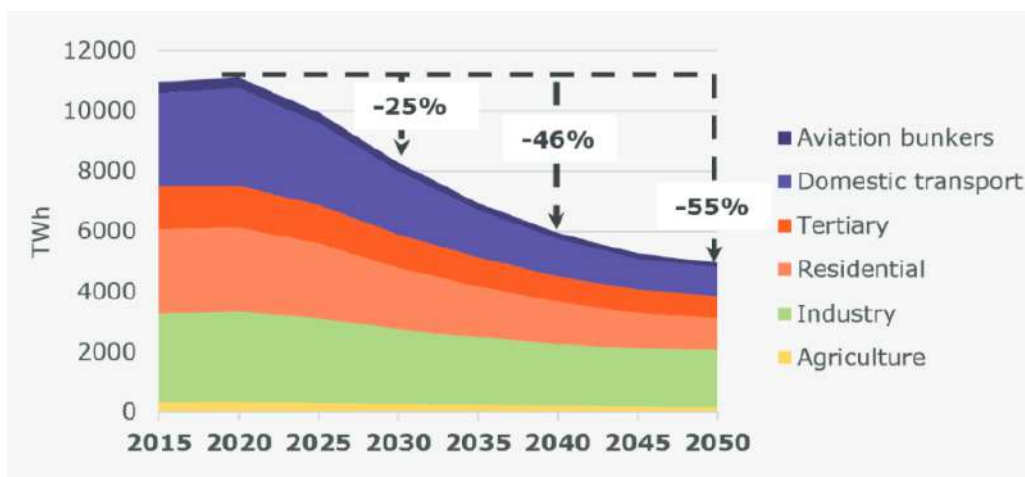
Country-targets on installed capacities for renewables and annual energy generation for conventional power plants

→ if not available, target is optimized by PyPSA-EUR

CO₂:

CO₂-budgets on European level for emissions in the different energy sectors as well as for Land Use, Land-Use Change and Forestry (LULUCF) related emissions

→ LULUCF related CO₂-budgets not included in PyPSA-EUR



Evaluation of final energy consumption for the EU27 in the CLEVER scenario

[CLEVER, S.24]

Model: PyPSA-EUR

Default workflow:

- Minimize total costs for given constraints (e.g., CO₂-budget, limits on wind/solar potentials)

Modified workflow:

Additional Constraints:

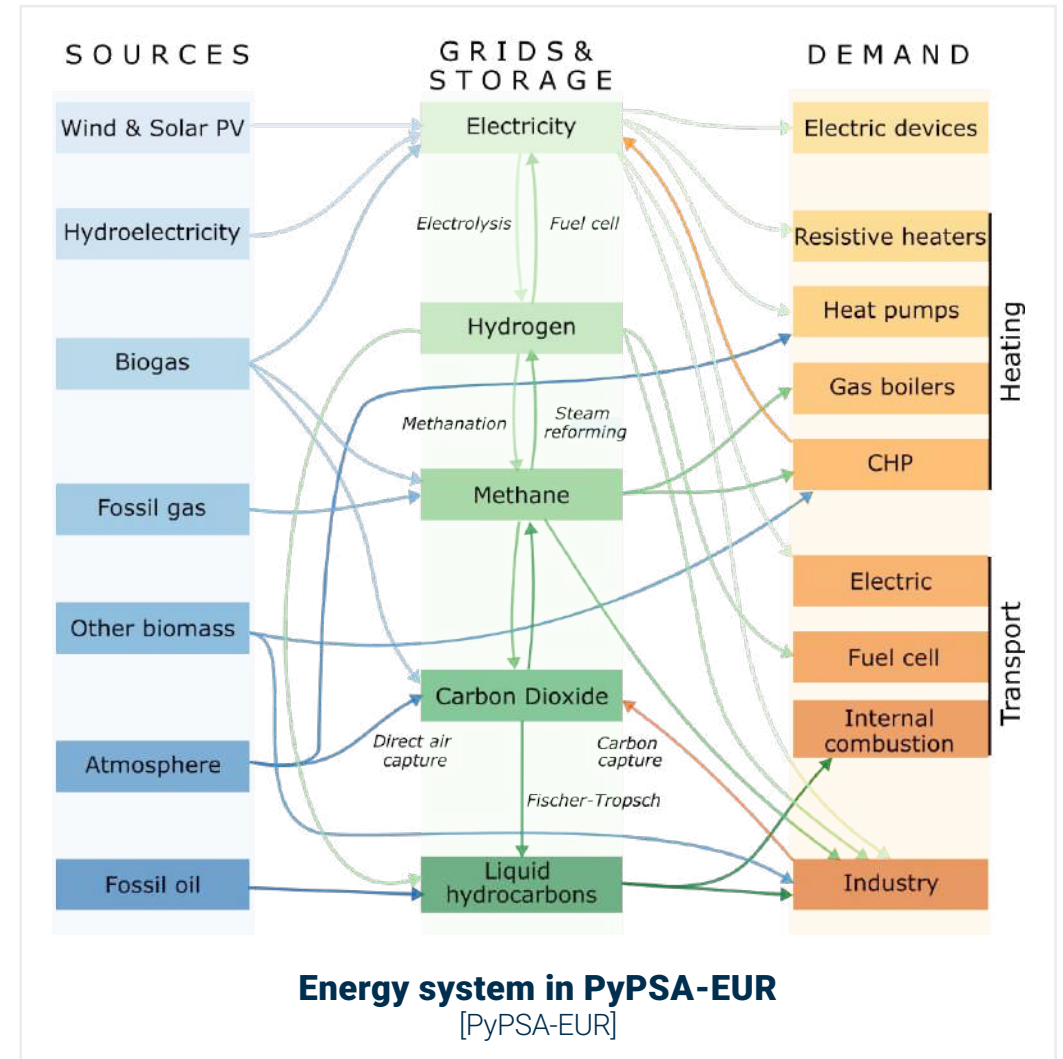
- Generator capacities for renewables
- Annual energy generation for conventional technologies and hydro power
- Introduction of slack variables

Objective:

- Minimize total costs **and** slack variables

Source code openly available on github

<https://github.com/rl-institut/pypsa-eur>



Area requirements: Energy System

Generation and storage technologies:

→ Calculated with specific area requirement and optimal installed capacity per region

Technology	Installable capacity
Wind onshore	10.42 MW/km ²
Wind offshore	10.42 MW/km ²
PV rooftop	152.46 MW/km ²
PV open space	50.31 MW/km ²
Electrolyser	5,882 MW/km ²
Hydrogen storage	100,000 MWh/km ²

Transmission grid:

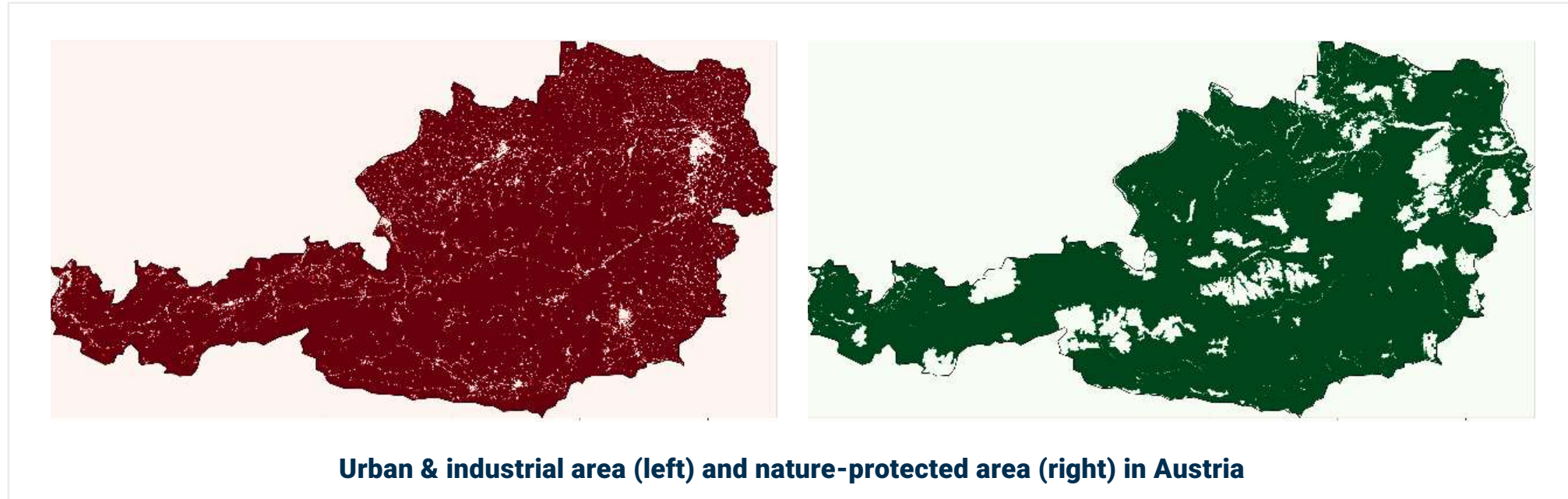
Assumption:

Space requirement in future is proportional to factor grid is expanded by

Space requirement in status quo:
Length of lines (from ENTSO-E) times surrounding security zone of 70 m

Grid expansion factor per region:
Ratio of grid capacity in year t and grid capacity in status quo (determined for clustered grid)

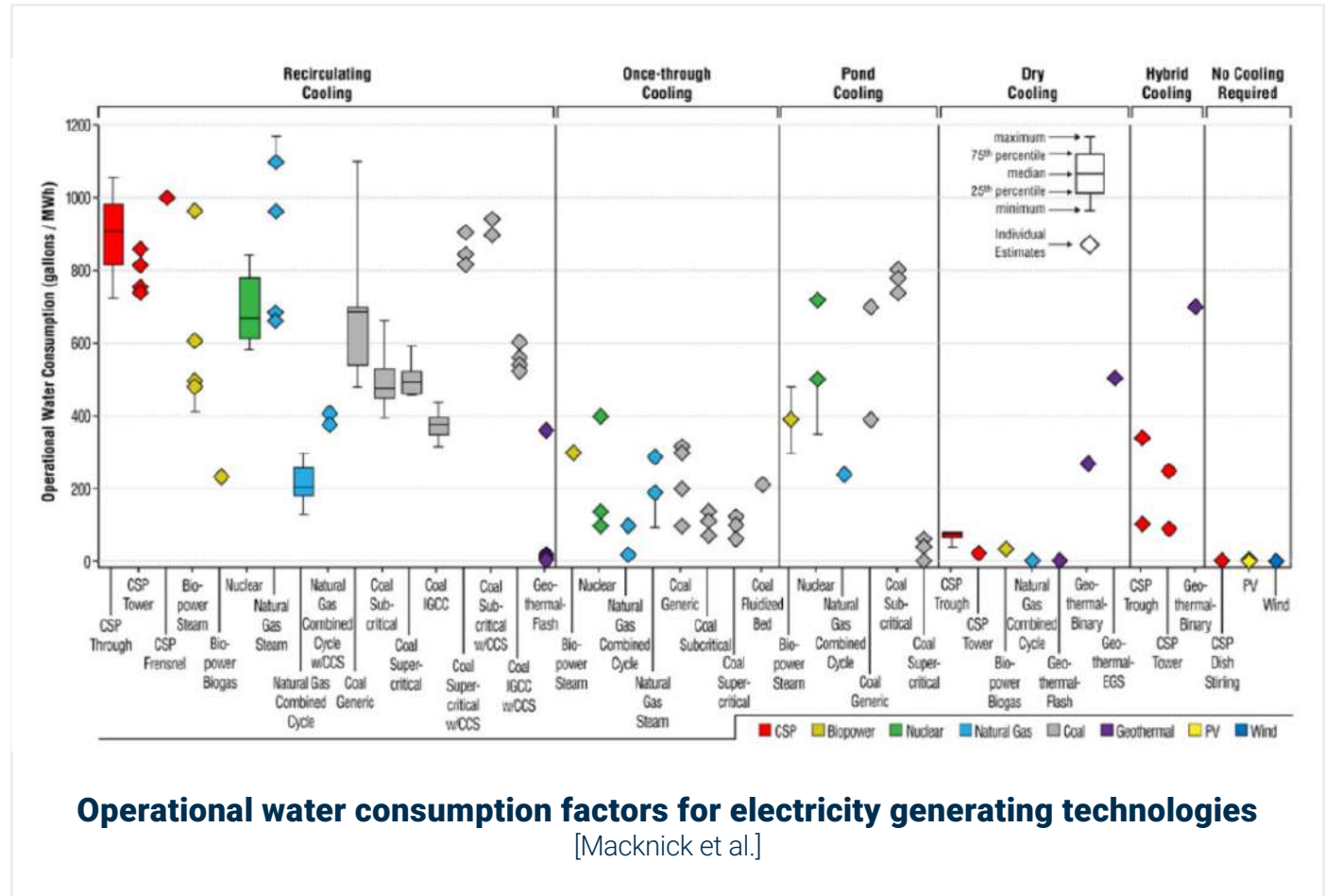
Area requirements: Land Use



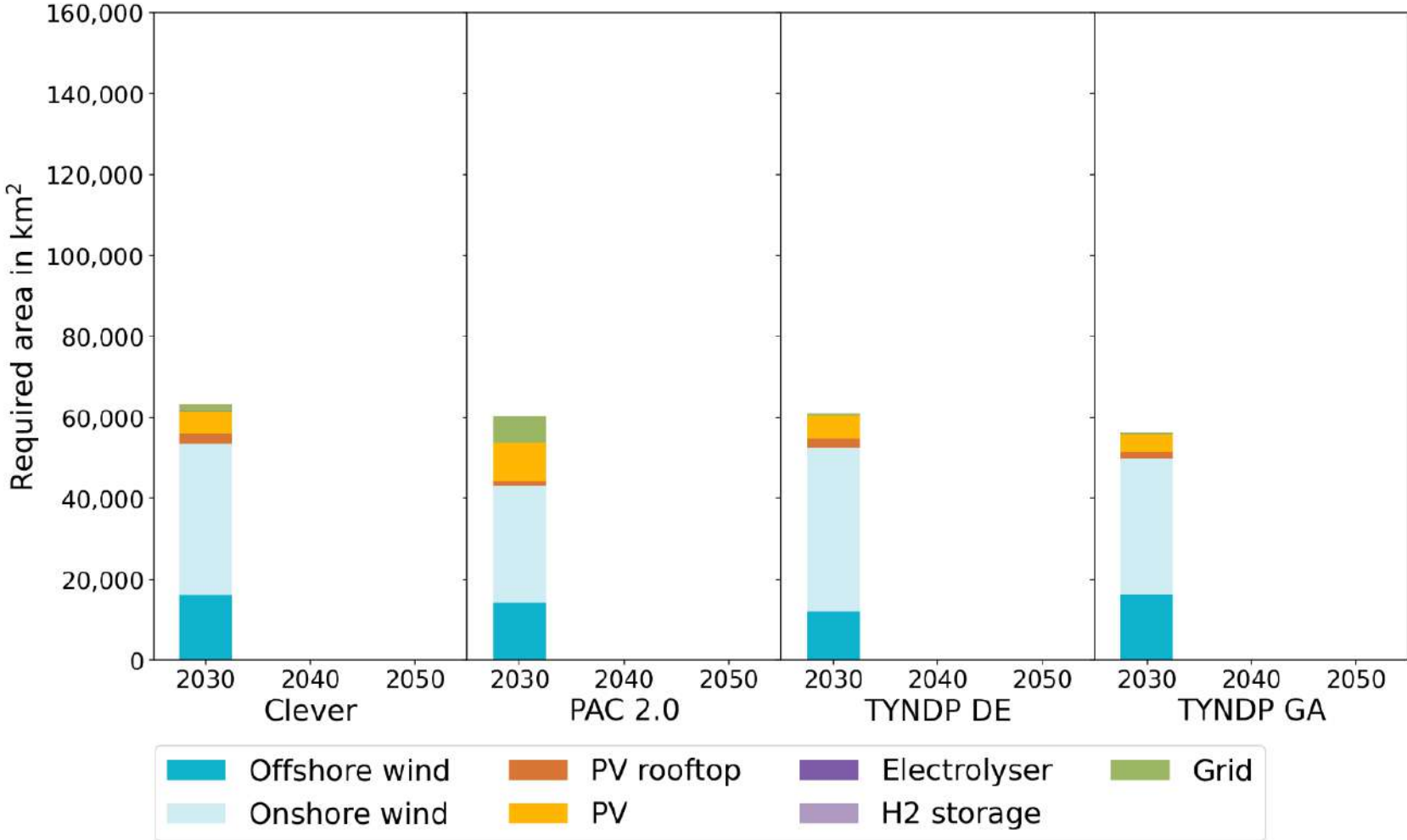
- Area footprints of on- & offshore nature-protected areas and urban & industrial areas
- Computed using atlite tool in combination with Natura2000 and CORINE datasets
- Land-use values do not change over time

Water requirements

- Includes thermal power plants, hydro power and hydrogen production facilities (electrolysers & SMR)
- Calculated using Water Use Intensity (WUI) factors and optimal annual electricity generation
- WUI factor depends on generator type and cooling technology
- Assignment of WUI factors using JRC Open Power Plant Database

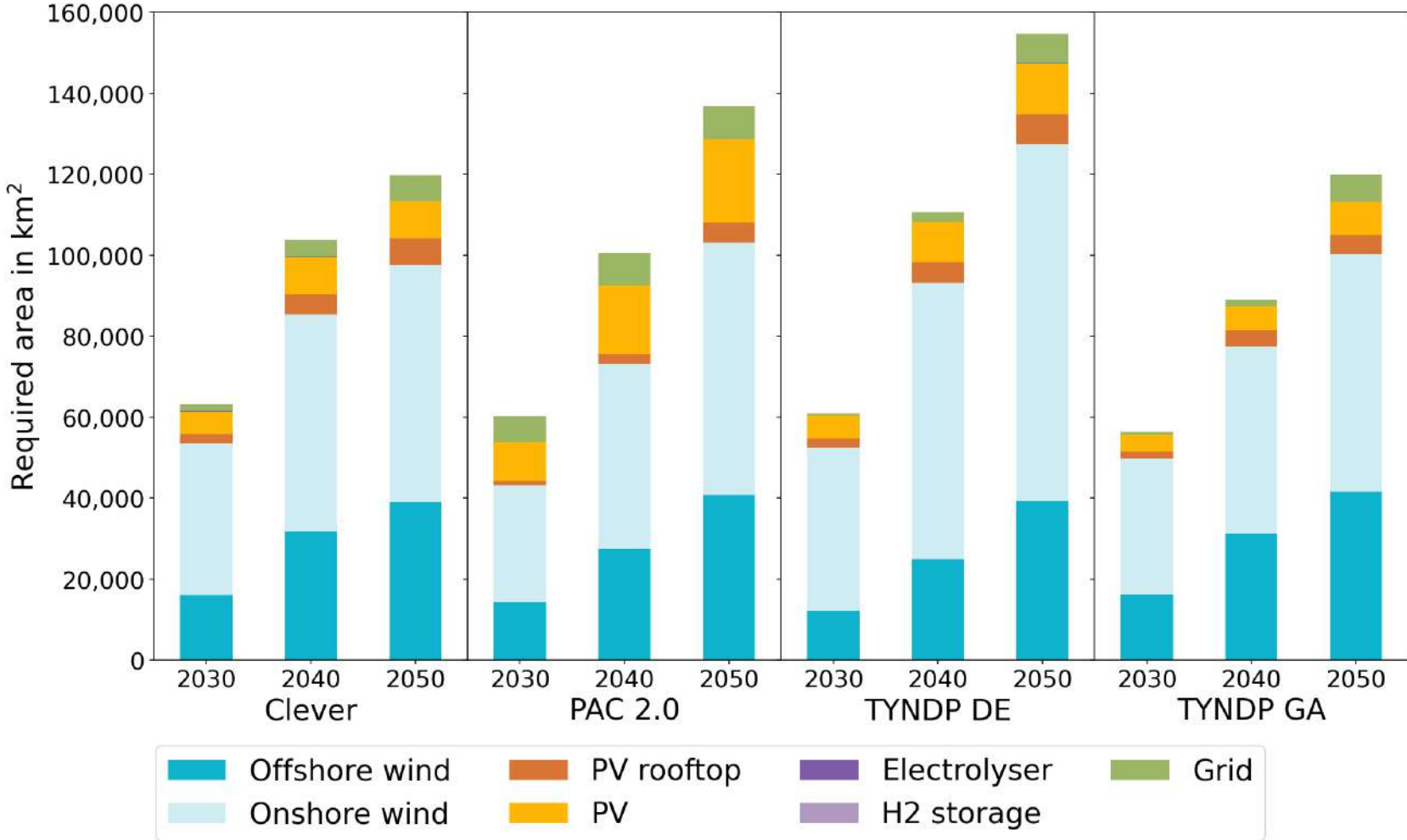


Results – Area requirements EU



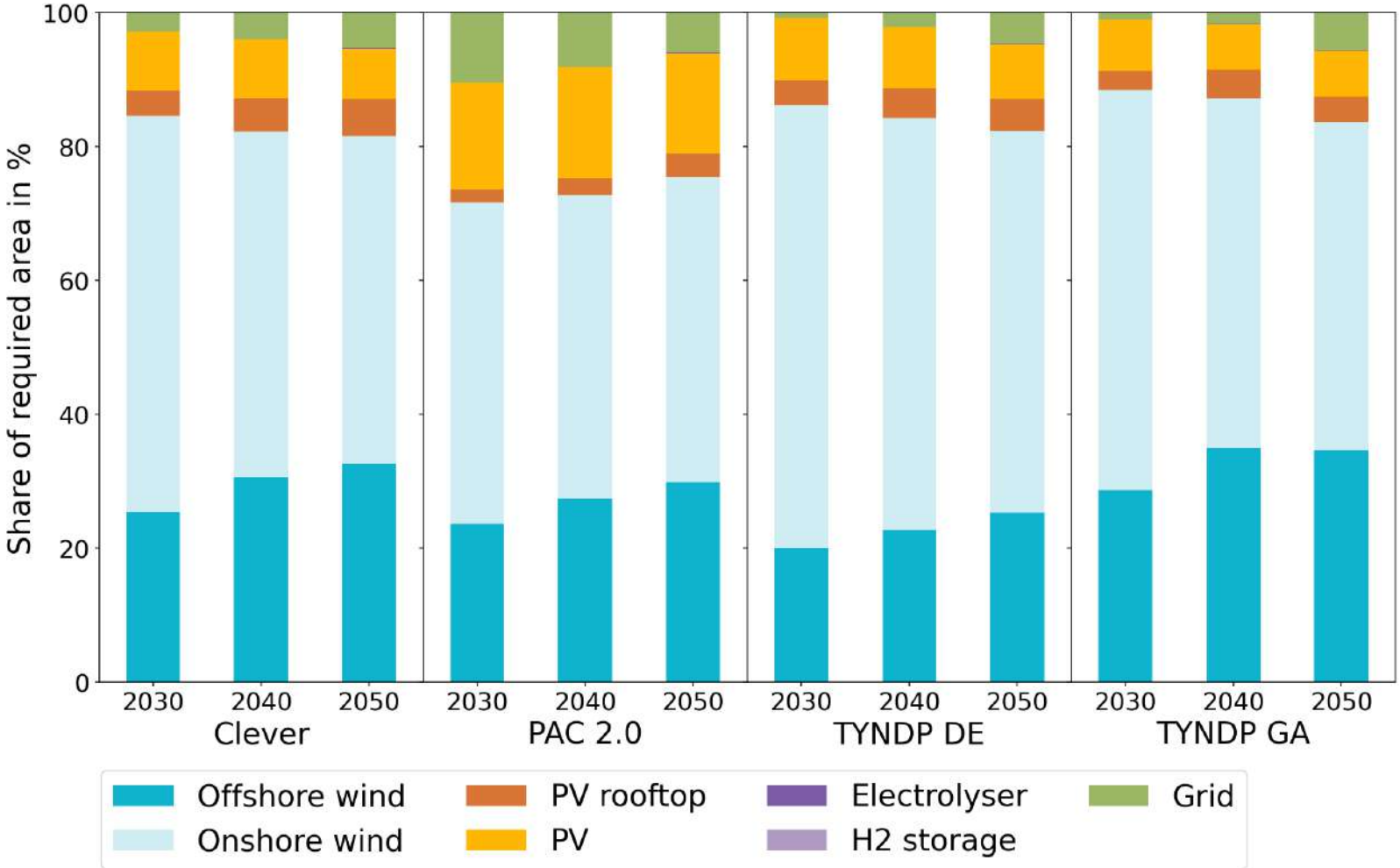
Onshore: ca. 0.9 – 1.1%
Offshore: ca. 0.3 – 0.5%

Results – Area requirements EU

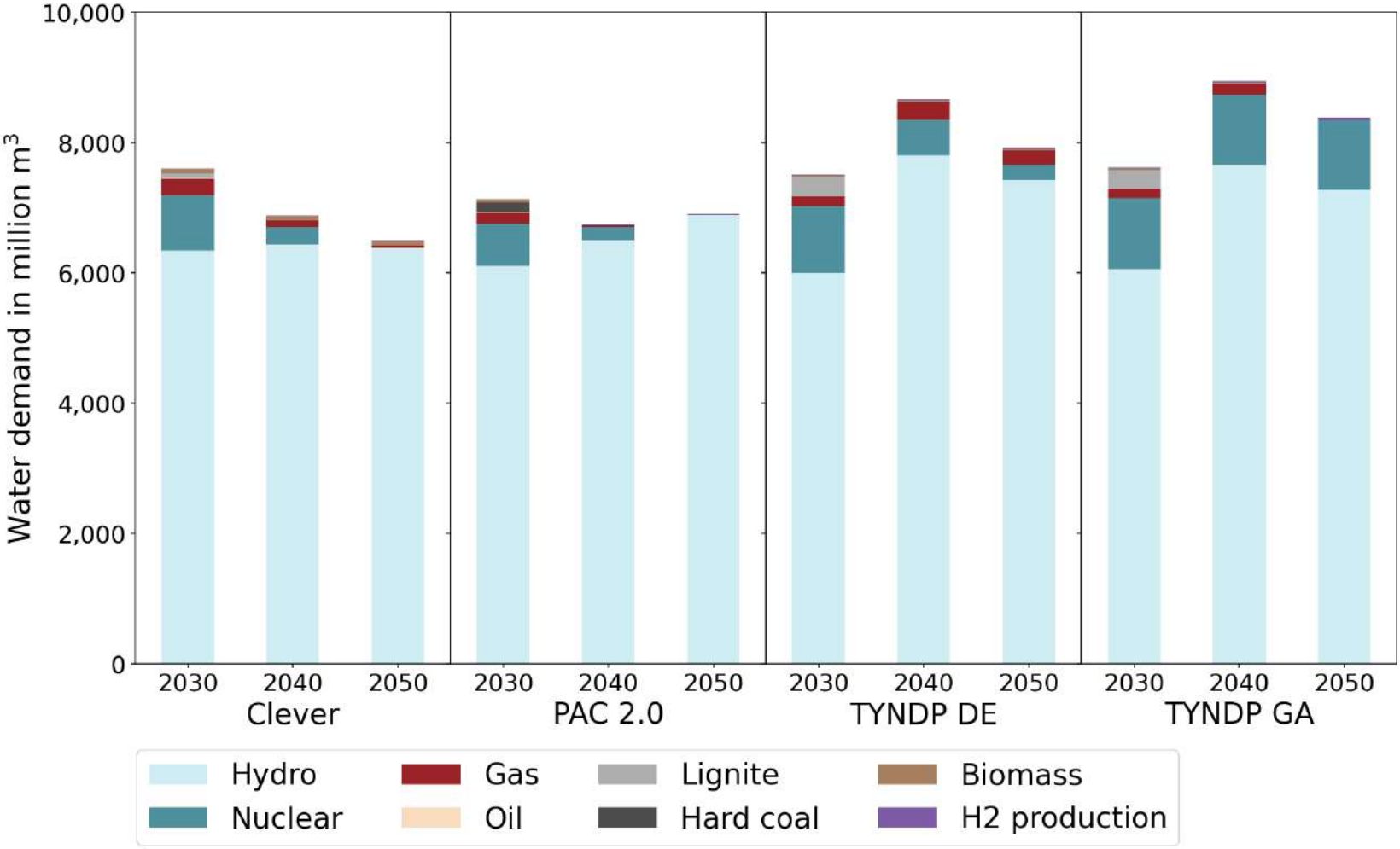


Onshore: ca. 1.8 – 2.7%
Offshore: ca. 1.0 – 1.4%

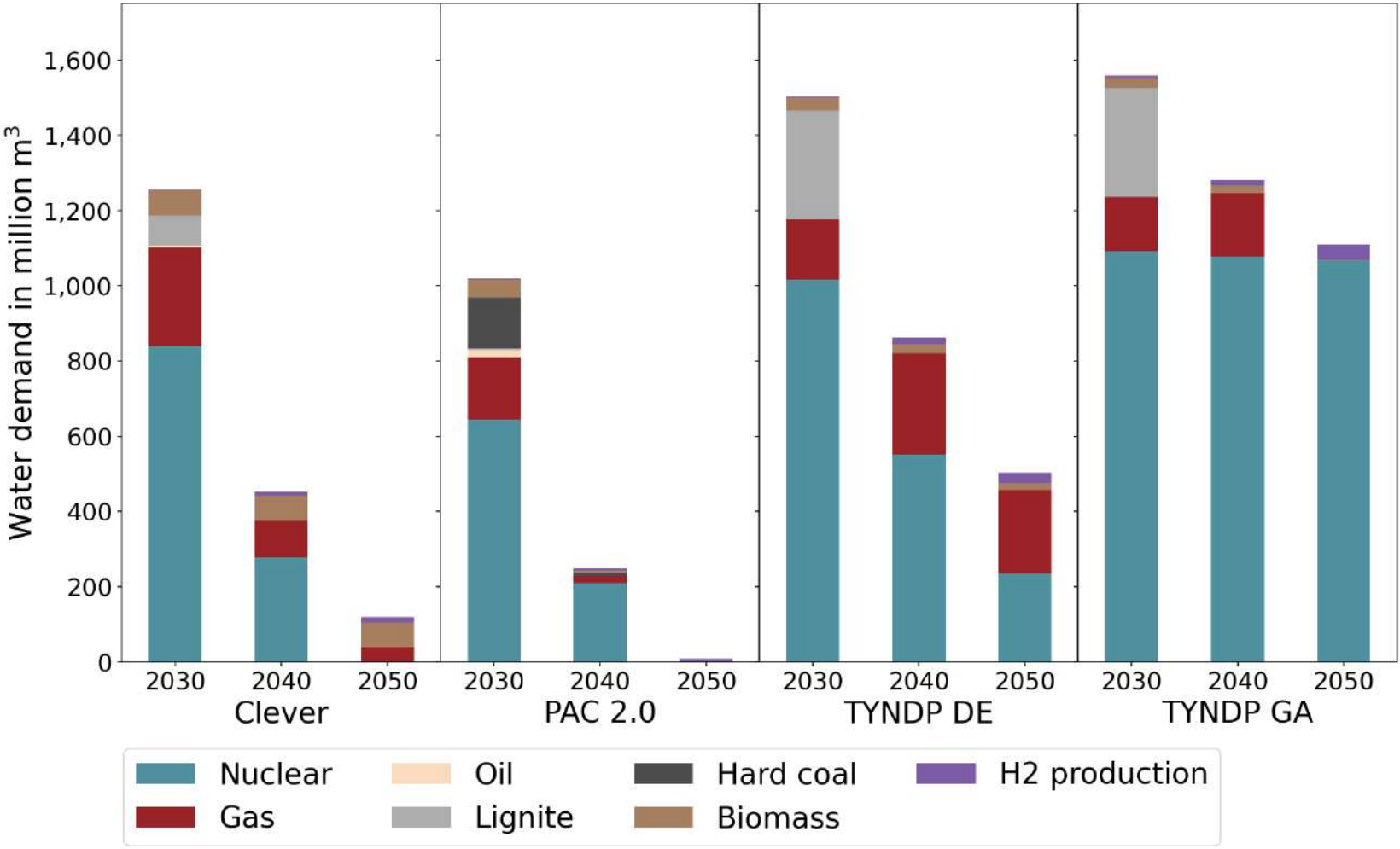
Results – Share of required area EU



Results – Water requirements EU

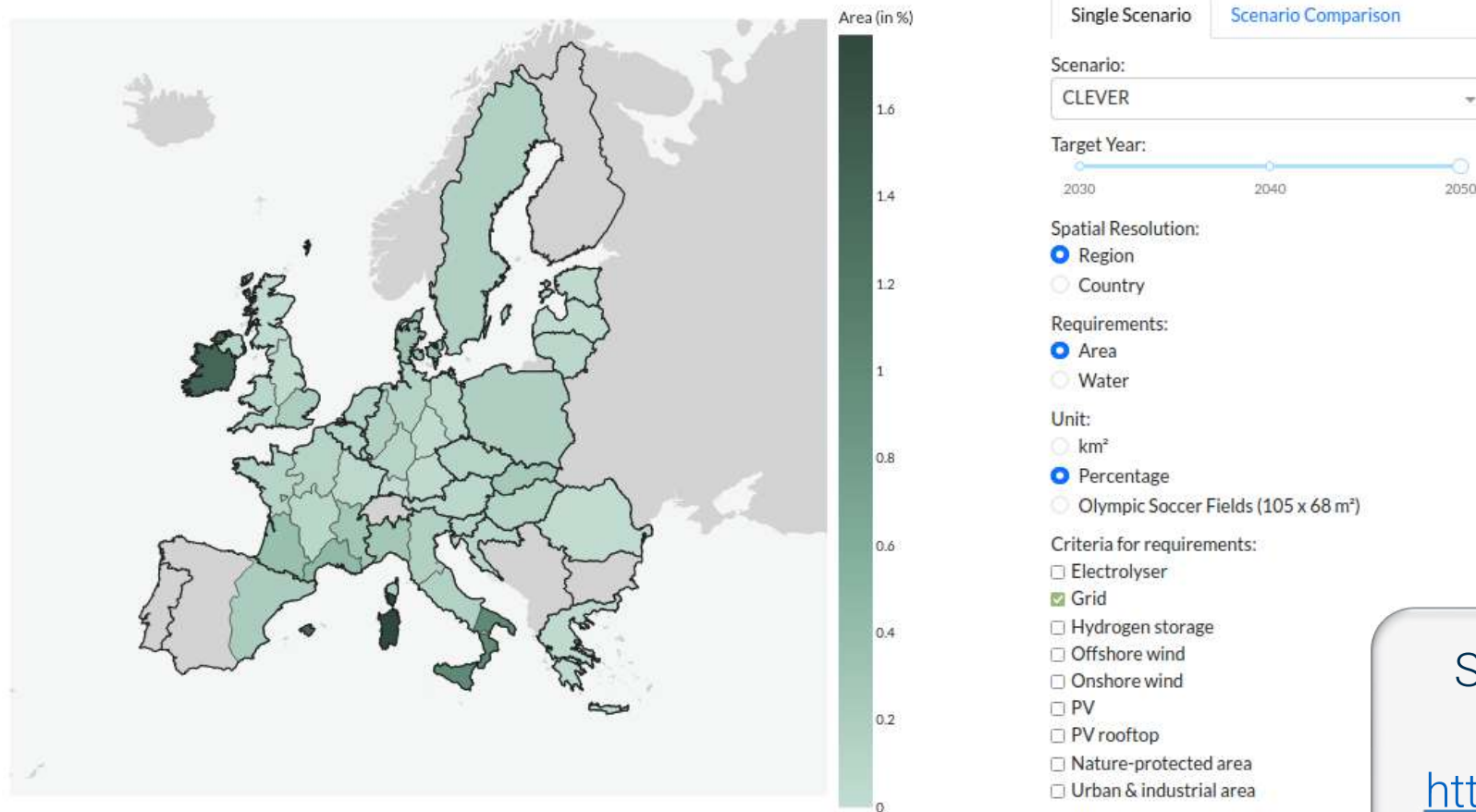


Results – Water requirements EU



Web Visualisation

CLEVER spatial area requirement for 2050



Source code and results data
available on github:

<https://github.com/rl-institut/rgi>

Sources

- [CLEVER] : https://clever-energy-scenario.eu/wp-content/uploads/2023/08/CLEVER_final-report.pdf
- [PyPSA-EUR] : <https://pypsa-eur.readthedocs.io/en/latest/>
- [Macknick et al.] : <https://iopscience.iop.org/article/10.1088/1748-9326/7/4/045802>

„Open should be the default, not the exception.“



Lizenz

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