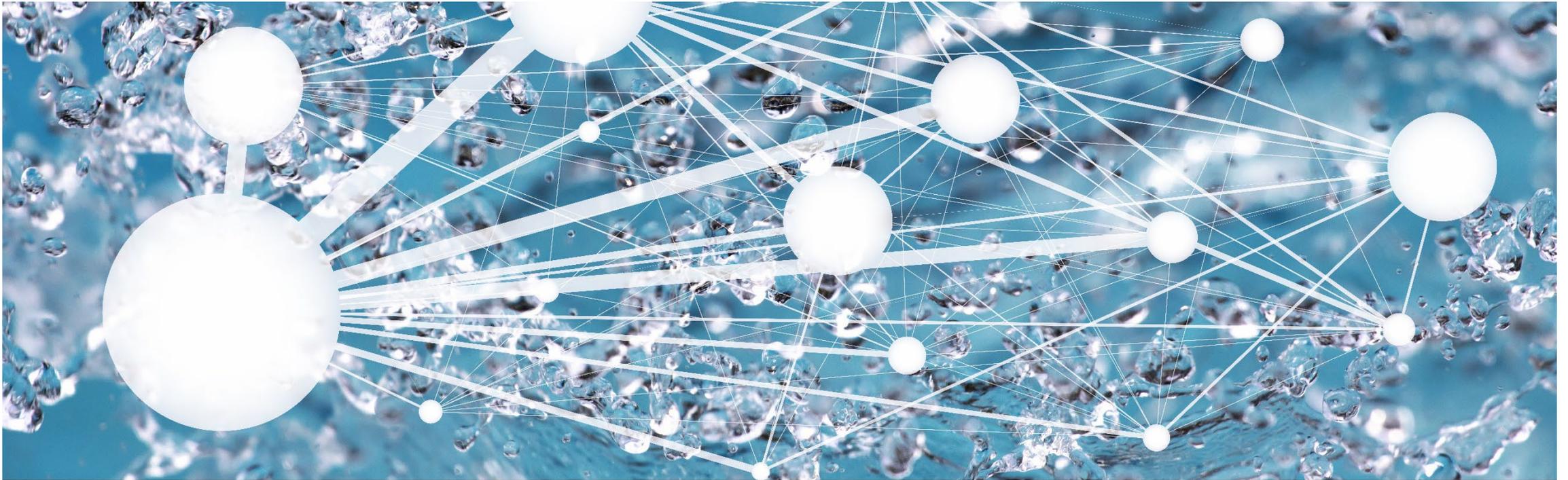

E-FUEL IMPORTS FROM THE MENA REGION AS AN OPTION FOR DECARBONIZING EUROPE'S ENERGY SYSTEM

Benjamin Lux, Benjamin Pfluger, Jakob Wachsmuth, Wolfgang Eichhammer



Motivation and Research question

■ Overall objective

- Paris Agreement (2015): Limit global warming to preferably 1.5 °K
- European Green Deal (2019): Greenhouse gas neutrality in the EU by 2050

■ Problem

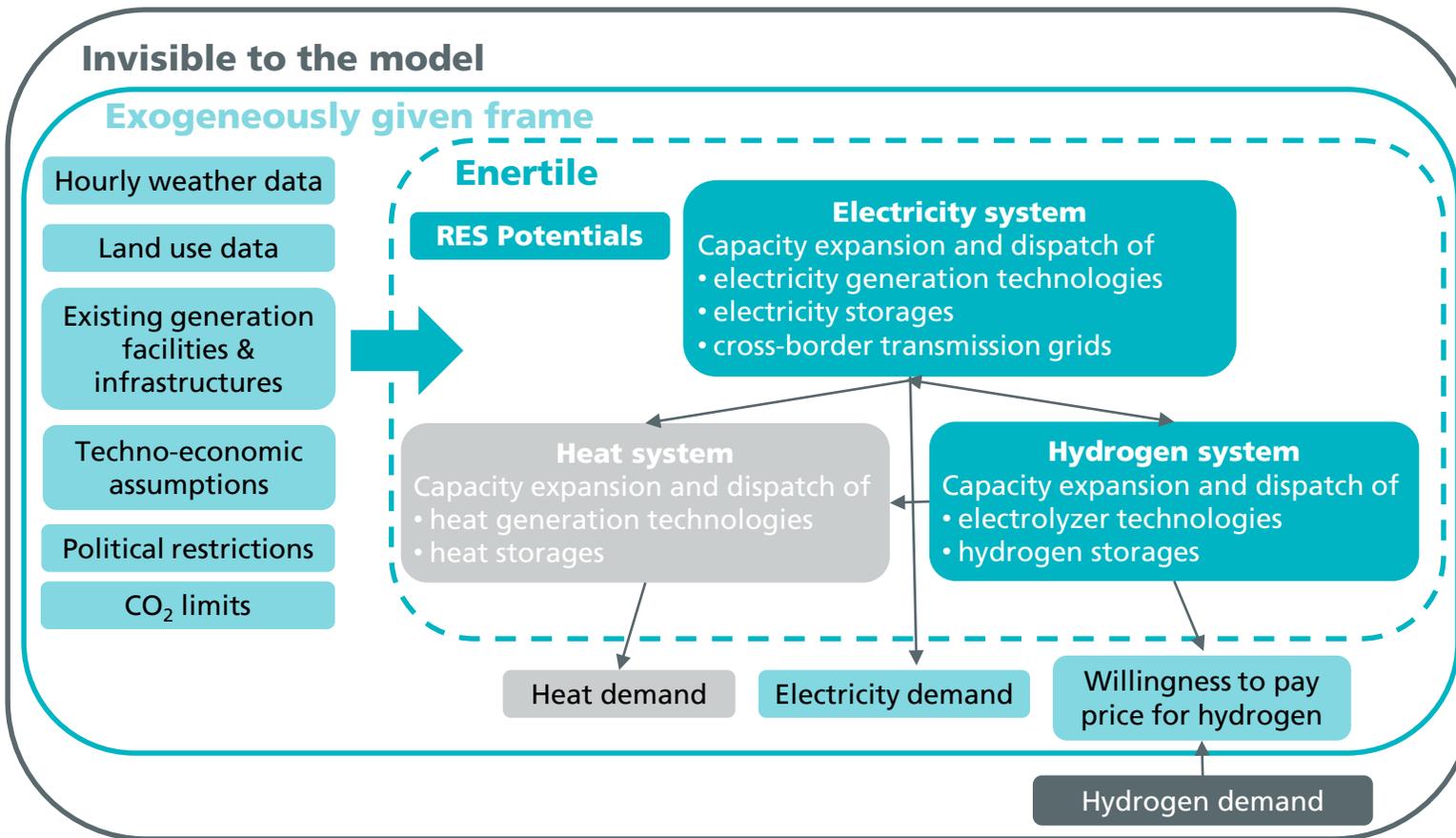
- Difficult to decarbonize applications/processes: long-distance transport, industrial processes such as steel production, etc.
- Utilization of green hydrogen or its derivatives could be an option, but must be covered by corresponding quantities of renewable electricity.

■ Research question

- Are hydrogen exports from MENA to Europe feasible?

Methodology

Energy system model *Enertile*

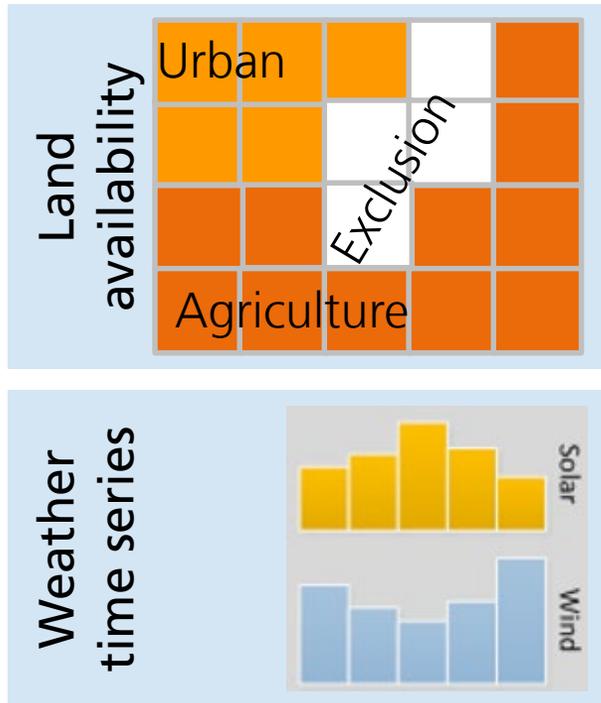


- **Aim:**
 - Cost-efficient supply of electricity, heat, and hydrogen.
- **Approach:**
 - Integrated cost optimization of investments and dispatch of renewable power plants, storage systems, transmission grids (NTCs), heat pumps, electrolyzers, etc.
 - Covering Europe or the MENA-Region in an hourly resolution for 2050.

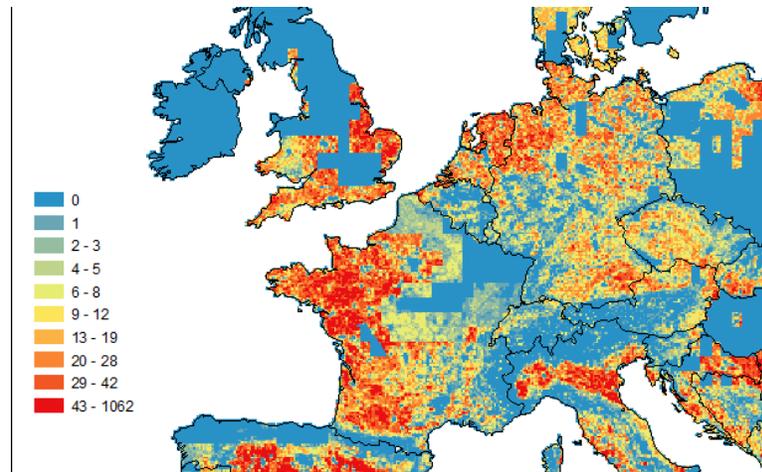
Enertile model representation based on: Lux B. & Pfluger B. (2020): "A supply curve of electricity-based hydrogen in a decarbonized European energy system in 2050" in Applied Energy

Methodology

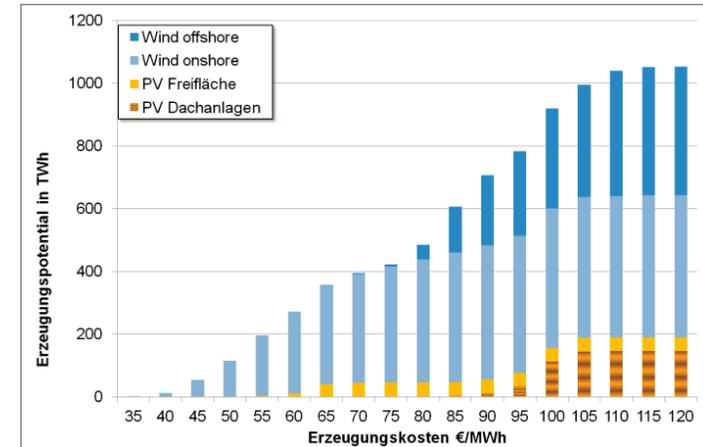
Renewable potential calculation



GIS-Data



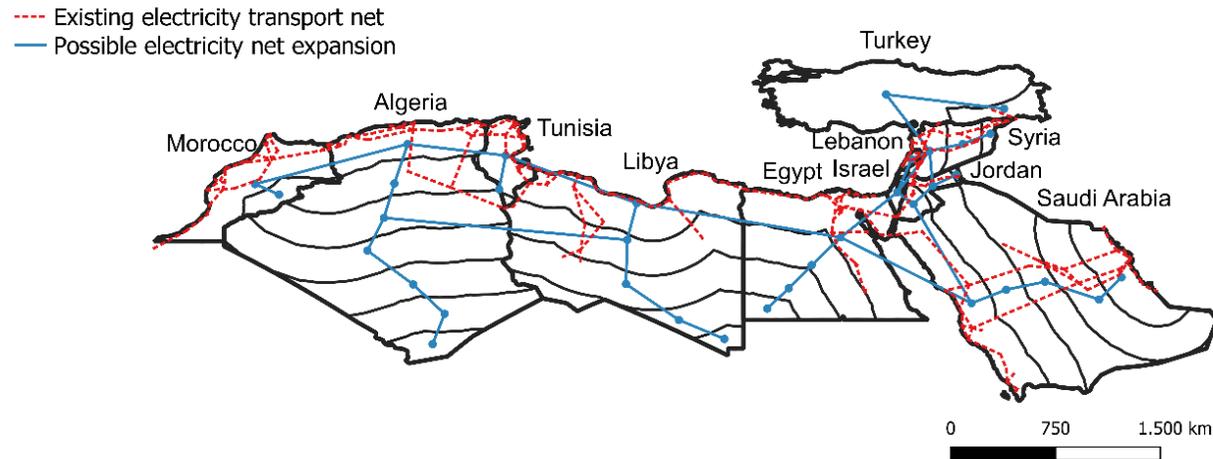
Tiles 6.5x6.5 km



Cost potential curves

Methodology

Set-up in MENA

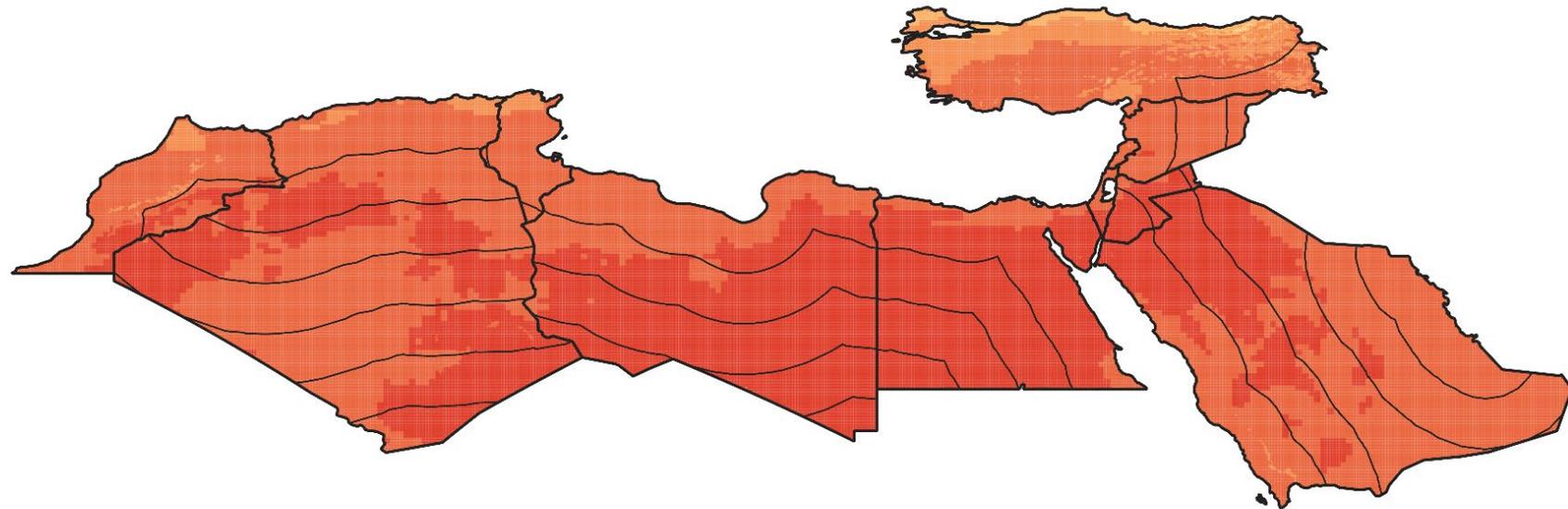
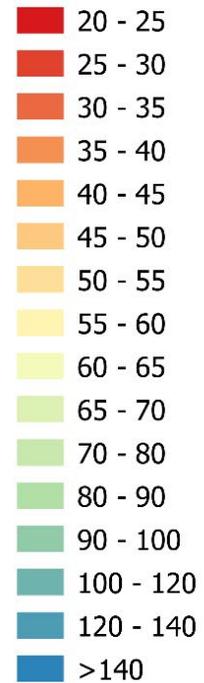


- Electricity demand
 - Load projections based on historical demands and population projections
 - Load 2050: 2,300 TWh
- Renewable electricity generation only
- Hydrogen production exclusively in coastal areas
- Power-to-Hydrogen process chains
 - PEM based: Invest 623 €/kW, Eff. 66%
 - SOEL based: Invest 690 €/kW, Eff. 69%
- Flat pipeline surcharge from MENA to Europe 21 €/MWh (~3,000km)

Results

Renewable electricity generation potentials – Solar PV

LCOE (€/MWh)



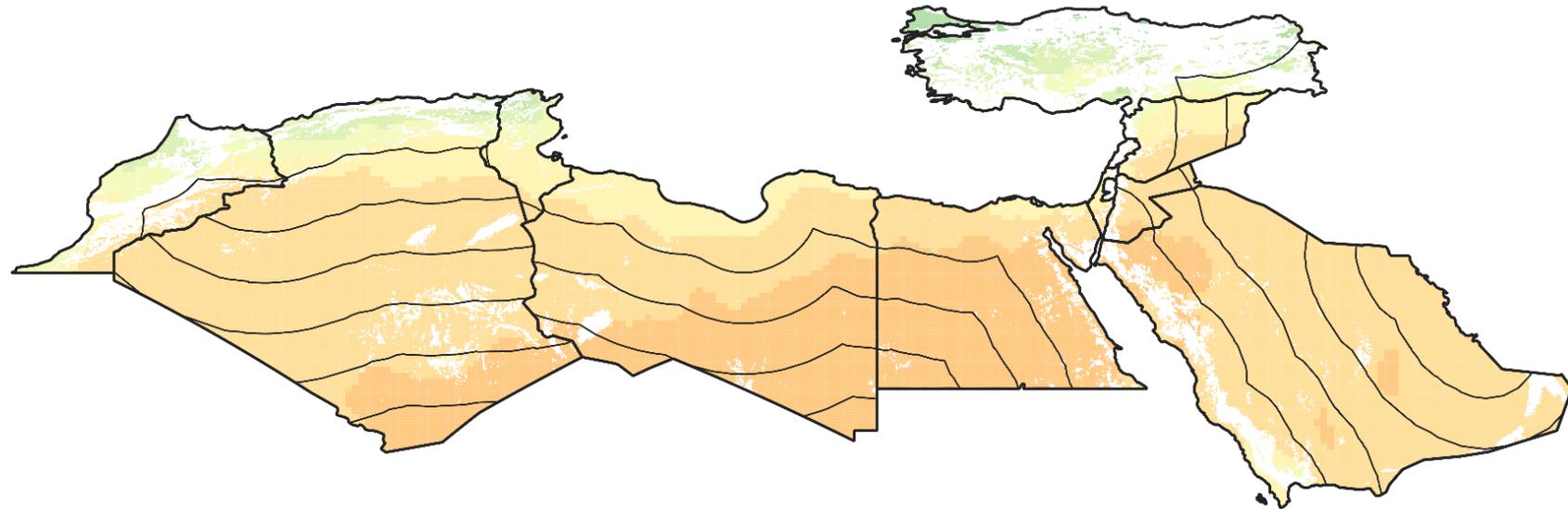
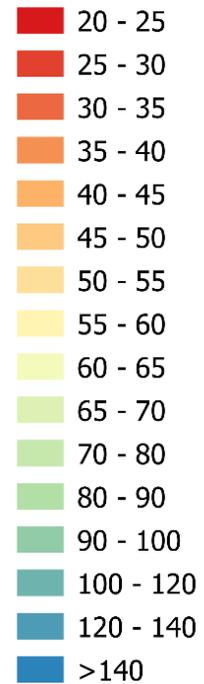
0 750 1,500 km

SOPV ID 133

Results

Renewable electricity generation potentials – CSP

LCOE (€/MWh)



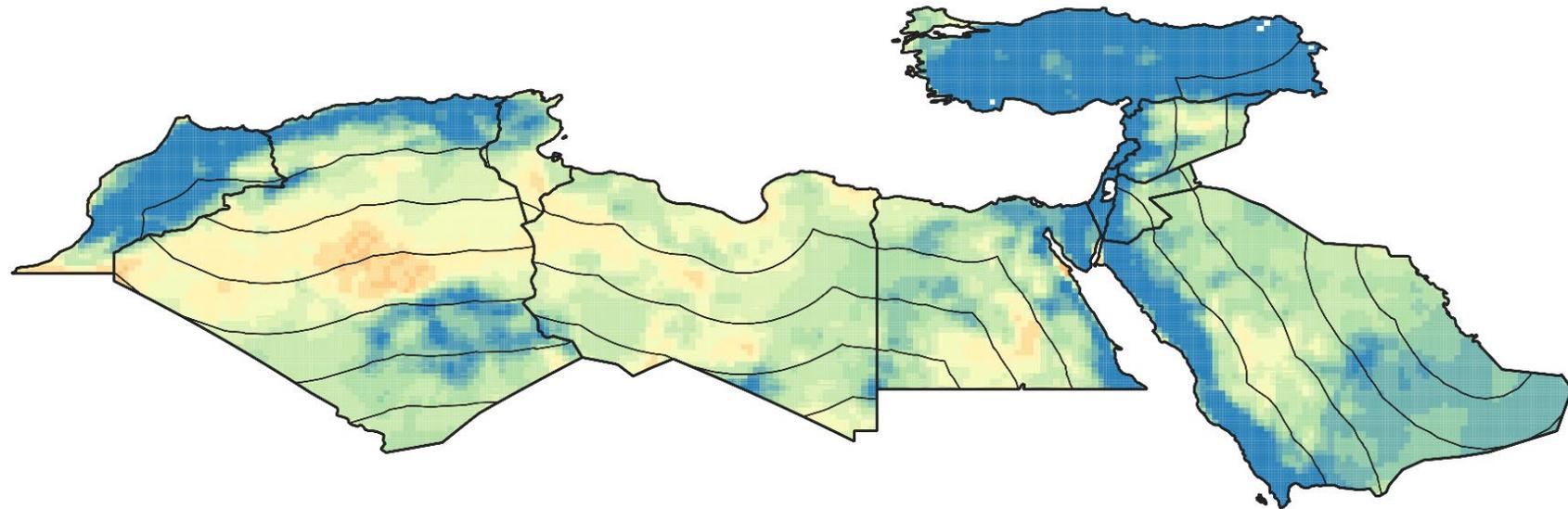
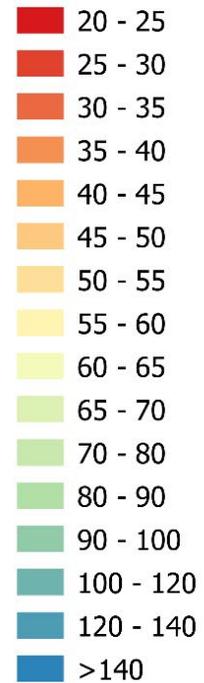
0 750 1,500 km

CSP ID 89

Results

Renewable electricity generation potentials – Wind onshore

LCOE (€/MWh)

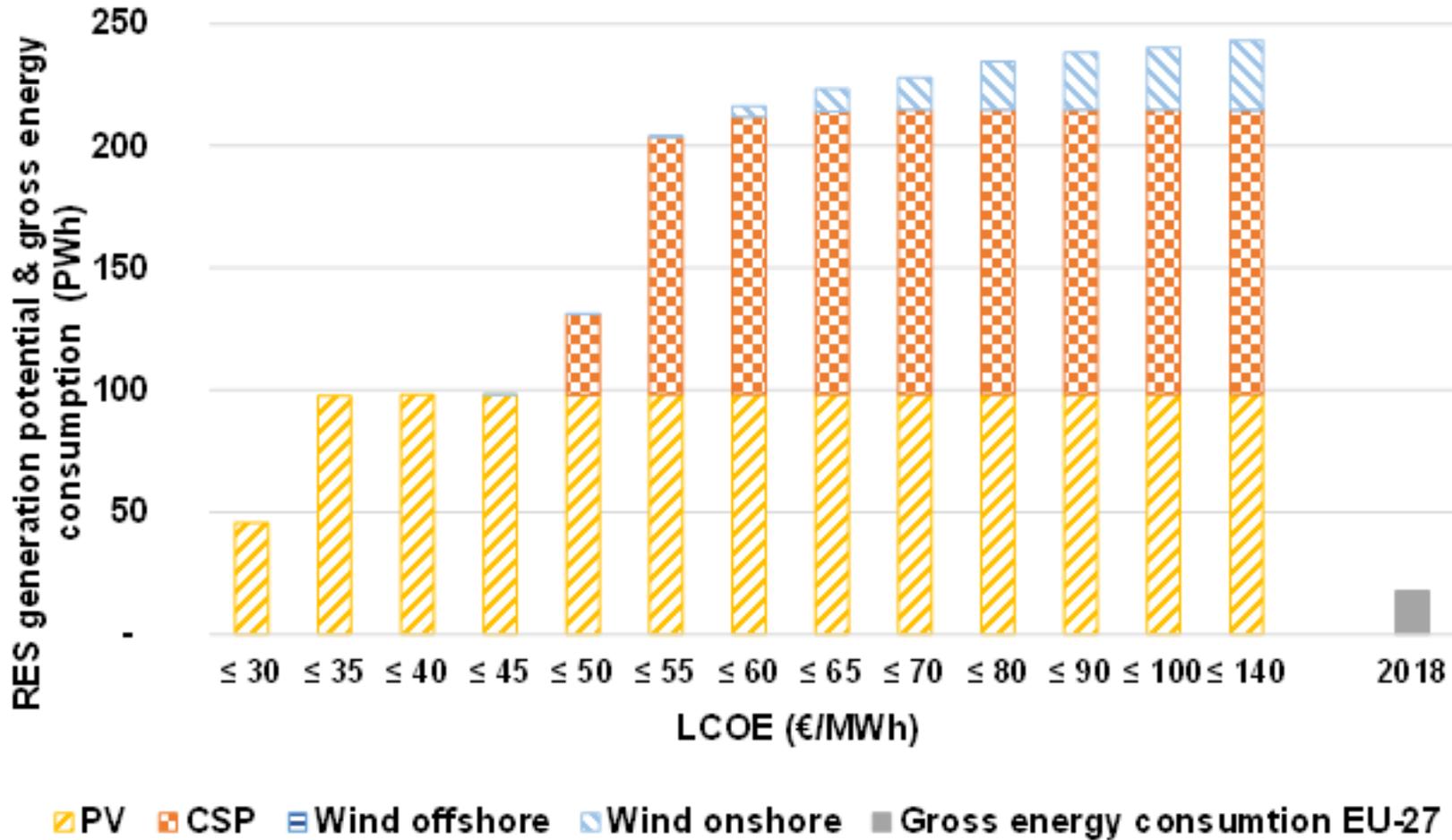


0 750 1.500 km

WINDONSHORE ID 166

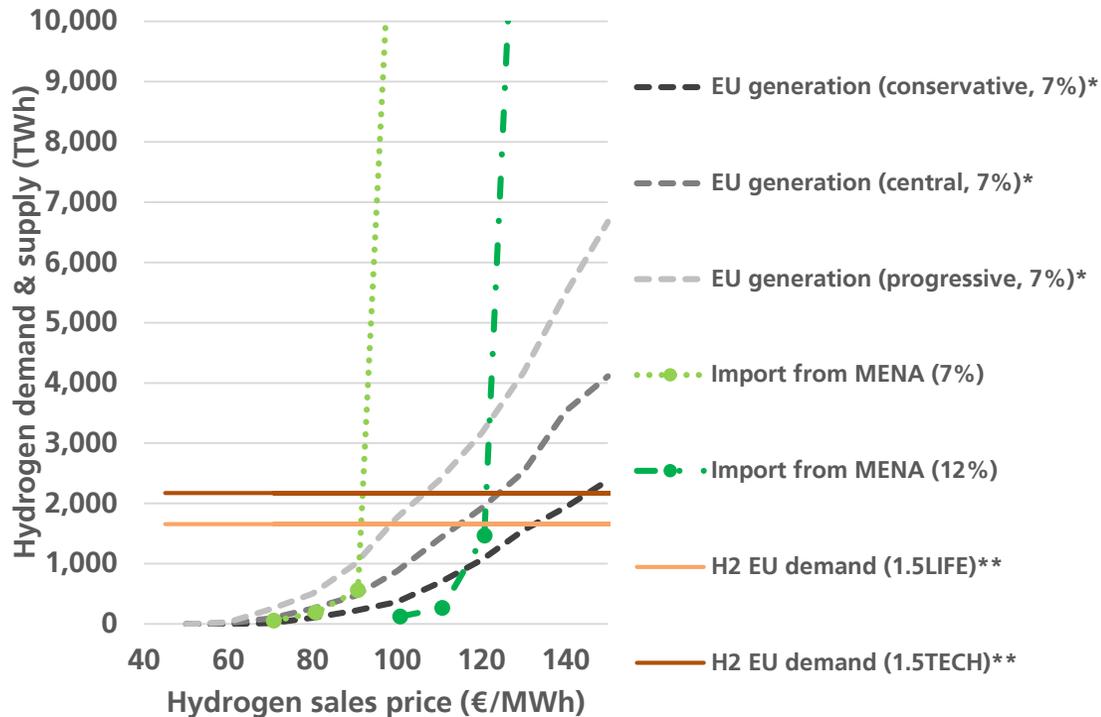
Results

Renewable electricity generation potentials



Results

Hydrogen supply curves



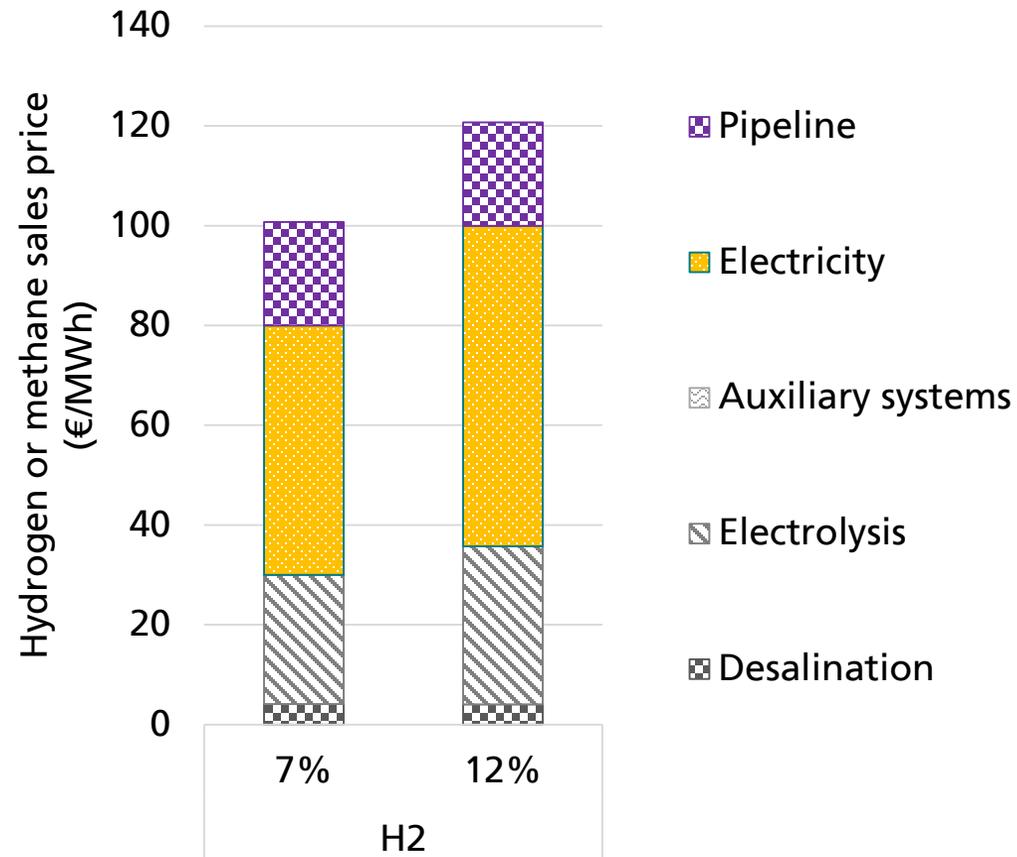
- Hydrogen exports from MENA to Europe (including pipeline transport):
 - Above sales prices of 91 €/MWh (7% WACC).
 - Above sales prices of 121 €/MWh (12% WACC).
- Exports are only feasible if equivalent capital costs for Europe and MENA are assumed.

* Lux B. & Pfluger B. (2020): "A supply curve of electricity-based hydrogen in a decarbonized European energy system in 2050" in Applied Energy

** European Commission (2018): „A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy“

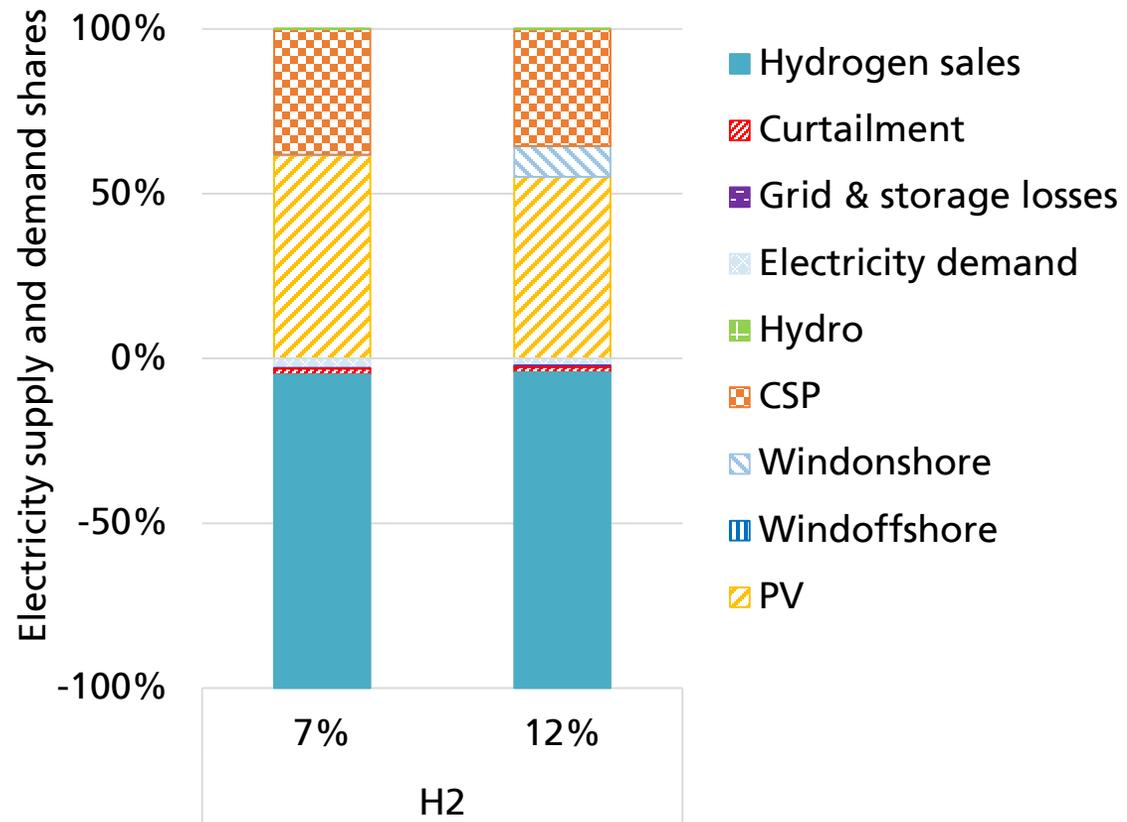
Results

Cost decomposition of hydrogen production in MENA



- Hydrogen production costs dominated by electricity supply.
- Desalination is only a minor cost component.
- Hydrogen transport with substantial cost contributions.

Results



- Electricity demands in MENA are not limiting the hydrogen generation potential.
- Power system dominated by solar technologies.

Summary and Conclusions

- The MENA region displays enormous renewable electricity generation potentials.
- Solar electricity generation technologies are dominant.
- The question whether hydrogen exports from MENA to Europe are feasible, remains open.
- Differences in capital costs and hydrogen transport costs may reduce or even nullify the advantages of low LCOE in the MENA region.
- Public acceptance issues concerning large numbers of solar power plants and wind power plants in Europe could be a game changer.