

Globale H₂-Potentiale

– eine Systemanalyse –

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Deutschland bezieht derzeit etwa 70% seiner Energie als Import

Dieses sinkt tendenziell mit erneuerbarer Energie

Systemstudie des IEK-3 ergibt ca. 40% Importe (stoffl. Verbrauch nicht darin enthalten)

Wenn volkswirtschaftl. Effekte wie Jobs mit berücksichtigt, dann weniger, jedoch >> 0

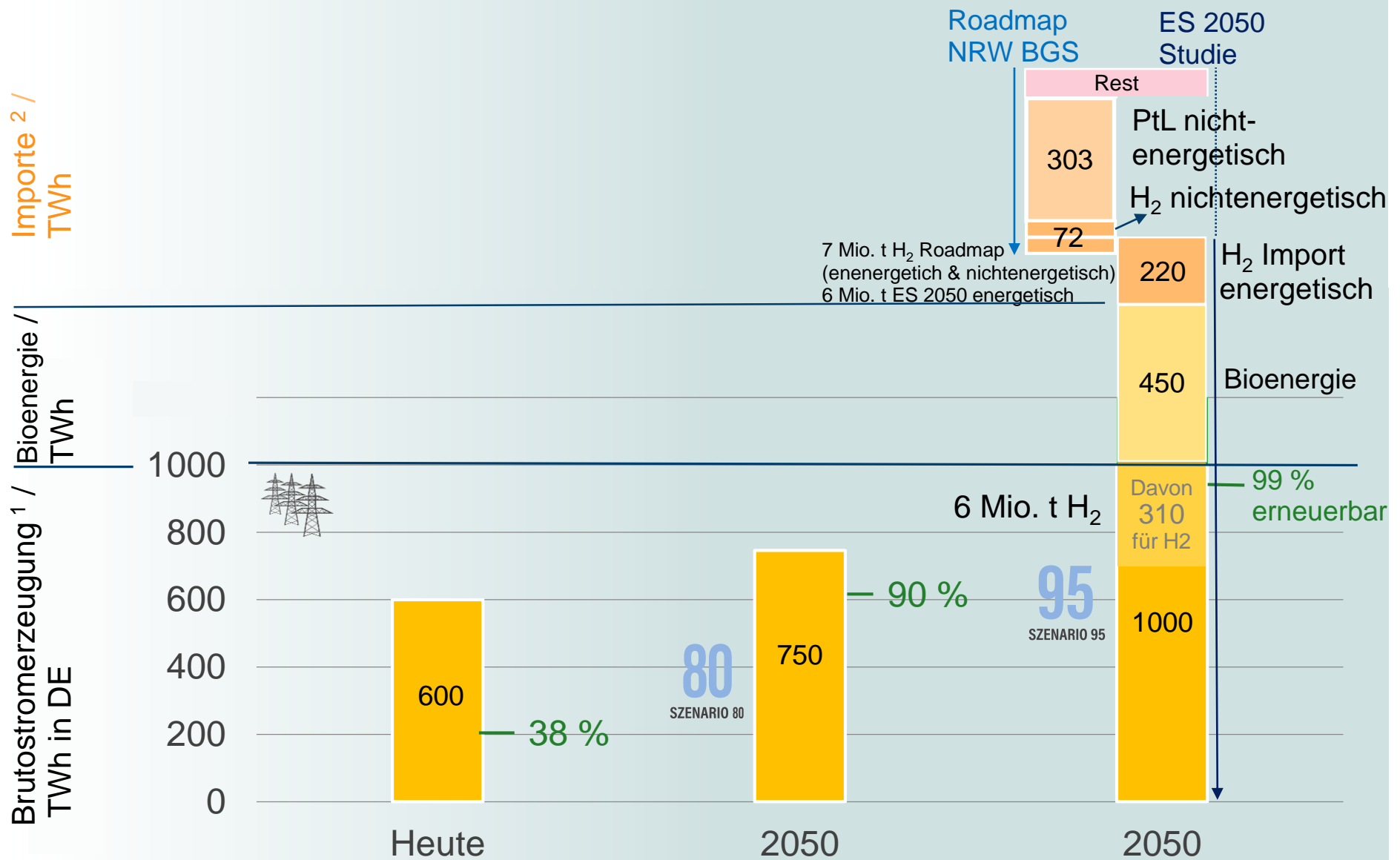
Vorteile

- Weniger „ungeliebte“ EE Anlagen im Land → **Ausweichstrategie**
- **Billigere** Erzeugungsmöglichkeiten in extrem sonnen- und windreichen Ländern
- Versorgungsstrang **außerhalb** einer **Klimazone** → Versorgungssicherheit bei Flauten
- Geringere Speichermengen zur **Vorsorge bei Flauten** nötig

Nachteile

- **Wertschöpfung** geht im Inland verloren → Jobs, auch einfachere Jobs zur Wartung
- Gefahr der **Abwanderung** der Industrie, die historisch dahin gegangen ist, wo es Energie gab

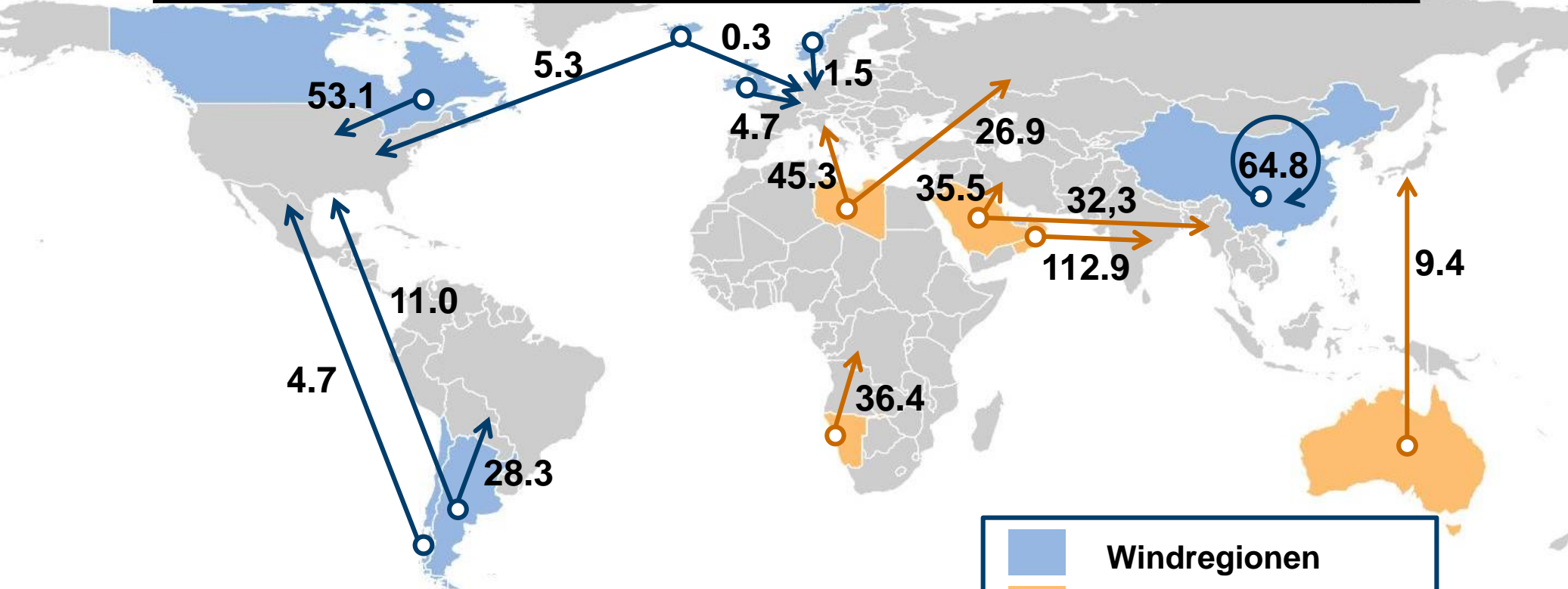
Ersatz fossiler Energie führt zu 95% CO₂ Reduktion



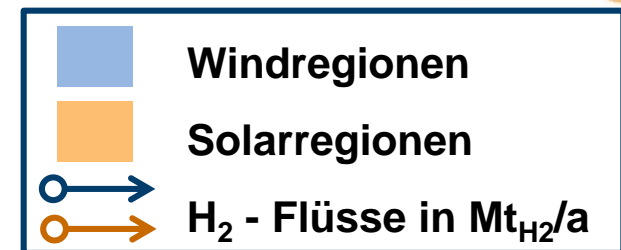
¹ ohne Strom Im- und Export, da vernachlässigbar; ² Importe als Primärenergie an dt. Grenze

1. Näherung für weltweiten H₂ Handel

	Deutschland	Japan	Europa	USA	China	Indien	SO Asien
Nachfrage/ Mt/a	6.57	9.6	45.3	59.9	102	52.9	54.7
Importkosten/ €/kg	3.86	4.46	3.83	3.70	4.10	3.73	3.95

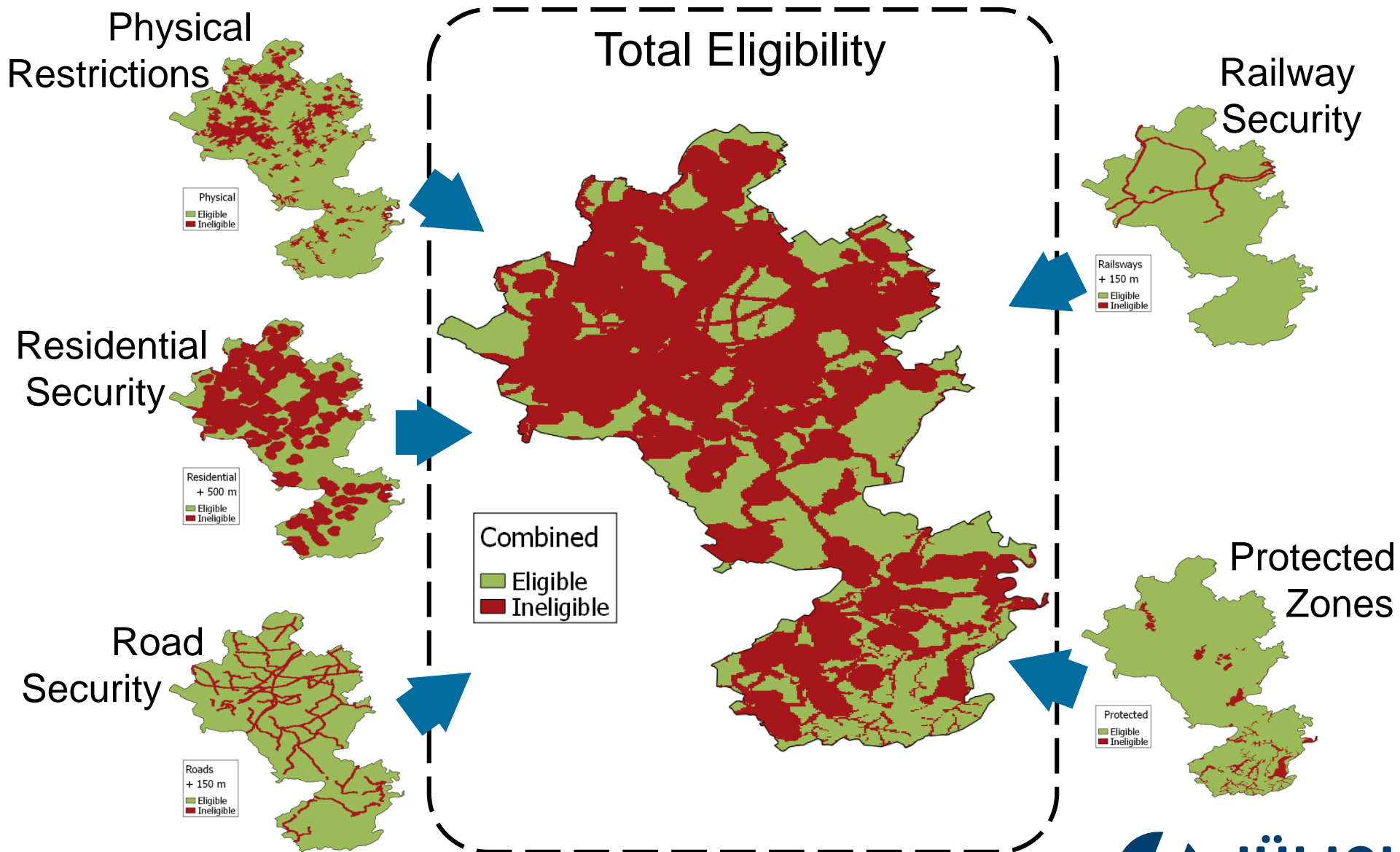


- H₂ Potential groß genug
- Kostengünstig erzeugbar
- Verbrauchsnahe Erzeugung bevorzugt, da höhere Transportkosten als Öl



Vorgehensweise

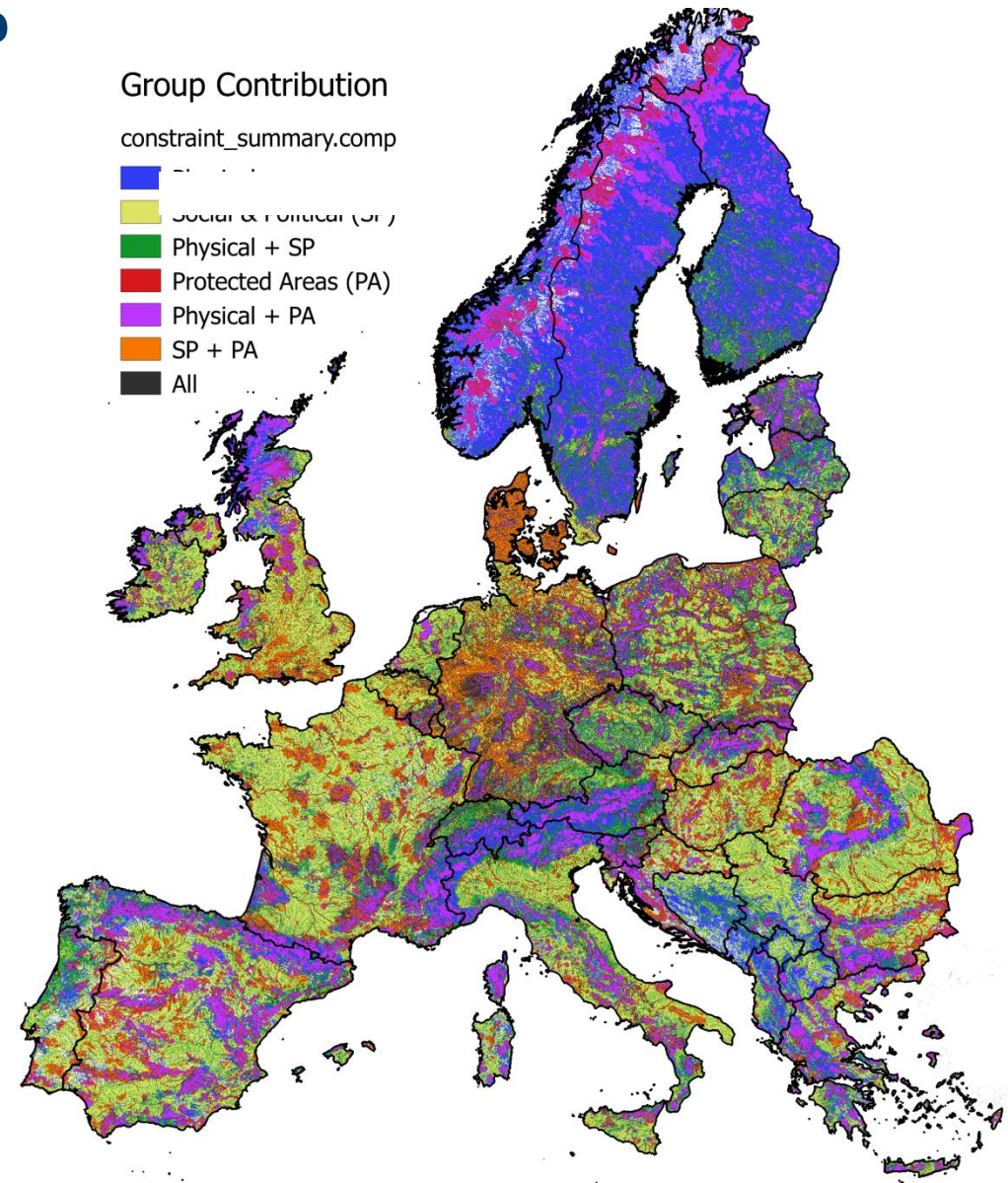
Methodologies – RES Production – Eligibility



Land Eligibility – Constraint Overlap

Investigation into constraint overlap:

1. Organized each constraint into a general group
 - Protected areas
 - Physical restrictions
 - Social and political directives
2. Aggregated constraints by group
3. Plotted overlap of groups
 - Each group received a unique color
 - Each combination of groups received a unique color



Shipping of Liquid Hydrogen for International Trade



Suiso Frontier is a 116-meter vessel designed to carry 1250 m³ LH₂ at -253°C. 1st of its kind vessel made by Kawasaki. Source: <https://www.oceanhydrowaycluster.no/member-area-hydrogen-vessels/kawasaki>

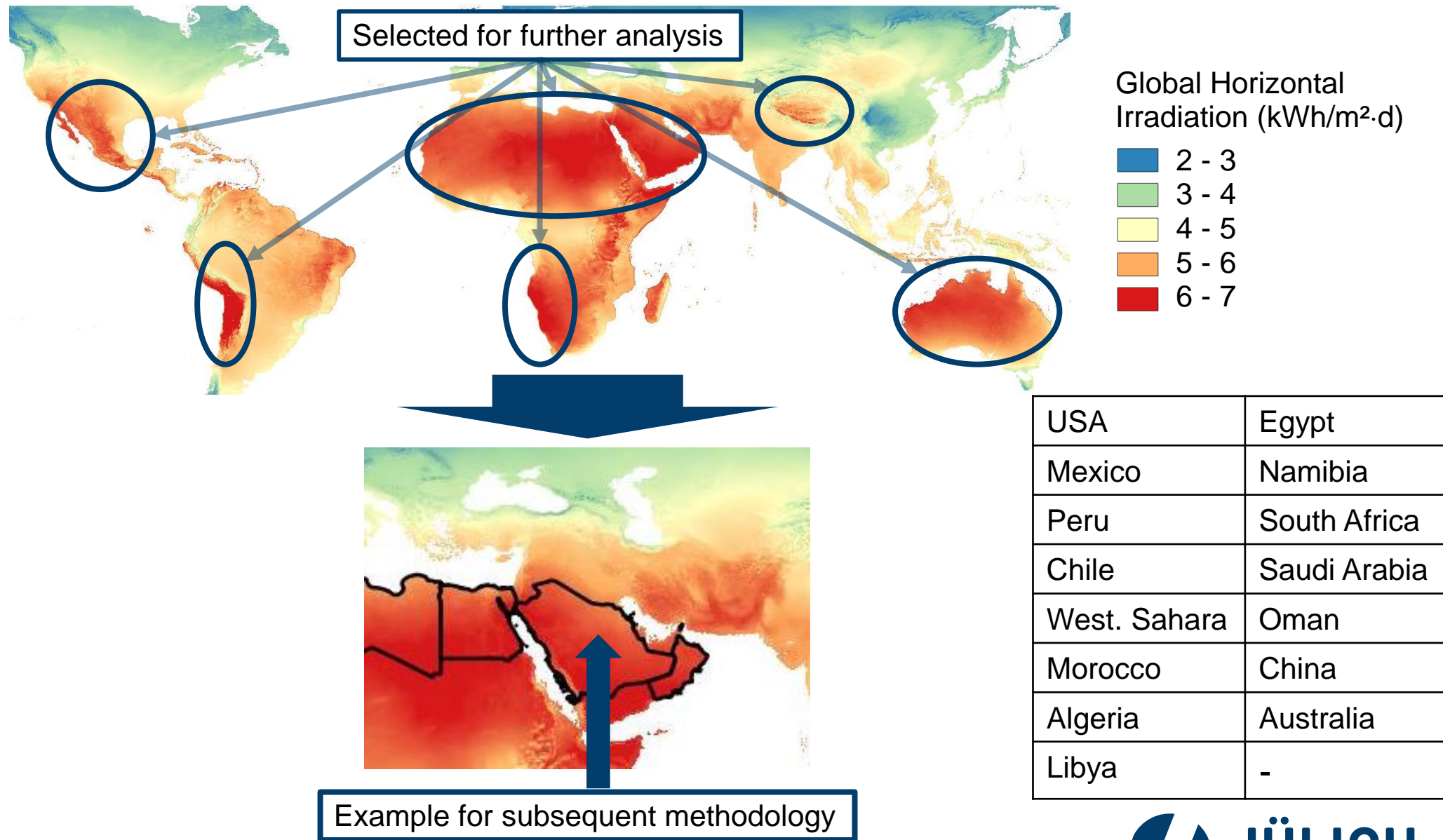


Same vessel with tank installed; 3/2020

Next generation carrier concept - 160,000m³ LH₂ (Image: Kawasaki)



Selection of High Insolation Countries by Global Horizontal Irradiation



Ergebnisse

Total Solar Potential of Saudi Arabia (weather year 2013)

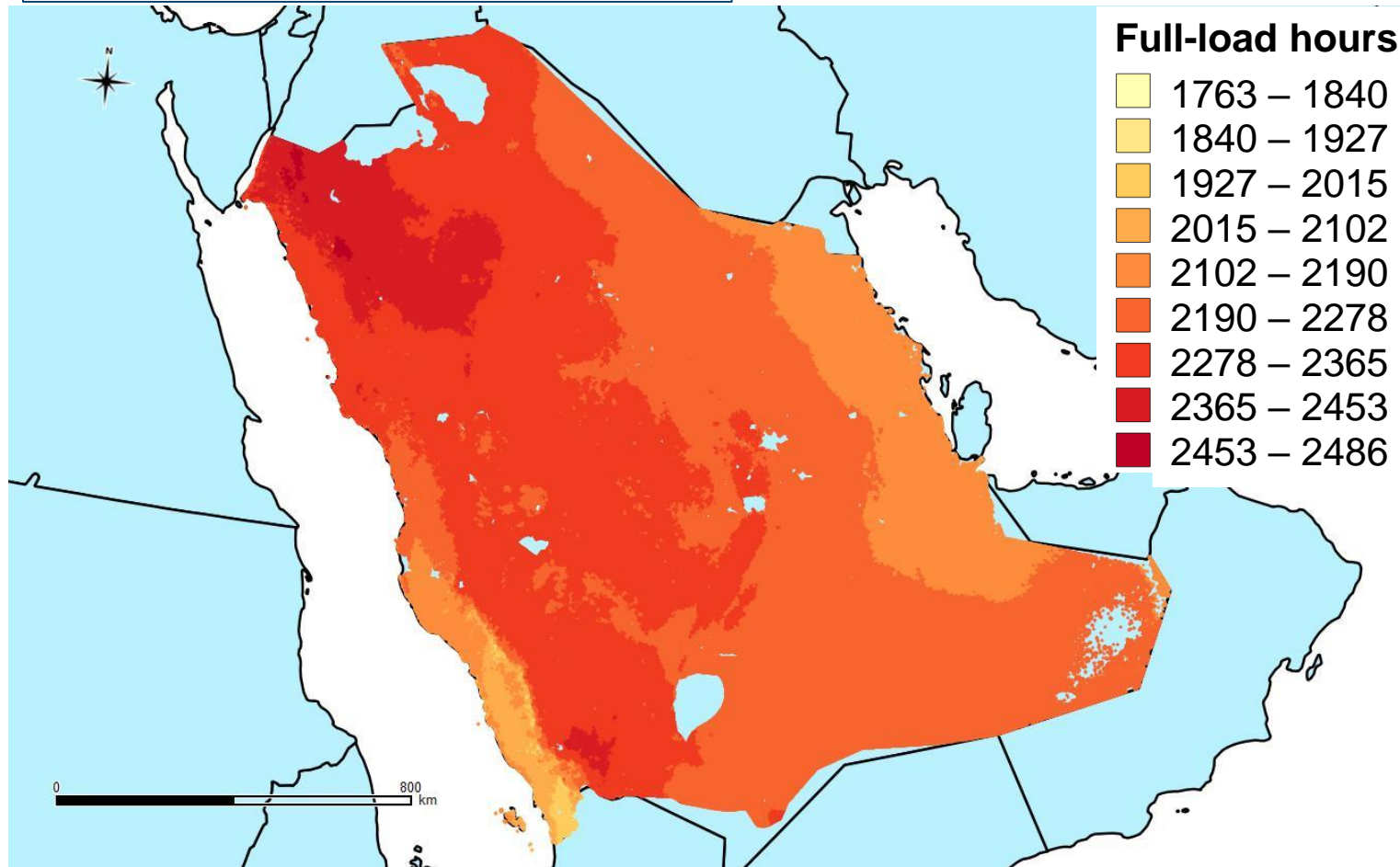
Overall PV potential in Saudi Arabia

- ~ 1.56 million km² eligible land
- ~ 1.6 million PV locations
- ~ 78,000 GW capacity



Vast PV potential

- Analog to wind analysis, lower bound required
- With regard to other countries not feasible in time



Selected Solar Locations of Saudi Arabia

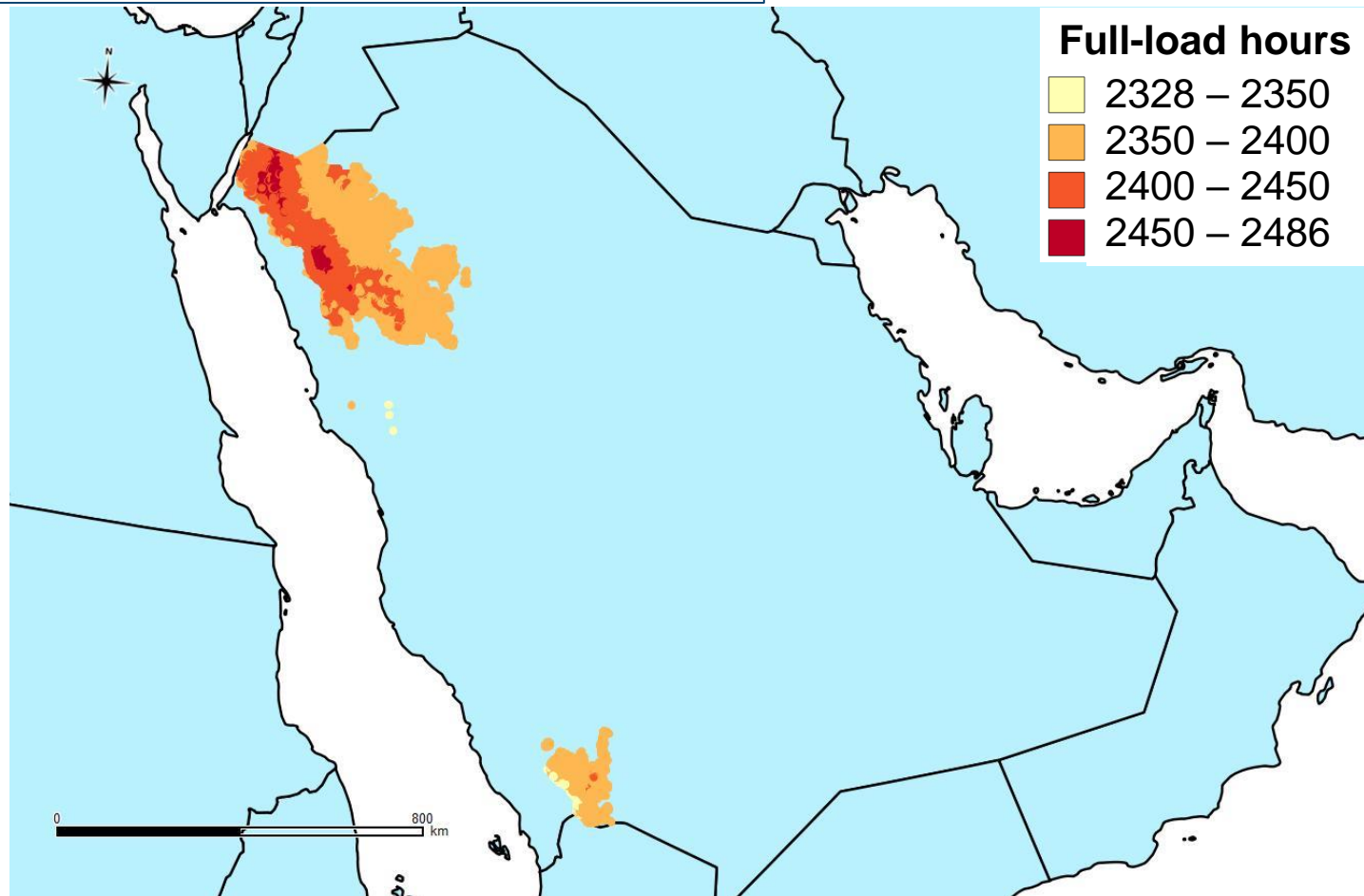
Analyzed PV potential in Saudi Arabia

- ~ 70,100 km² eligible land
- ~ 76,720 PV locations
- ~ 3,505 GW capacity

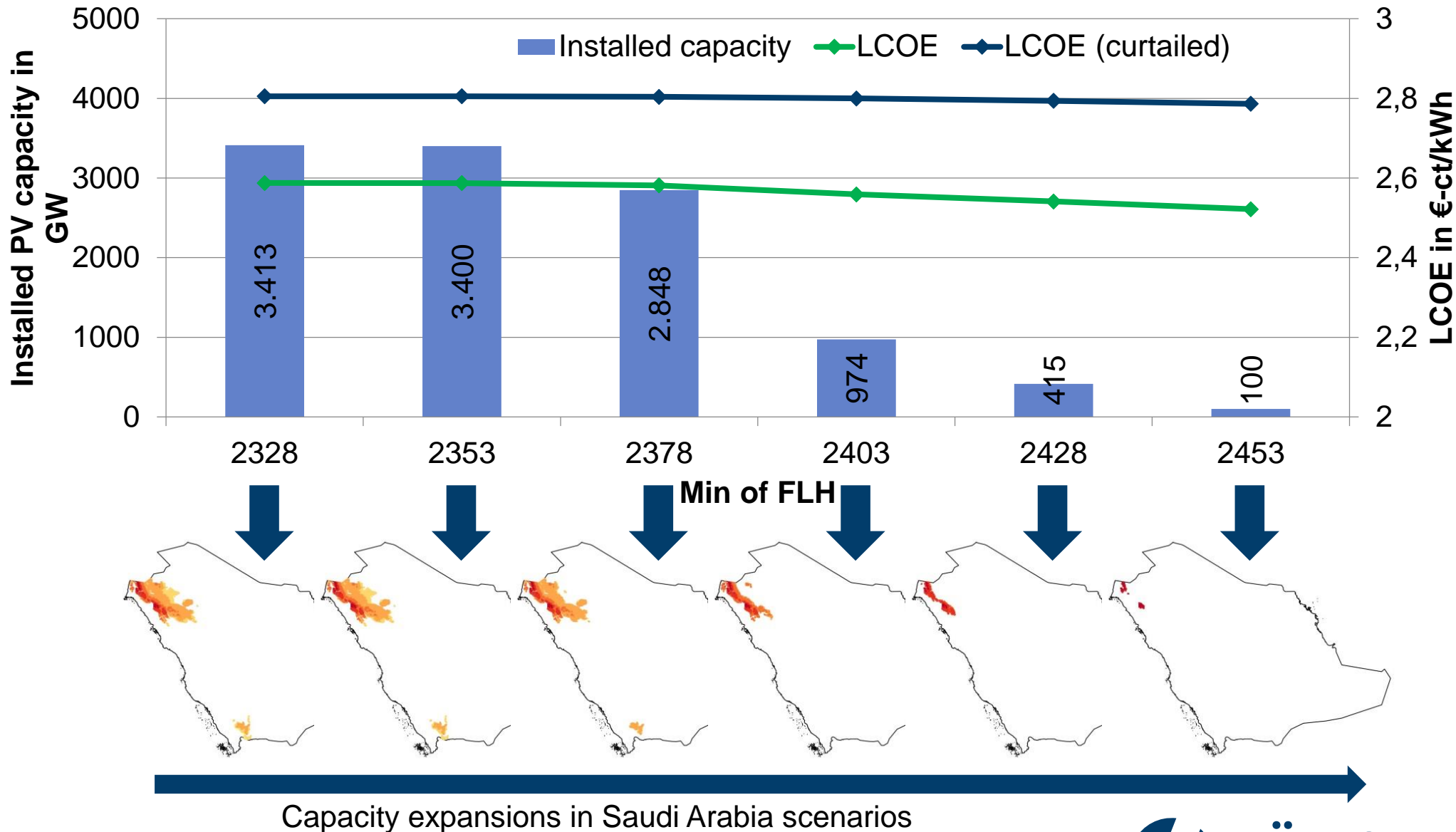


Additional restrictions:

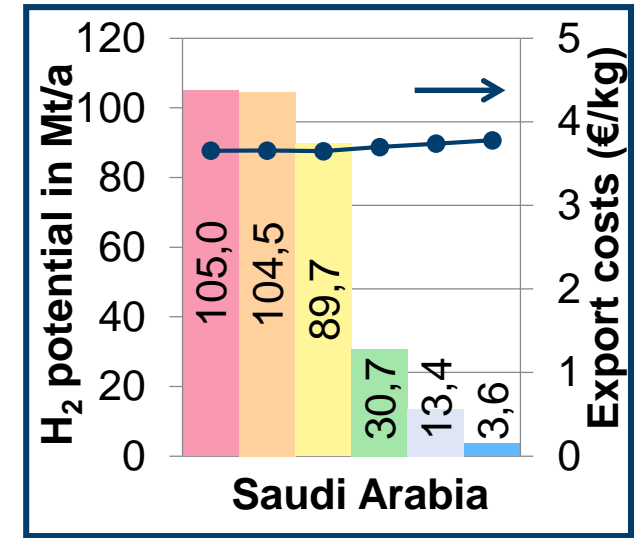
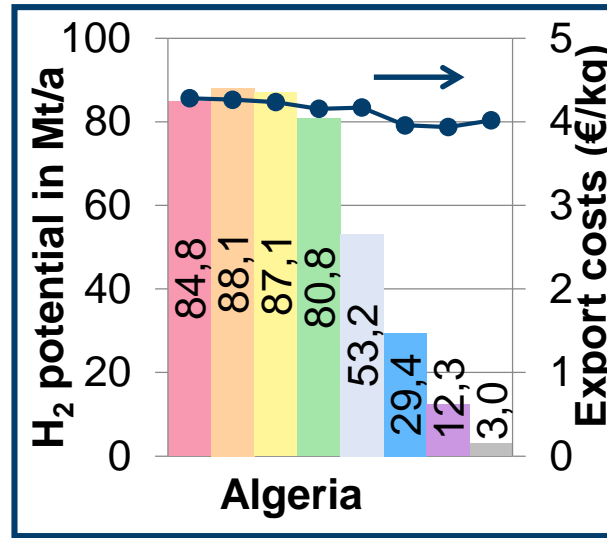
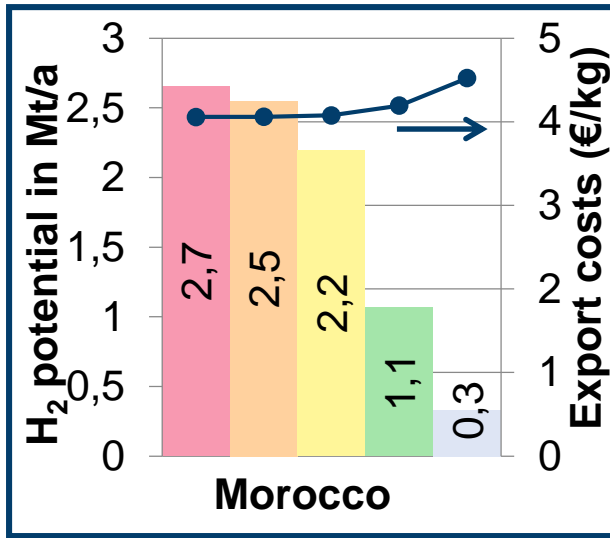
- Best 5% of all possible locations
- Minimum of full-load hours = 1900



Exemplary Results for Saudi Arabia



Worldwide H₂ Export Potential in Exemplary High Insolation Countries (*)



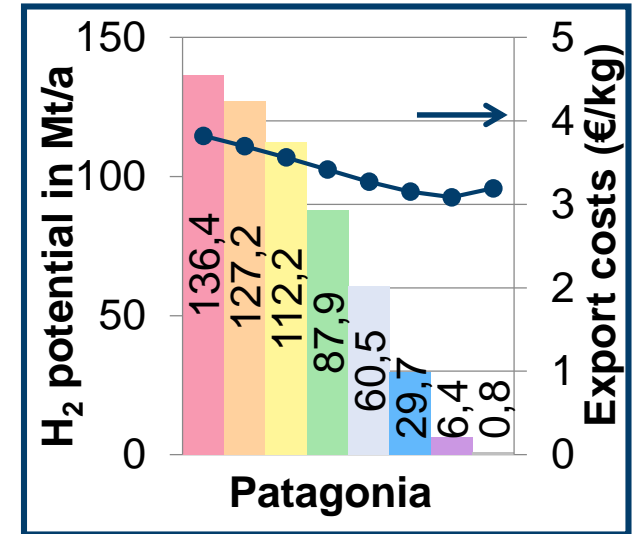
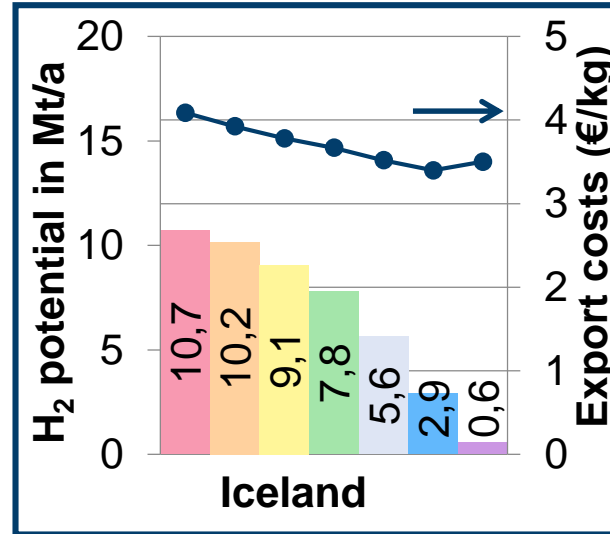
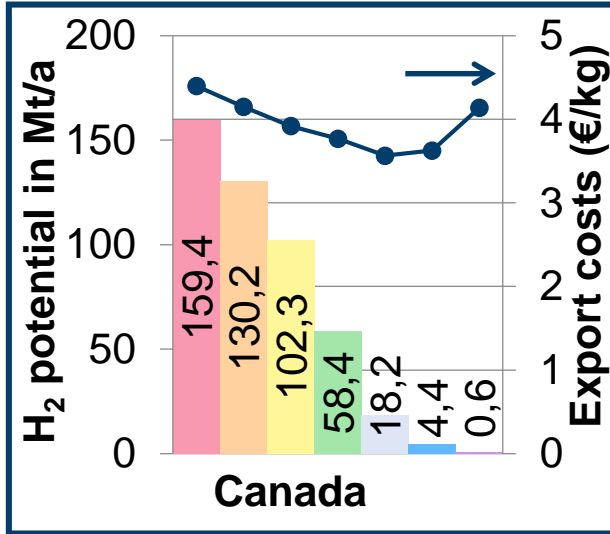
Capacity expansion state

- No. 8
- No. 7
- No. 6
- No. 5
- No. 4
- No. 3
- No. 2
- No. 1

Capacity expansion
=
Degree of potential
utilization

(*) Export costs excl. shipping

Worldwide H₂ Export Potential in Exemplary Strong Wind Countries (*)



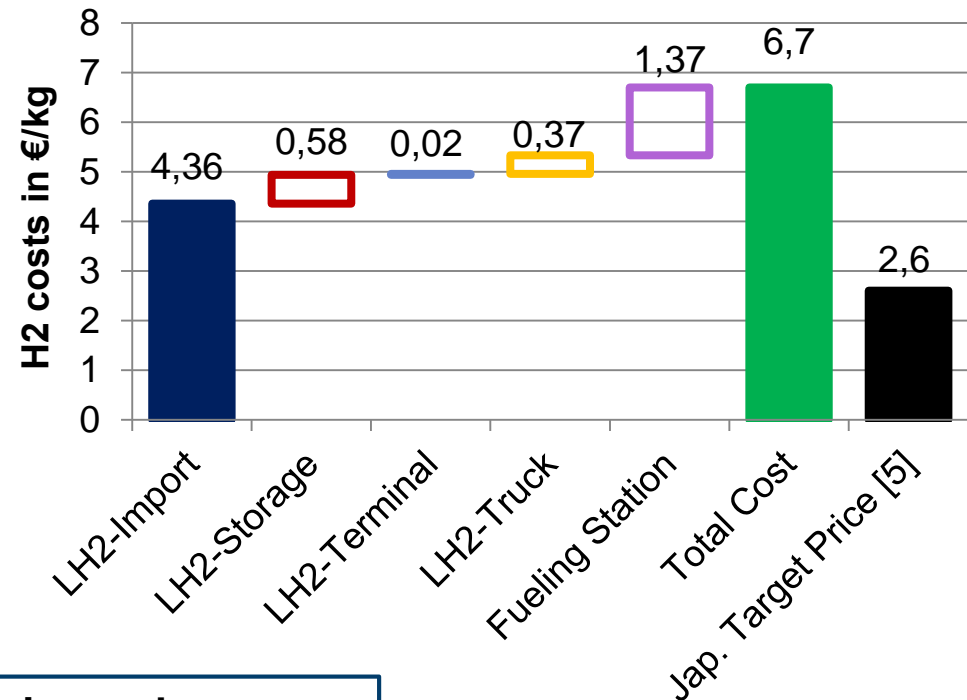
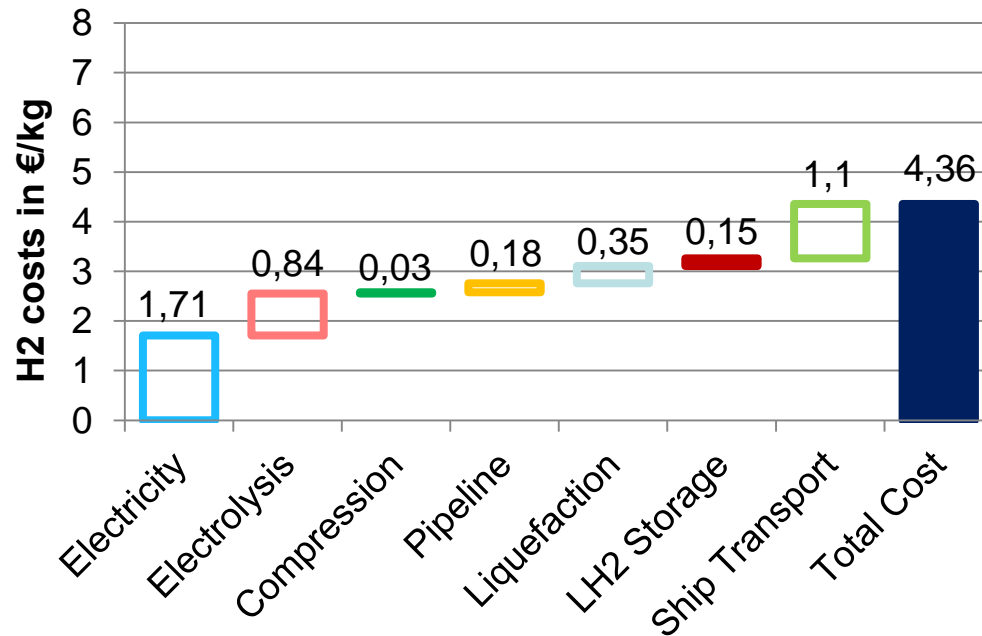
min. FLH



(*) Export costs excl. shipping costs

Wind hydrogen from Patagonia Potentially Economical in Japan

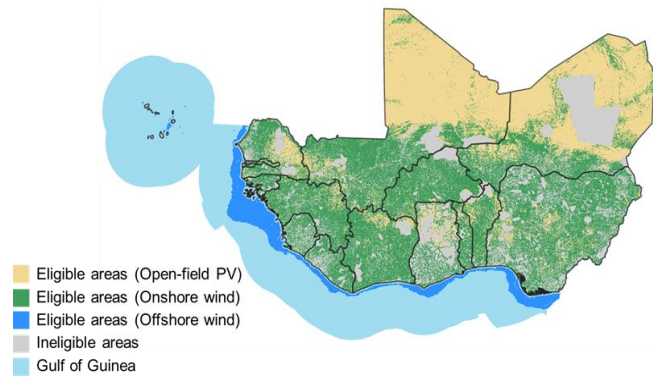
- **Wind potential in Patagonia sufficient to provide Japan with hydrogen**
 - *Potential of 18 Mt/a of hydrogen for assumed demand of 1.85 Mt/a for 2050 (only mobility)*
- **LCOH for provision at the fueling stations: 6.70 €/kg_{H2} / 7.84 \$/kg_{H2}**
(20.1 €-ct/kWh / 23.52 \$-c/kWh @ twice the efficiency of gasoline, gasoline: 6.3 €-ct/kWh / 7.37 \$-c/kWh)



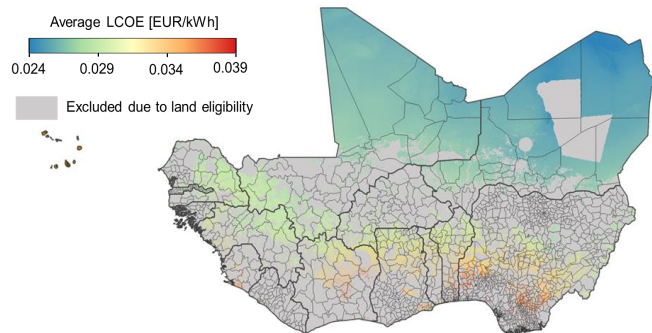
➤ **Wind-generated hydrogen from Patagonia can be economically competitive to conventional fuels in Japan (with reference to pretax costs)**

Green Hydrogen Atlas for West Africa

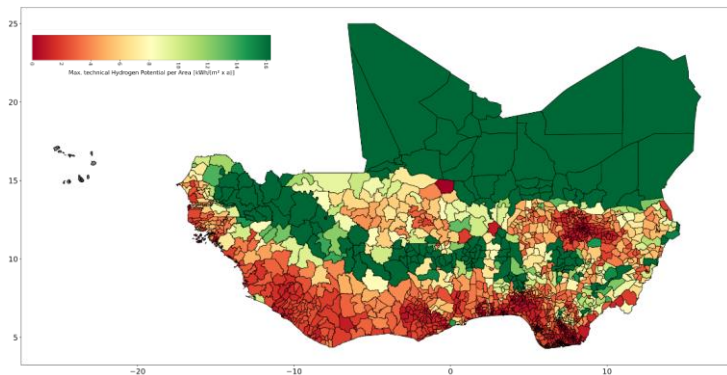
Local Renewable Energies for Regional Hydrogen Production



Land eligibility &
Placement of wind turbines and PV parks

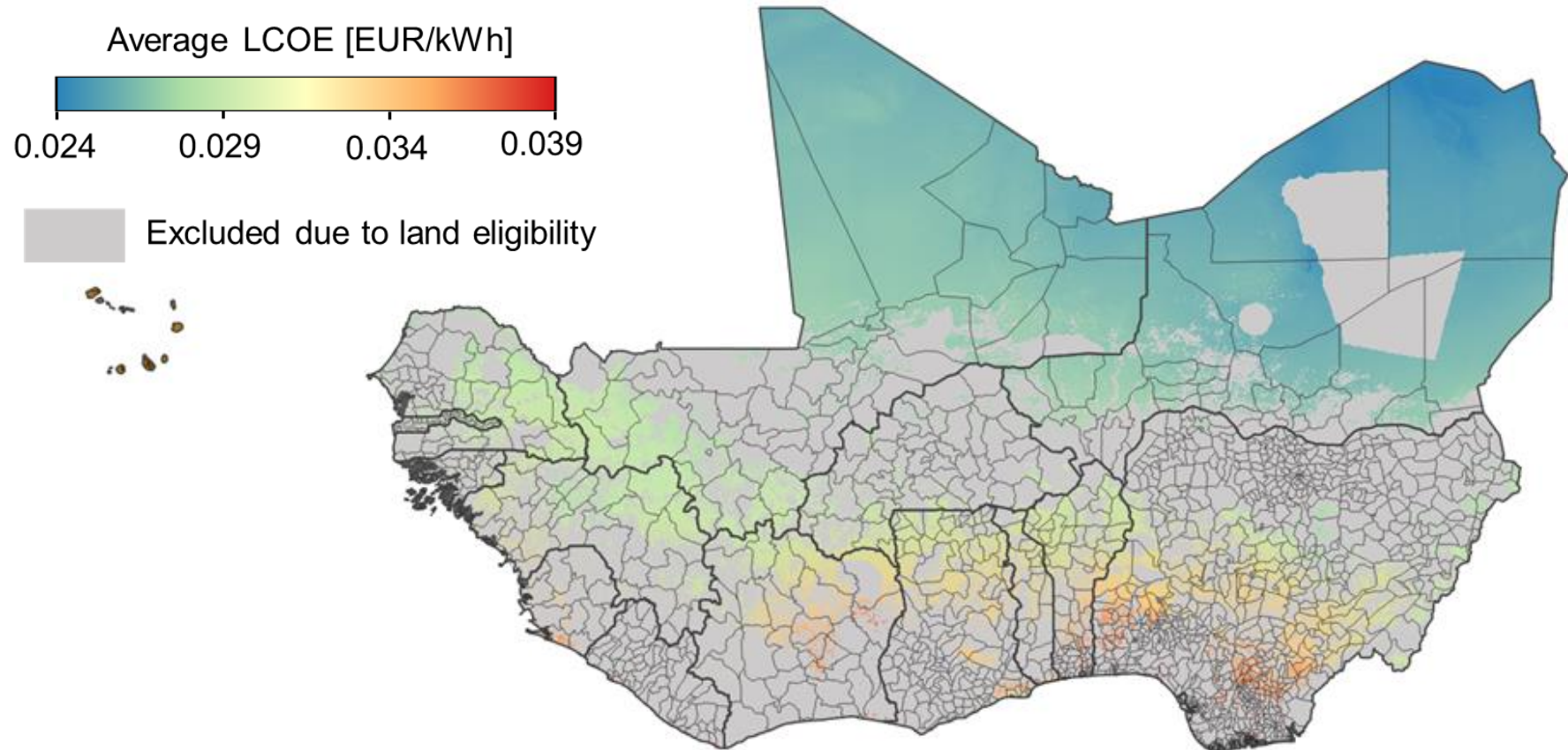


Renewable energy potential & cost



Local green hydrogen potential & cost

Result 1: Abundant & Cheap Open-Field Photovoltaic Potential



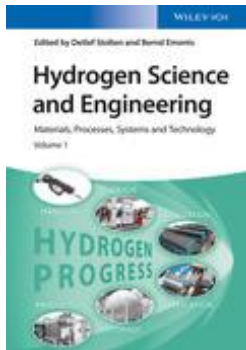
- The most promising potentials for open-field photovoltaic exist in the North of West Africa, while the main demand centers are located in the South near the coast
- Interconnections are required to utilize the huge photovoltaic potentials

Vielen Dank für Ihre Aufmerksamkeit

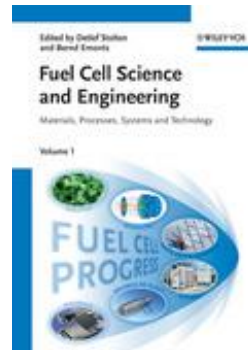


Vielen Dank für Ihre Aufmerksamkeit!

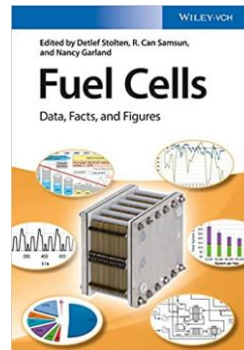
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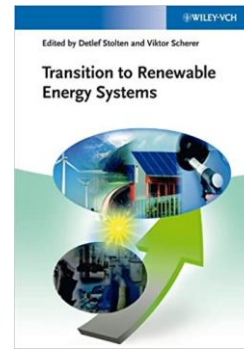
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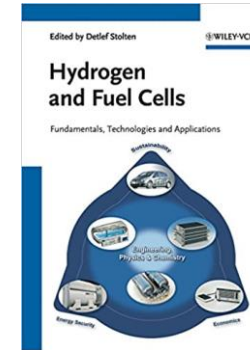
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