GIS-BASED SITE SUITABILITY ANALYSIS FOR SOLAR AND WIND TO HYDROGEN POTENTIAL IN EU AND NORTH-AFRICA IN 2030 & 2040

The effect on Europe's energy system by introducing mass-scale green Hydrogen

Content

1. Introduction
2. Methodology
3. Results
4. Discussion
5. Where I see that GeoAi can optimize my model
6. Q&A + panel discussion

Introduction

PROBLEM

There is little research on what the effect of introducing green hydrogen into the European energy system will be on the import and export of energy products in the future

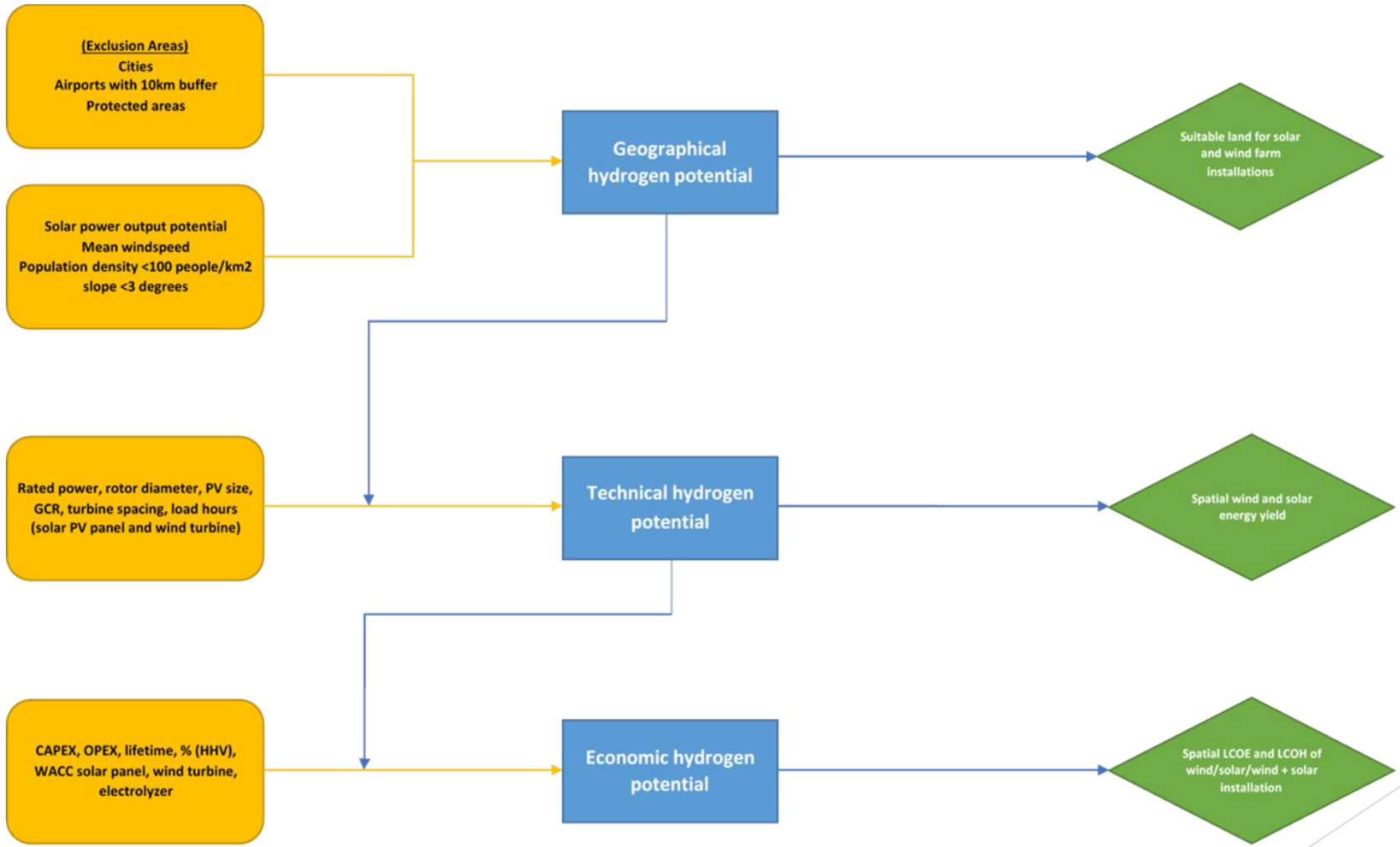
LITERATURE

Its impact on energy import/export hinges on the price per unit. Production cost depends on factors from production to space availability. Accurately assessing space needs for large-scale projects remains uncertain.

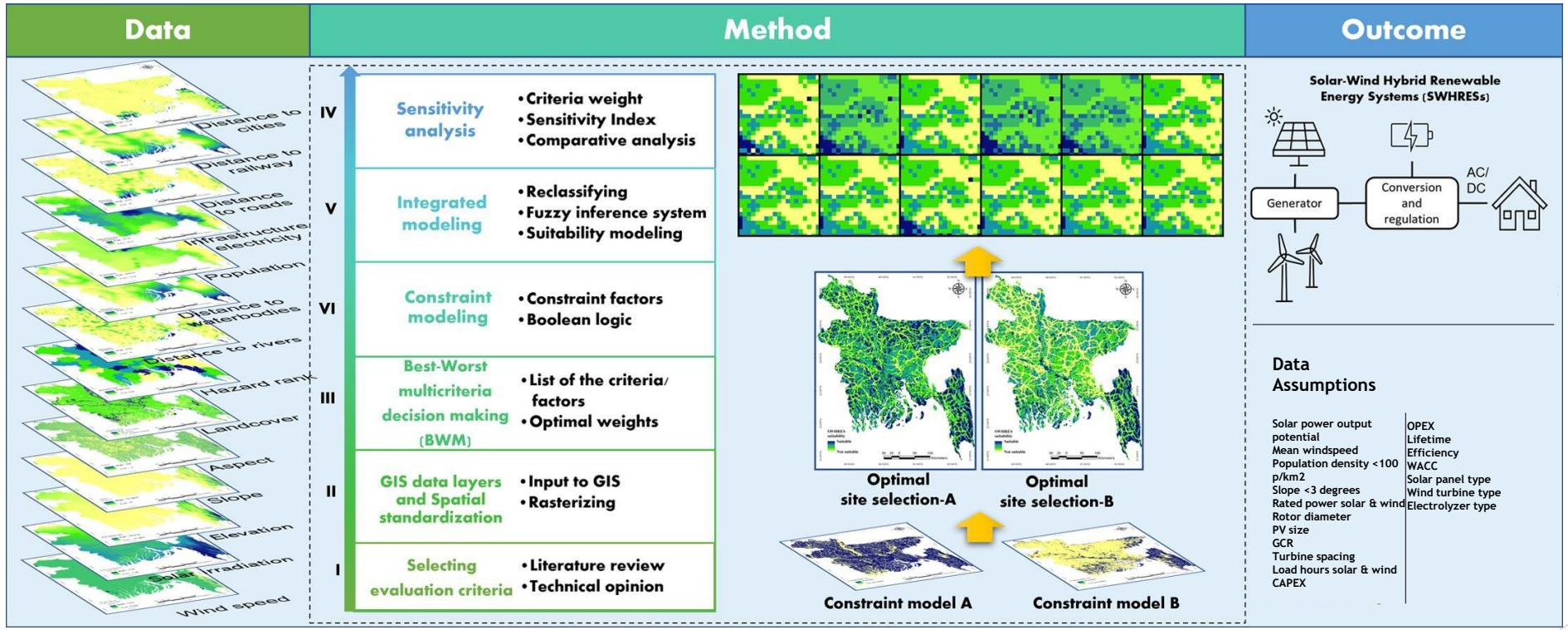
RES. QUESTION

"What is the potential for low-cost large-scale green hydrogen production in Europe and the Mediterranean region in 2030 & 2040?"

Workflow of research

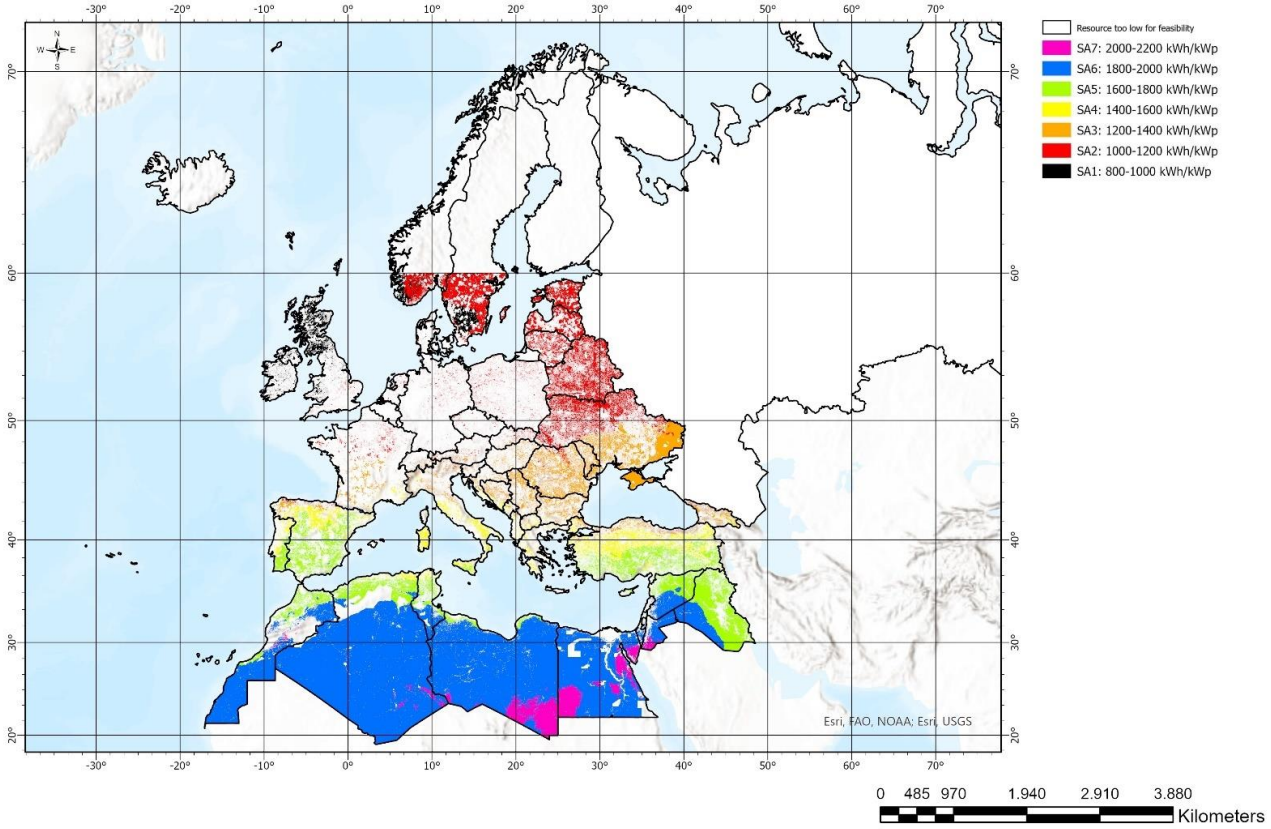


Methodology & Data collection

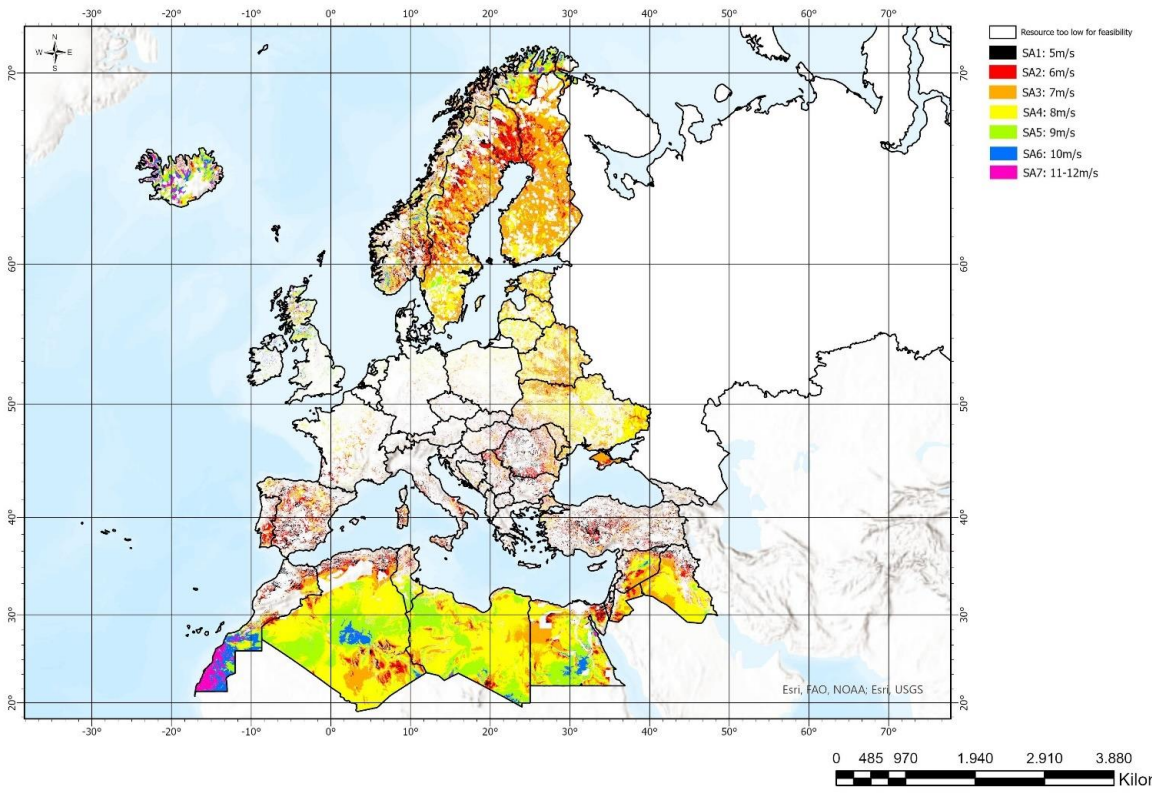


Geographical analysis

Solar

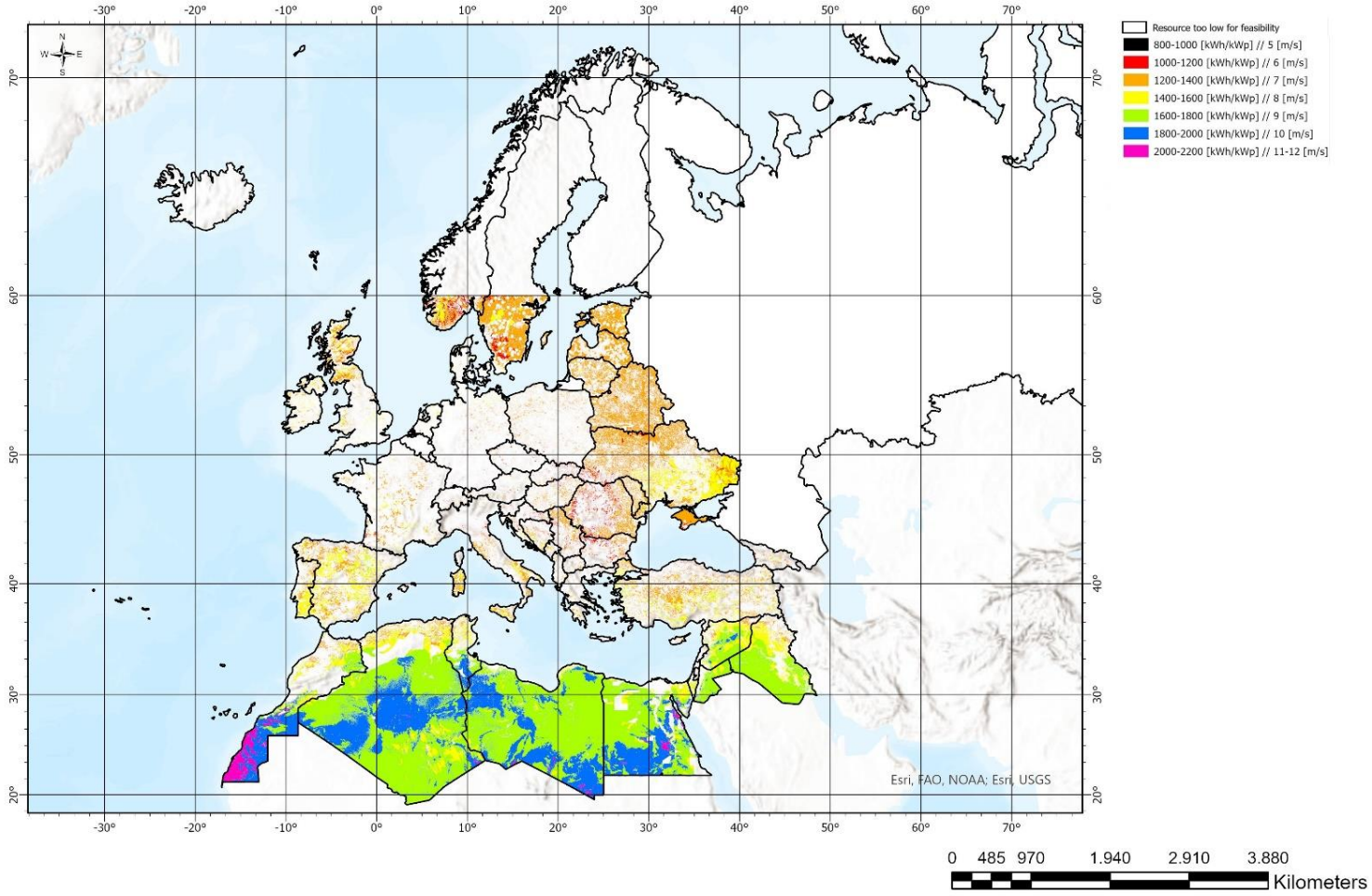


Wind



Geographical analysis

Solar & Wind



Technical analysis

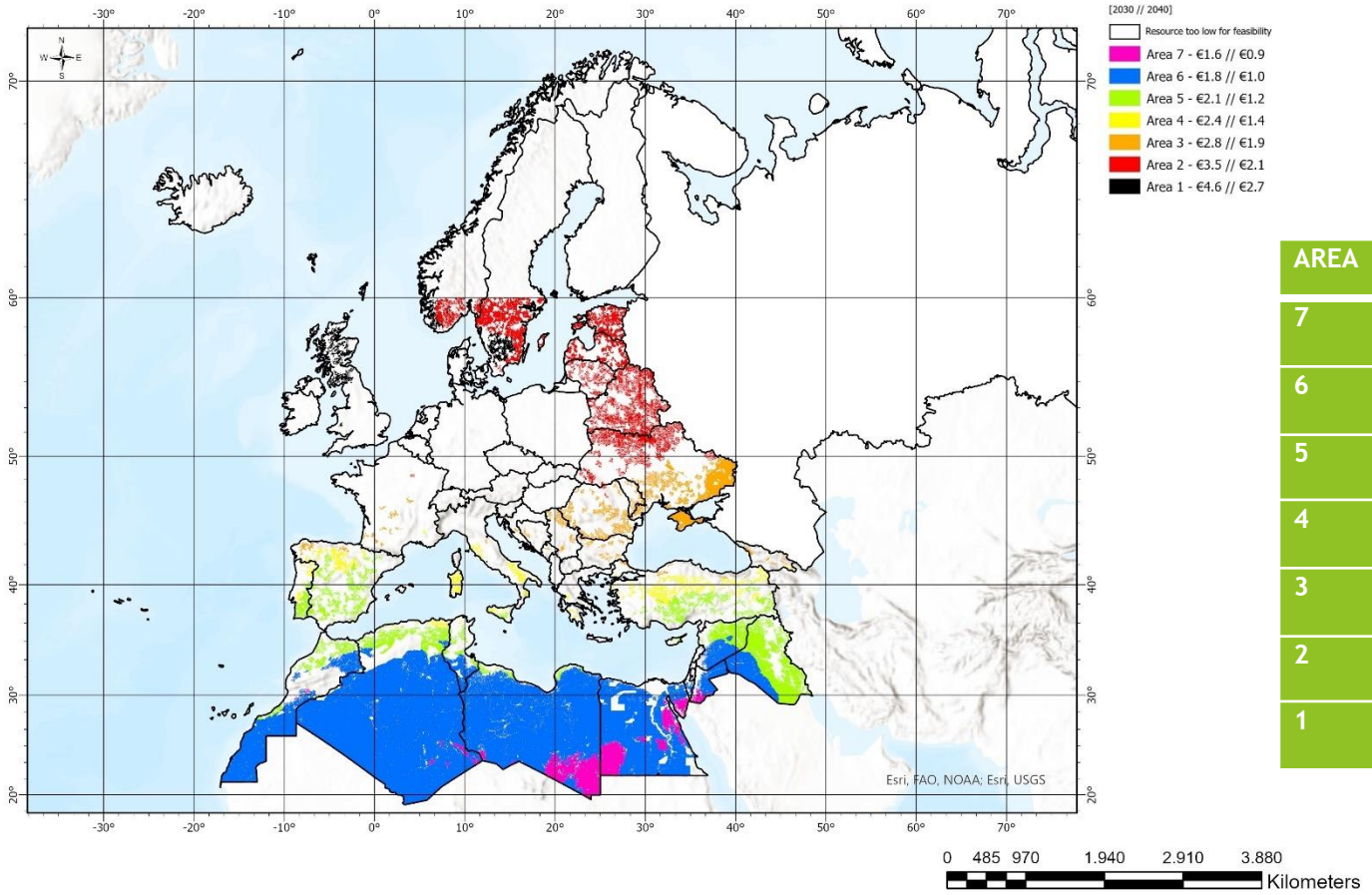
Solar	$Yield_S = C_S * FL_S$
Wind	$Yield_W = C_W * FL_W$
Solar and Wind	$Yield_{SW} = C * (Yield_{Solar} + Yield_{Wind})$
Electrolyser	$Mton\ H2\ /\ km2\ /\ Power\ Yield\ area$

Economic analysis

Solar	Wind	Solar and Wind	Electrolyser

WACC
OPEX (Solar, wind)
CAPEX (Solar, wind, electrolyser)
Electrolyser lifetime

Results – Case study Solar 2030&2040

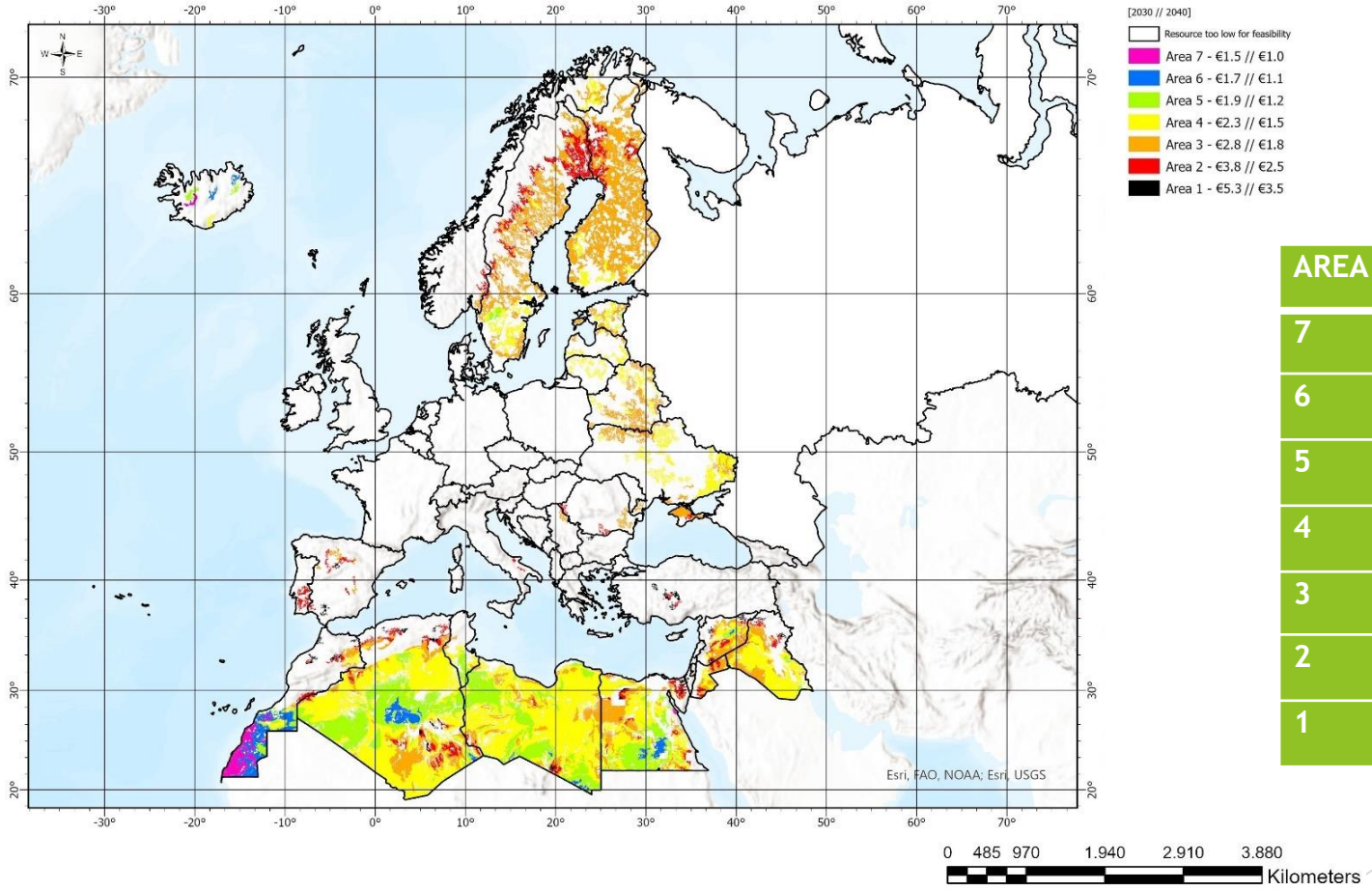


AREA	kWh/kWp	2030	2040
7	2200-2000	€ 1.6	€ 0.9
6	2000-1800	€ 1.8	€ 1.0
5	1800-1600	€ 2.1	€ 1.2
4	1600-1400	€ 2.4	€ 1.4
3	1400-1200	€ 2.8	€ 1.9
2	1200-1000	€ 3.5	€ 2.1
1	800-1000	€ 4.6	€ 2.7

Results – Case study Solar 2030&2040

	2030	2040	2030	2040
Area	Mton H2 per 500 km2	Mton H2 per 500 km2	Area size for 1Mton of hydrogen (km^2)	Area size for 1Mton of hydrogen (km^2)
7	2.40	2.87	208	174
6	2.09	2.50	239	200
5	1.80	2.16	278	231
4	1.57	1.88	319	266
3	1.32	1.58	379	316
2	1.02	1.22	490	410
1	0.80	0.96	625	521

Results – Case study Wind 2030&2040

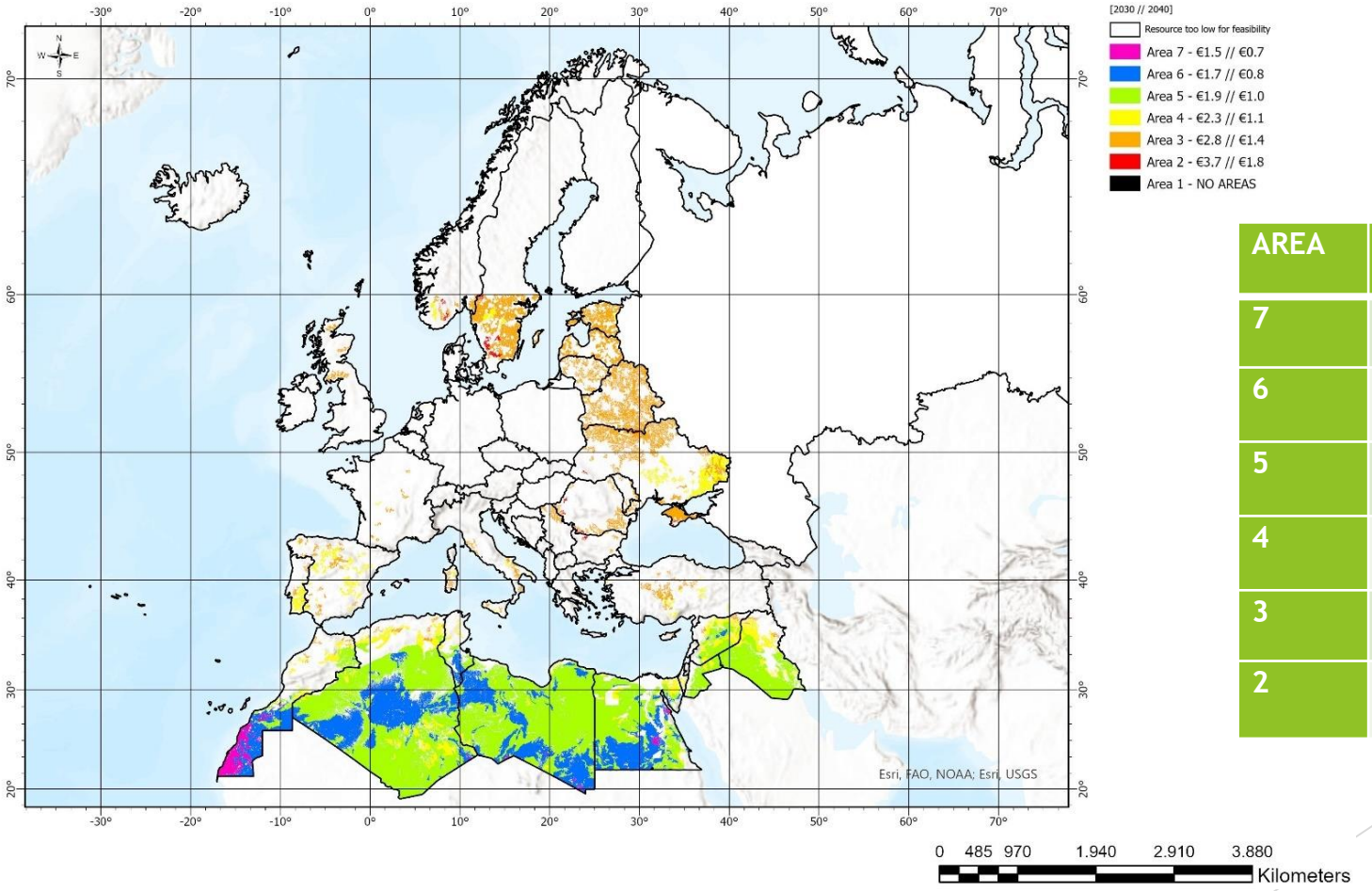


AREA	m/s	2030	2040
7	11-12	€ 1.5	€ 1.0
6	10	€ 1.7	€ 1.1
5	9	€ 2.3	€ 1.2
4	8	€ 2.4	€ 1.5
3	7	€ 2.8	€ 1.8
2	6	€ 3.8	€ 2.5
1	5	€ 5.2	€ 3.5

Results – Case study Wind 2030&2040

	2030	2040	2030	2040
Area	Mton H2 per 500 km2	Mton H2 per 500 km2	Area size for 1Mton of hydrogen (km^2)	Area size for 1Mton of hydrogen (km^2)
7	0.33	0.45	1515	1111
6	0.31	0.44	1613	1136
5	0.29	0.41	1724	1220
4	0.25	0.35	2000	1429
3	0.22	0.31	2272	1613
2	0.17	0.24	2941	2083
1	0.13	0.15	3846	3333

Results – Case study Solar&Wind 2030&2040



AREA	kWh/kWp	m/s	2030	2040
7	2200-2000	11-12	€ 1.5	€ 0.7
6	2000-1800	10	€ 1.7	€ 0.8
5	1800-1600	9	€ 1.9	€ 1.0
4	1600-1400	8	€ 2.3	€ 1.1
3	1400-1200	7	€ 2.8	€ 1.4
2	1200-1000	6	€ 3.7	€ 1.8

Results – Case study Solar&Wind 2030&2040

2030				
Area	Load hours	Electrolyzer capacity (GW)	Mton H2 per 500 km2	Area size for 1Mton of hydrogen (km^2)
7	4094	12.11	2.46	204
6	3759	13.19	2.16	221
5	3416	14.50	1.90	243
4	3038	16.29	1.64	273
3	2678	18.50	1.37	310
2	2222	22.26	1.07	373
1	No areas feasible	No areas feasible	No areas feasible	No feasible areas

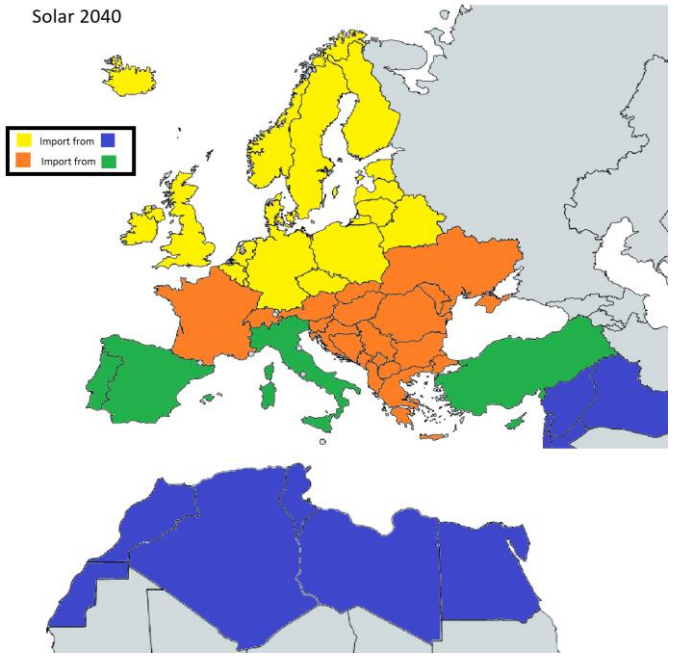
Results

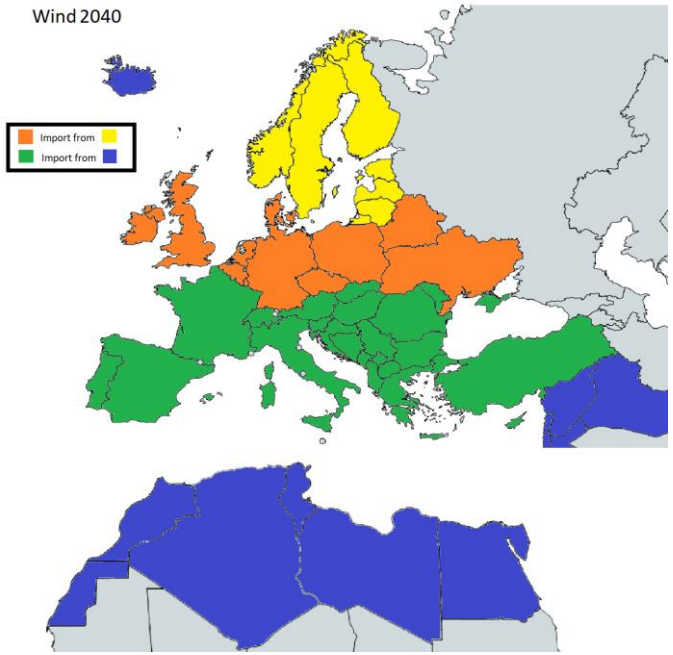
Region	Scenario	Potential 2040 (Mton) for <1.5 €/kg
North-Europe	Solar	0
South-Europe	Solar	1059
North Africa	Solar	26181
North-Europe	Wind	22
South-Europe	Wind	0
North Africa	Wind	2704
North-Europe	Solar&wind	1483
South-Europe	Solar&wind	1332
North Africa	Solar&wind	24006

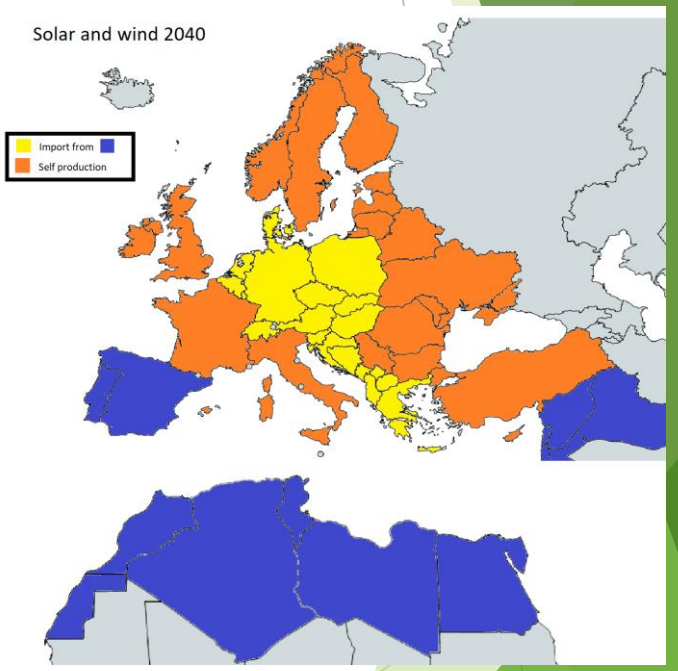
Results

Production price (€/kg)	Max. distance for transport (km)	Transport costs (€/kg)	Storage costs (€/kg)	Overall costs (€/kg)	This region must import or export or self-produce
1.5 ≥	NA	NA	0.1	1.6 ≥	Import
1.4	0	0	0.1	1.5	Self-produce with no export
1.3	1000	0.1	0.1	1.5	Export with max distance 1000 km
1.2	2000	0.2	0.1	1.5	Export with max distance 2000 km
1.1	3000	0.3	0.1	1.5	Export with max distance 3000 km
1.0	4000	0.4	0.1	1.5	Export with max distance 4000 km
< 1.0	5000 ≥	0.5 ≥	0.1	1.5	Export with max distance ≥ 5000 km

Results


Solar 2040
Import from
Import from


Wind 2040
Import from
Import from


Solar and wind 2040
Import from
Self production

Discussion

Methodology	• Results across renewable energy scenarios hinges on the choice of datasets and parameters • Use a AHP to get more precise divisions between weights
Geographical	• Limitations due to unresolved issues in software (ArcGIS Pro) • Limitations on datasets was defined by: Choice of data, Availability, recency, and precision
Technical	• Electrolyzer, solar panel-, and wind turbine type & power output & price will differ in future and therefor effect the hydrogen production estimates
Economic	• CAPEX for solar, wind, and electrolyzer technology are estimated from research • Transport and storage costs are now emphasized in this research • WACC is assumed to be fixed for 2030 & 2040, although it may vary in the future
GIS size criterion	• Reducing the size criterion in the model increases the potential shown on suitability maps. In this research, the smallest size is set to 5 km2 for high accuracy. The chosen size criteria appear too high for the solar scenario and too low for the wind scenario(S&W is not considered)

Conclusion and future work

RESEARCH QUESTION

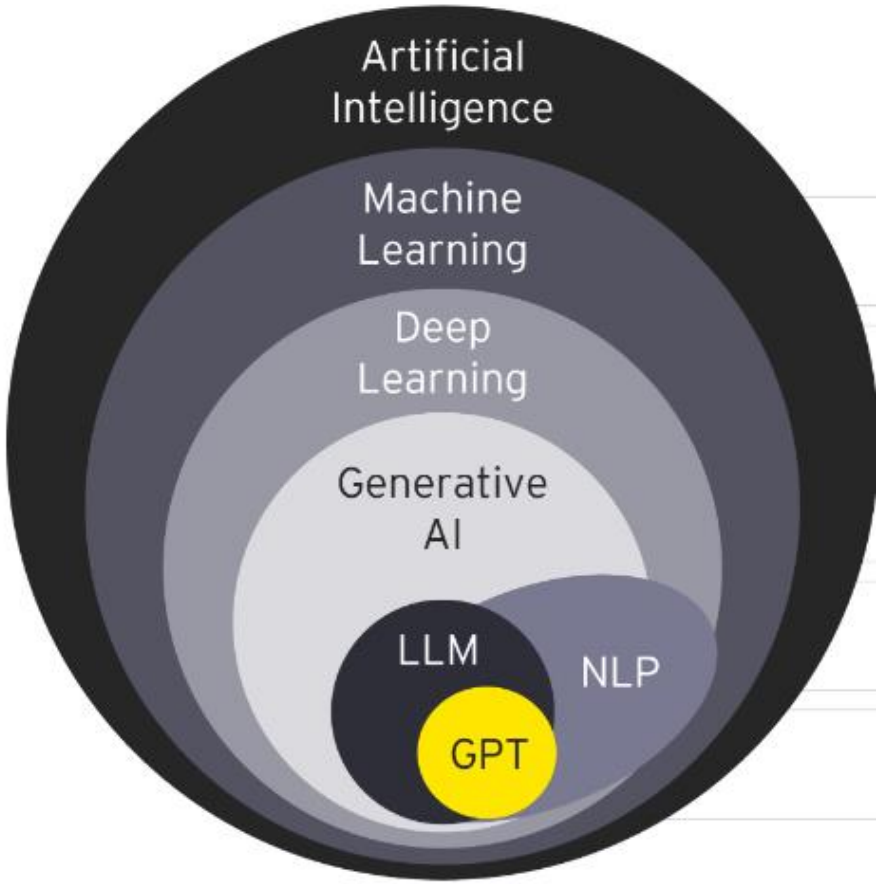
“What is the potential for low-cost large-scale green hydrogen production in Europe and the Nort-African region in 2030 & 2040?”

ANSWER

1. **Potential for Green Hydrogen**
2. **Influence on the European Energy system depends on Three Factors:**
    1. **Space and Resource Availability**
    2. **Production Price**
    3. **Production Potential**

In summary, this research identified the importance of space, production price, and production potential in determining the feasibility and competitiveness of green hydrogen as an energy solution.

AI and GeoAI



Artificial Intelligence encompasses the development of computer systems that can perform tasks requiring human-like intelligence

Machine Learning learns patterns and makes predictions or decisions based on that data provided instead of explicitly programming rules

Deep Learning is particularly effective for tasks like image and speech recognition

Generative AI refers to AI systems that can generate content or data that is not explicitly present in the training data

LLM(Language translations), NLP(Chatbots), GPT(text & image transformtion() are sub-sets of GenAI

Where do I see that Geo-AI can improve my model?

- **Computer Vision: Data integration with layers overlaid - (Deep learning)**
  This refers to the process of integrating data by overlaying multiple layers. In computer vision, this could involve combining different visual data sources or adding context layers to images or videos.

- **Spatial Analysis: Extrapolating sample sizes - (Machine Learning)**
  Spatial analysis is the examination of geographical or spatial data. "Extrapolating sample sizes" means estimating data for a larger area based on the information from a smaller sample. This is often used in spatial statistics to make predictions or inferences about a larger spatial region based on limited data.

- **Forecasting: LCOE prices for wind, solar, and electrolyzers - (Machine Learning)**
  Forecasting involves making predictions about future trends or values. In this context, it specifically refers to forecasting the Levelized Cost of Electricity (LCOE) for different energy sources, such as wind and solar power, as well as for the cost of electrolyzers. These forecasts help in estimating the future costs of these technologies for energy production.

Thank you!

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Q&A - Discussion

Appendix

Economic analysis - Solar

Solar

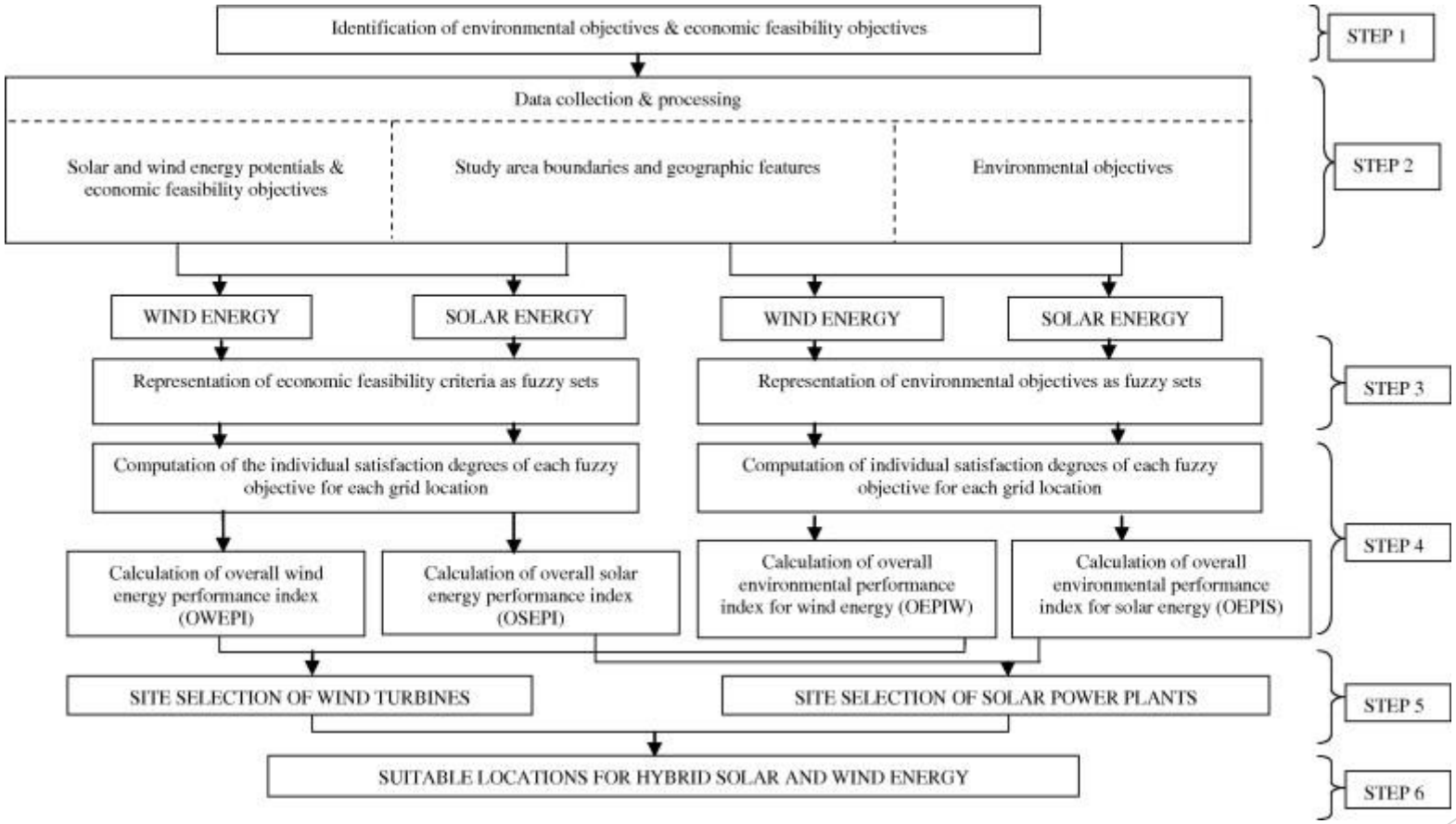
$$Capex_{2040} = \frac{Capex_{Area7\ 2040}}{Capex_{Area7\ 2030}} * Capex_{Area\ X\ 2030}$$

Input	2030	2040
CAPEX [€/kW]	500 - 300	417 - 250
Lifetime [yr]	20	20

Area (2030)	€/kW (2030)	Area (2040)	€/kW (2040)
7	300	7	250
6	320	6	267
5	350	5	292
4	380	4	317
3	420	3	350
2	460	2	383
1	500	1	417

Input	2030	2040
LCOE solar [€/kWh]	0.014 - 0.052	0.010 - 0.039

Methodology site selection



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South-Europe	Solar	0	1059
North Africa	Solar	0	26181
North-Europe	Wind	1	22
South-Europe	Wind	0	0
North Africa	Wind	58	2704
North-Europe	Solar&wind	0	1483
South-Europe	Solar&wind	0	1332
North Africa	Solar&wind	493	24006