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Green hydrogen trade from North Africa to Europe: optional long-term scenarios with the JRC-EU-TIMES model

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Research context and objective

Methodology and instruments

Results and discussion

Main remarks and future work

Research context

- No announced clean H_2 projects growing fast worldwide.
- Governments foster national strategies & funding for large-scale projects.
- Ambitious growth for electrolysers' manufacture.
- Measures needed to support clean H_2 uptake.
- Private sector involved at mostly on small scale project.
- International cooperations are growing but demand signals are not clear.
- Scaling-up clean H_2 is the key enabler to support trade.

Green hydrogen as key driver of the transition: *opportunities* to be enanched and *challenges* to be addressed

- Increase in equipment/financial costs, due to inflation.
- Slow implementation of support schemes delaying investment.
- Increased H_2 demand but concentrated in traditional applications.
- Measures for clean H_2 uptake not sufficient to support decarbonization.
- Regulation and certification are still barriers.
- Key factors impacting clean H_2 uptake: (i) "hard" as production and transport costs, and (ii) "soft" as geopolitics, trade dependencies and policies.

Research context and objective

we move

FOCUSING ON INTERNATIONAL COOPERATION

Focus on green hydrogen import from North Africa as challenging and valuable opportunity for EU long-term ambitious targets.

TARGETING COMPETITIVENESS THROUGH UNCERTAINTY

Study to what extent green hydrogen imports from North Africa could support the European carbon-neutrality target for 2050.

WORKING ON UNCERTAINTY

Uncertainty of parameters involving production potentials and costs, alternative transport pathways and financial risks affect trade effectiveness and competitiveness.

Methodology and instruments

Starting from the JRC-EU-TIMES (JET) model [1,2], specific settings are studied to elaborate ad-hoc scenarios:

1. Availability of volumes for trade

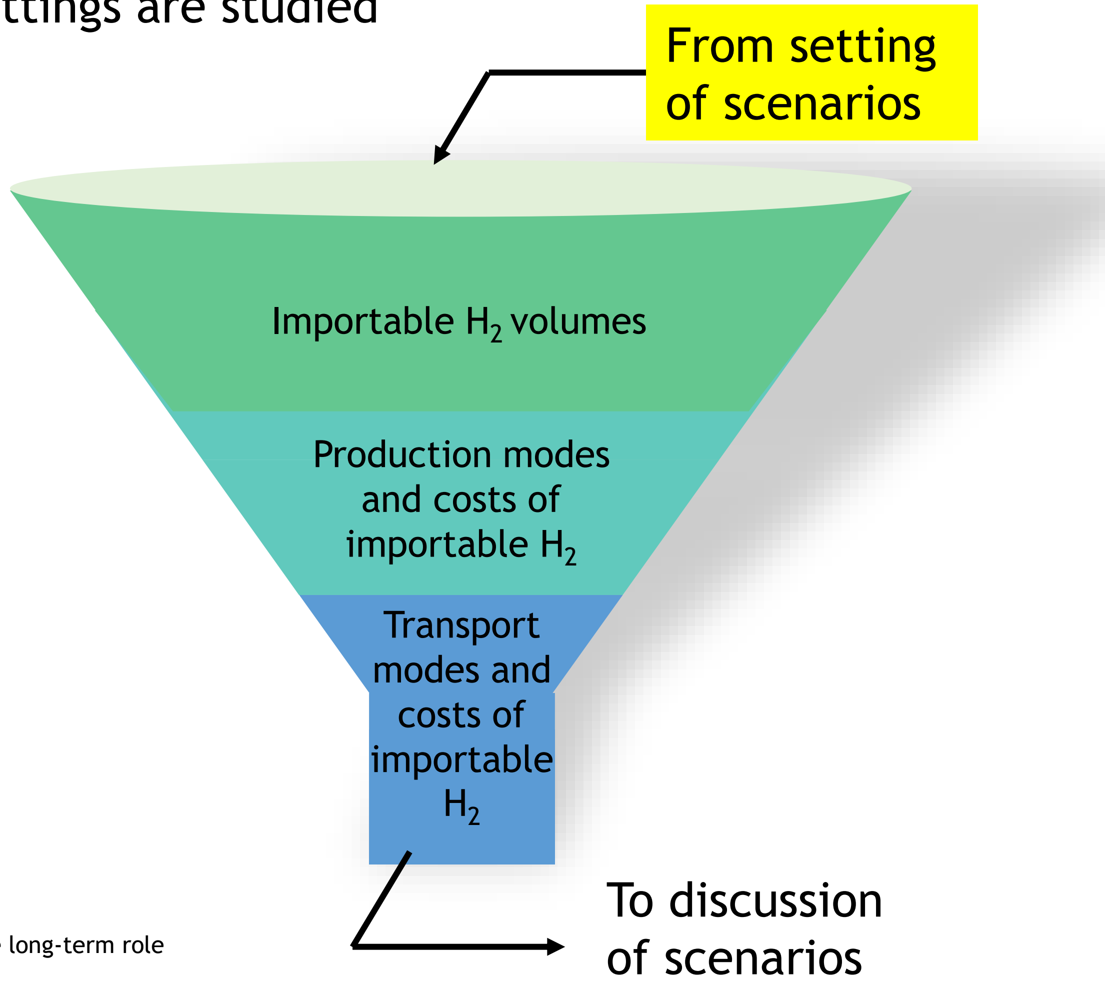
Analysis of local strategies of North African countries involved in the assessment.

2. Alternative production pathways

Calculation of the Levelized Cost of Hydrogen to address different technological pathways for production and financial risks.

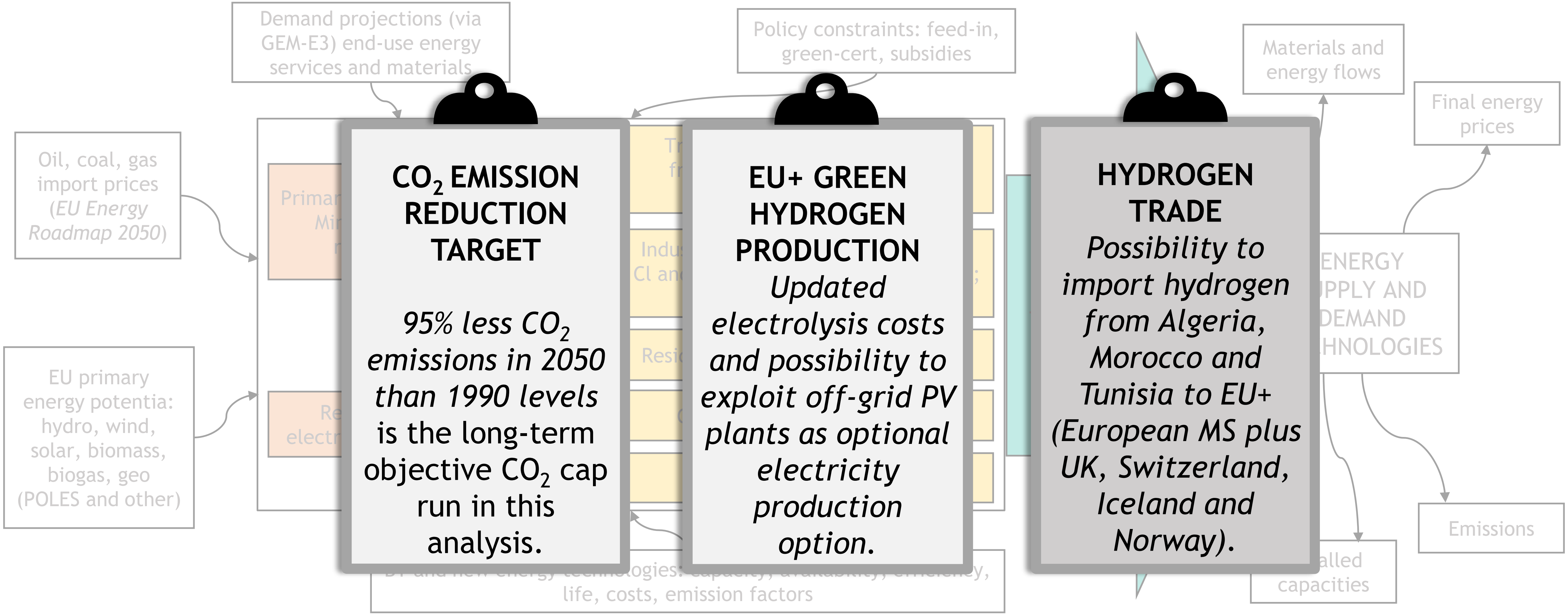
3. Alternative transport pathways

Elaboration of costs for different transport options through the definition of ad-hoc routes from North Africa to Europe.



[1] S. Simoes, W. Nijs, P. Ruiz, A. Sgobbi, D. Radu, P. Bolat, C. Thiel e S. Peteves, «The JRC-EU-TIMES model: assessing the long-term role of the SET Plan Energy Technologies. Report EUR 26292 EN» 2013
[2] S. Simoes, W. Nijs, P. Ruiz-Castello, A. Sgobbi e C. Thiel, «Comparing policy routes for low-carbon power technology deployment in EU – an energy system analysis» Energy Policy, vol. 101, p. pp. 353–365, 2017

Methodology and instruments



CO_2 EMISSION REDUCTION TARGET

95% less CO_2 emissions in 2050 than 1990 levels is the long-term objective CO_2 cap run in this analysis.

EU+ GREEN HYDROGEN PRODUCTION

Updated electrolysis costs and possibility to exploit off-grid PV plants as optional electricity production option.

HYDROGEN TRADE

Possibility to import hydrogen from Algeria, Morocco and Tunisia to EU+ (European MS plus UK, Switzerland, Iceland and Norway).

[1] S. Simoes, W. Nijs, P. Ruiz, A. Sgobbi, D. Radu, P. Bolat, C. Thiel e S. Peteves, «The JRC-EU-TIMES model: assessing the long-term role of the SET Plan Energy Technologies. Report EUR 26292 EN» 2013

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Methodology and instruments

HYDROGEN TRADE
Possibility to import hydrogen from Algeria, Morocco and Tunisia to EU+ (European MS plus UK, Switzerland, Iceland and Norway).

Six new processes are added to the model:

1. From Algeria by pipelines
2. From Algeria by ships
3. From Morocco by pipelines
4. From Morocco by ships
5. From Tunisia by pipelines
6. From Tunisia by ships

Working on:

1. Importable H_2 volumes
2. Production modes and costs of importable H_2
3. Transport modes and costs of importable H_2

Methodology and instruments - *Setting of scenarios*

Availability for trade: *Analysis of local strategies*

- **Algeria**: declaration on national export-oriented H_2 strategy to Europe [3].
- **Morocco**: national green H_2 roadmap [4] sets values for H_2 exports.
- **Tunisia**: announced H_2 roadmap for March 2023, not published yet. Government announcement based on the results of the EHB initiative [5,6].

→ **30 to 40 TWh** of H_2 and hydrogen-based fuels exported to Europe **by 2040** [3].

→ **46 to 92 TWh** of H_2 and hydrogen-based fuels to be exported to Europe **by 2040 (92 to 230 TWh by 2050)** [4].

→ **180 to 200 TWh** of H_2 exported to Europe **by 2050** [5,6].

[3] L. Collins, «Algeria aims to supply Europe with 10% of its clean hydrogen needs by 2040 in new national H2 roadmap,» March 2023. [Online].
[4] Royaume of Morocco, «Feuille de route: Hydrogène Vert, Vecteur de Transition Energetique et de Croissance Durable. (in French),» January 2021.
[5] Agency Tunis Afrique Press, «Tunisia can export over 5.5mln tonnes of green hydrogen to Europe by 2050,» 26 May 2023. [Online].
[6] European Hydrogen Backbone (EHB), «Five hydrogen supply corridors for Europe in 2030,» 2022.

Methodology and instruments - *Setting of scenarios*

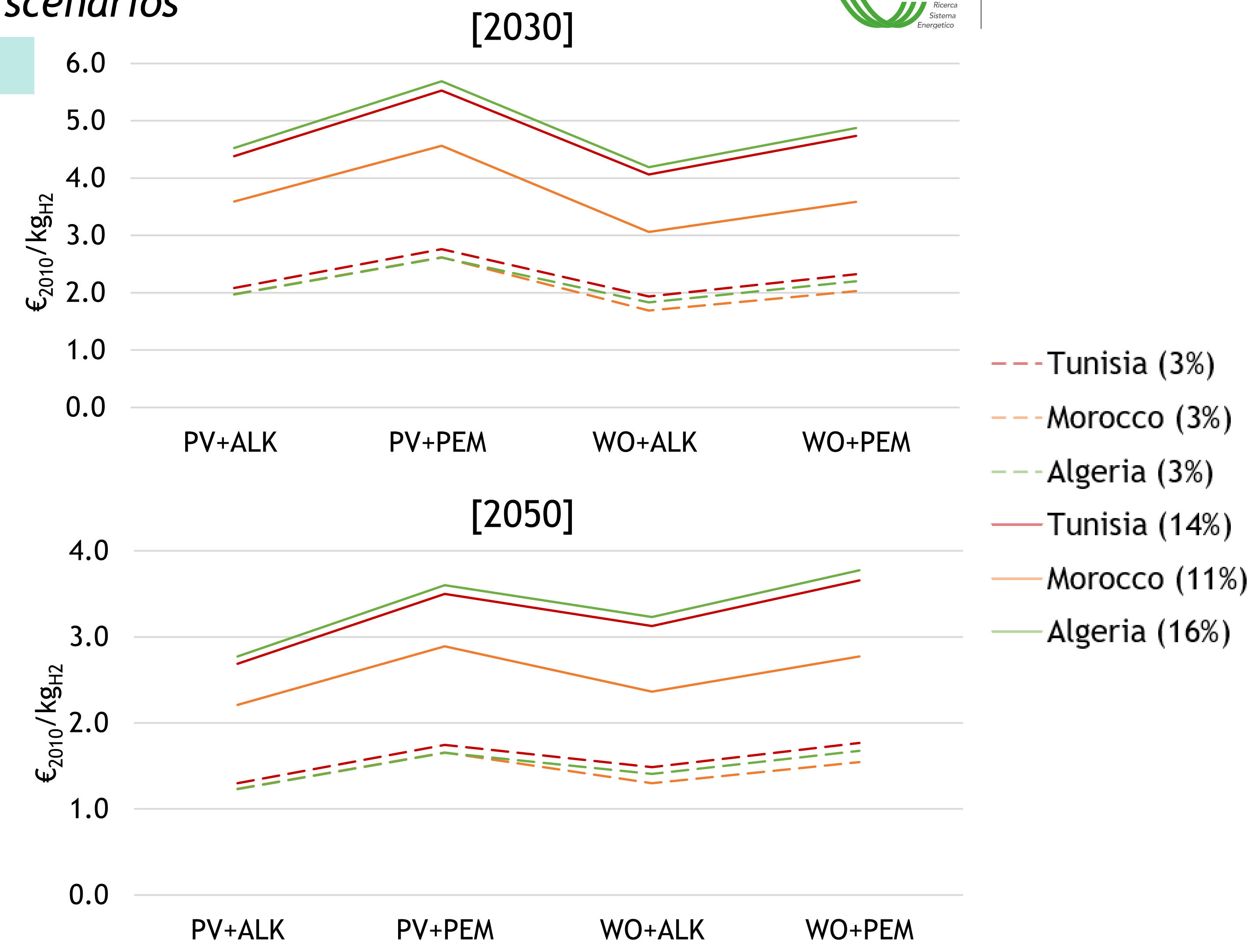
Alternative production pathways: *Calculation of LCOH*

LCOH calculated as the average of four technological combinations:

- PV+alkaline,
- PV+PEM,
- Wind onshore + alkaline,
- Wind onshore + PEM.

An optimistic and pessimistic case:

- WACC of 3%,
- increase of +5% to country-specific WACC from IRENA report [7].

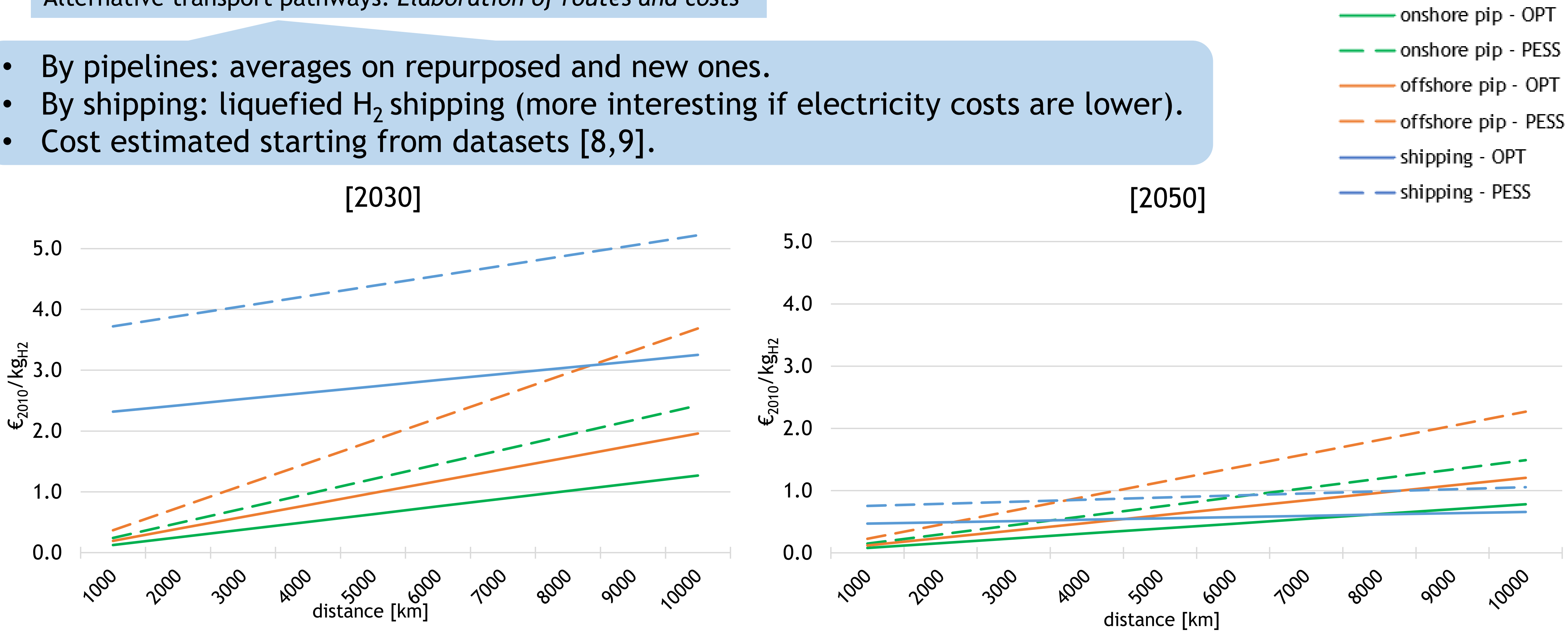


[7] International Renewable Energy Agency (IRENA), «The cost of financing for renewable power (Data Appendix),» Abu Dhabi, 2023.

Methodology and instruments - *Setting of scenarios*

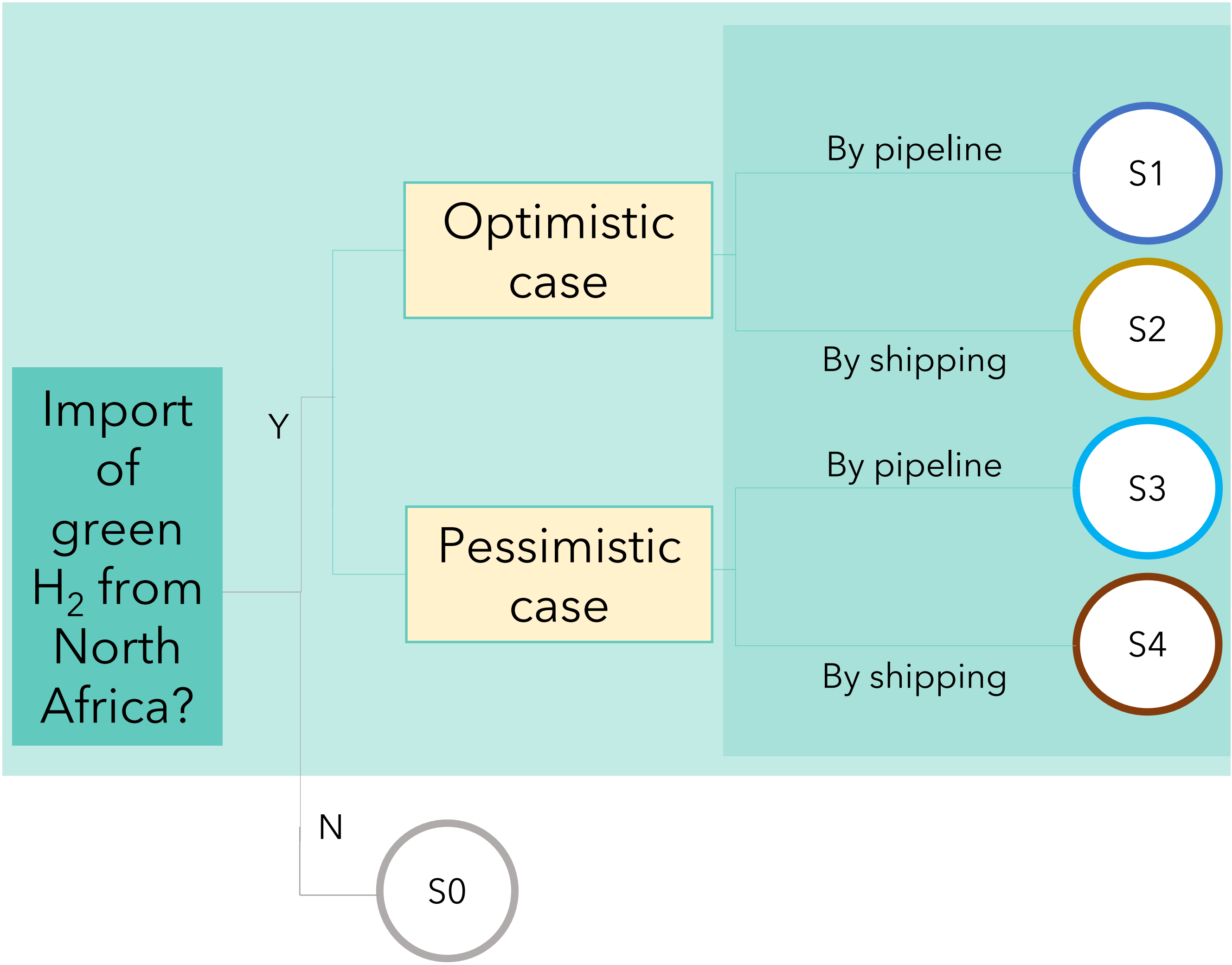
Alternative transport pathways: *Elaboration of routes and costs*

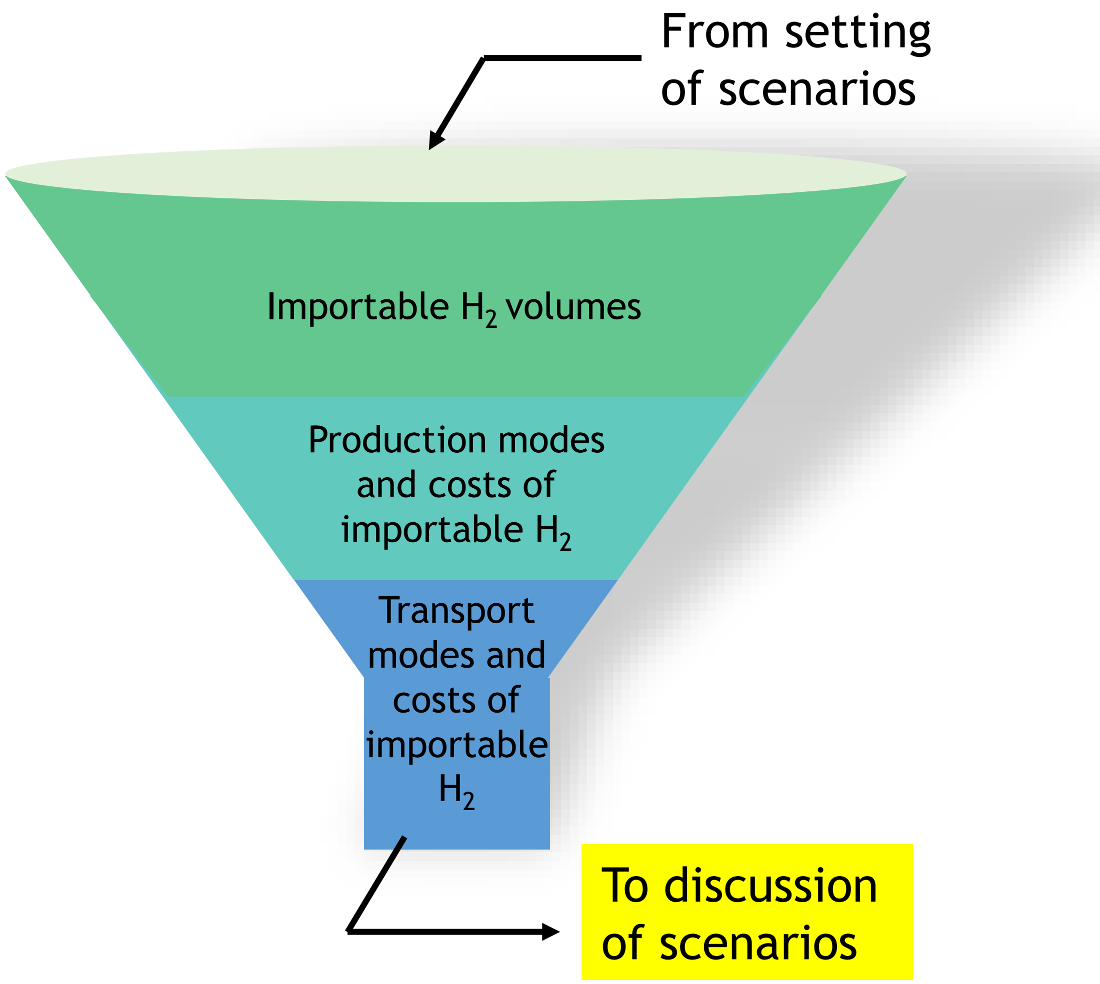
- By pipelines: averages on repurposed and new ones.
- By shipping: liquefied H_2 shipping (more interesting if electricity costs are lower).
- Cost estimated starting from datasets [8,9].



[8] International Renewable Energy Agency (IRENA), «Global hydrogen trade to meet the 1.5°C climate goal: Part II – Technology Review of Hydrogen Carriers,» Abu Dhabi, 2022.
[9] European Hydrogen Backbone, «A European hydrogen infrastructure vision covering 28 countries,» 2022.

Methodology and instruments - ***Elaboration of scenarios***





Methodology and instruments - *Elaboration of scenarios*

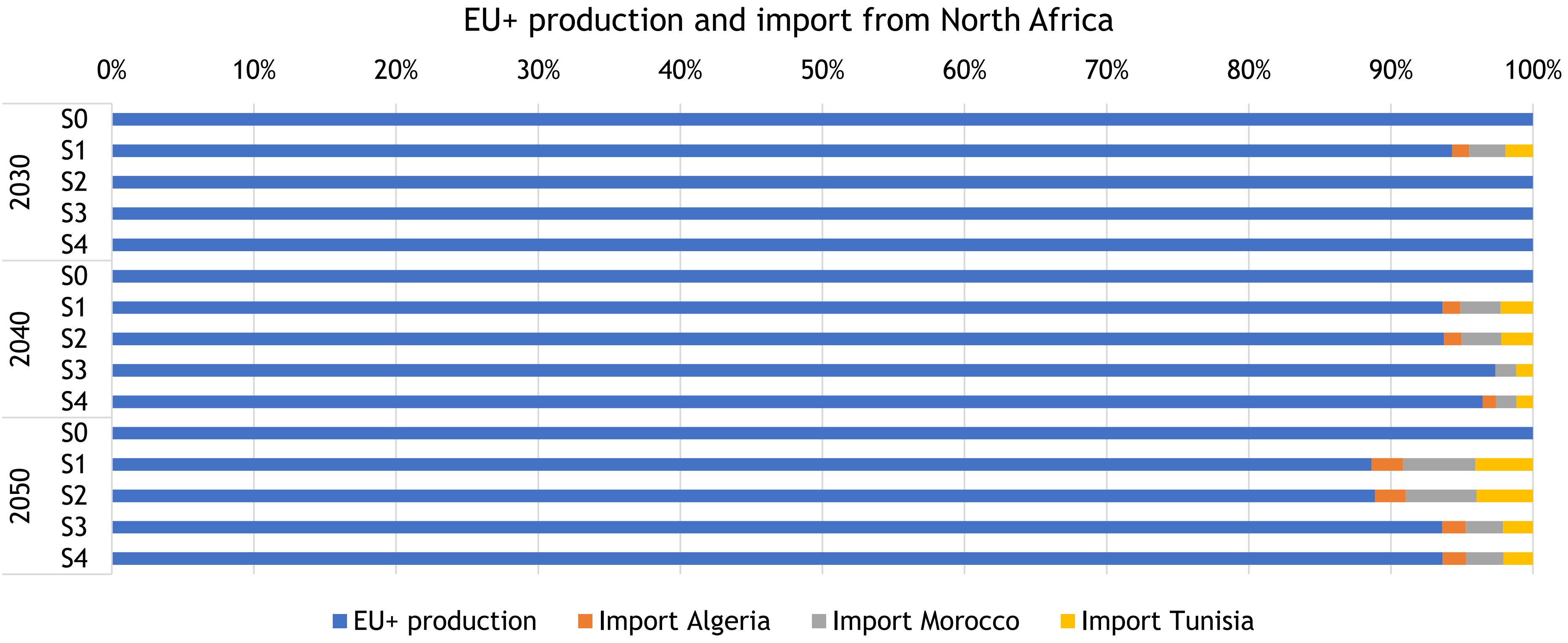
	Traded H_2 volumes [Mt_{H2}]		Production cost [$€_{2010}/kg_{H2}$]		Transport cost [$€_{2010}/kg_{H2}$]	
	2030	2050	2030	2050	2030	2050
S0	-	-	-	-	-	-
S1	ALG: 0.30 Mt_{H2} MOR: 0.65 Mt_{H2} TUN: 0.5 Mt_{H2}	ALG: 3.0 Mt_{H2} MOR: 6.89 Mt_{H2} TUN: 5.5 Mt_{H2}	ALG: 2.15 €/kg_{H2} MOR: 2.08 €/kg_{H2} TUN: 2.28 €/kg_{H2}	ALG: 1.49 €/kg_{H2} MOR: 1.43 €/kg_{H2} TUN: 1.57 €/kg_{H2}	On. pip.: 0.13 €/kg_{H2}/1000km Off. pip.: 0.20 €/kg_{H2}/1000km	On. pip.: 0.08 €/kg_{H2}/1000km Off. pip.: 0.12 €/kg_{H2}/1000km
S2					LH2 ships: @1000 km: 2.61 €/kg_{H2} @6000 km: 3.19 €/kg_{H2}	LH2 ships: @1000 km: 0.53 €/kg_{H2} @6000 km: 0.65 €/kg_{H2}
S3	ALG: 0.23 Mt_{H2} MOR: 0.31 Mt_{H2} TUN: 0.2 Mt_{H2}	ALG: 2.25 Mt_{H2} MOR: 2.75 Mt_{H2} TUN: 2.8 Mt_{H2}	ALG: 4.82 €/kg_{H2} MOR: 3.7 €/kg_{H2} TUN: 4.67 €/kg_{H2}	ALG: 3.34 €/kg_{H2} MOR: 2.56 €/kg_{H2} TUN: 3.24 €/kg_{H2}	On. pip.: 0.24 €/kg_{H2}/1000km Off. pip.: 0.37 €/kg_{H2}/1000km	On. pip.: 0.15 €/kg_{H2}/1000km Off. pip.: 0.23 €/kg_{H2}/1000km
S4					LH2 ships: @1000 km: 4.18 €/kg_{H2} @6000 km: 5.12 €/kg_{H2}	LH2 ships: @1000 km: 0.85 €/kg_{H2} @6000 km: 1.04 €/kg_{H2}

Results and discussions

Q1	How much will Europe rely on H_2 trade from North Africa? How do the transport options affect the trade?	EU+ production vs North Africa import; pipelines and shipping trade
Q2	Which EU+ consumption sectors are affected by H_2 from North Africa?	Consumption and conversion of H_2 in Europe
Q3	Which countries are impacted by H_2 trade from North Africa and how?	Countries involved and impacted by North African trade

Results and discussions

Q1 How much will Europe rely on H_2 trade from North Africa? How do the transport options affect the trade?

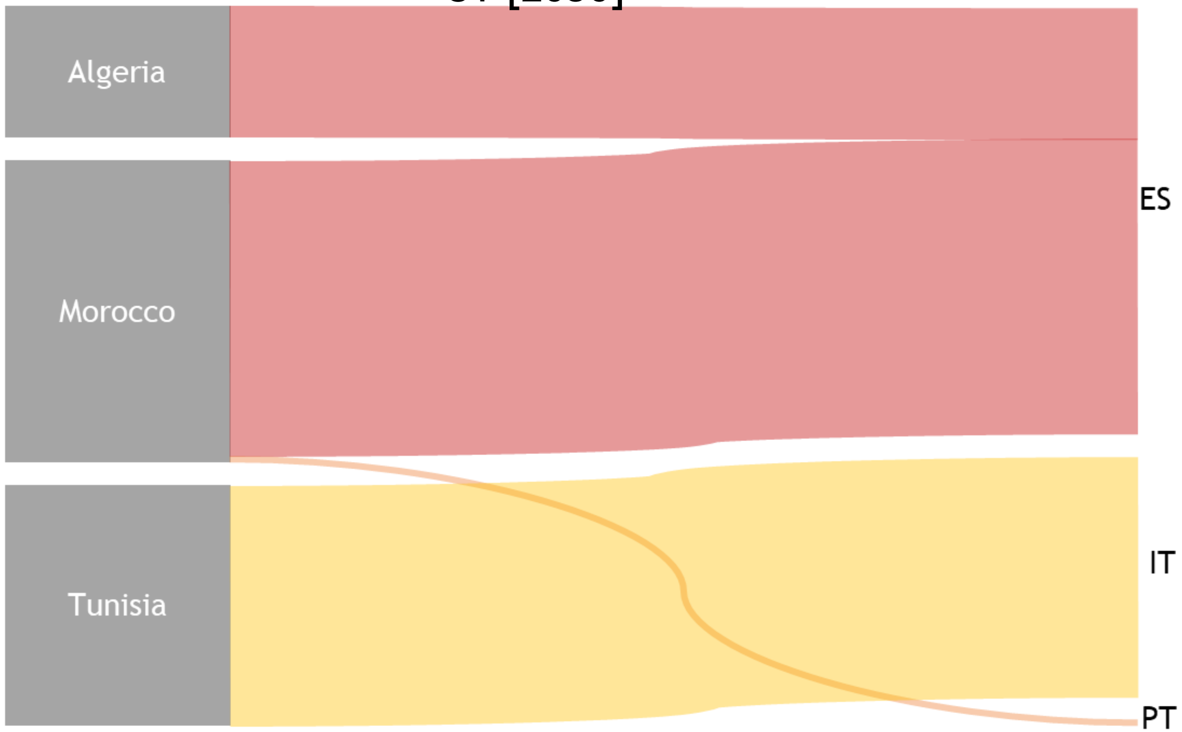


*The domestic production is very optimistic; data are under review; in any case all the hydrogen from North Africa is imported by 2050. The "impact" of North Africa is at least 10%, it can be more.

Results and discussions

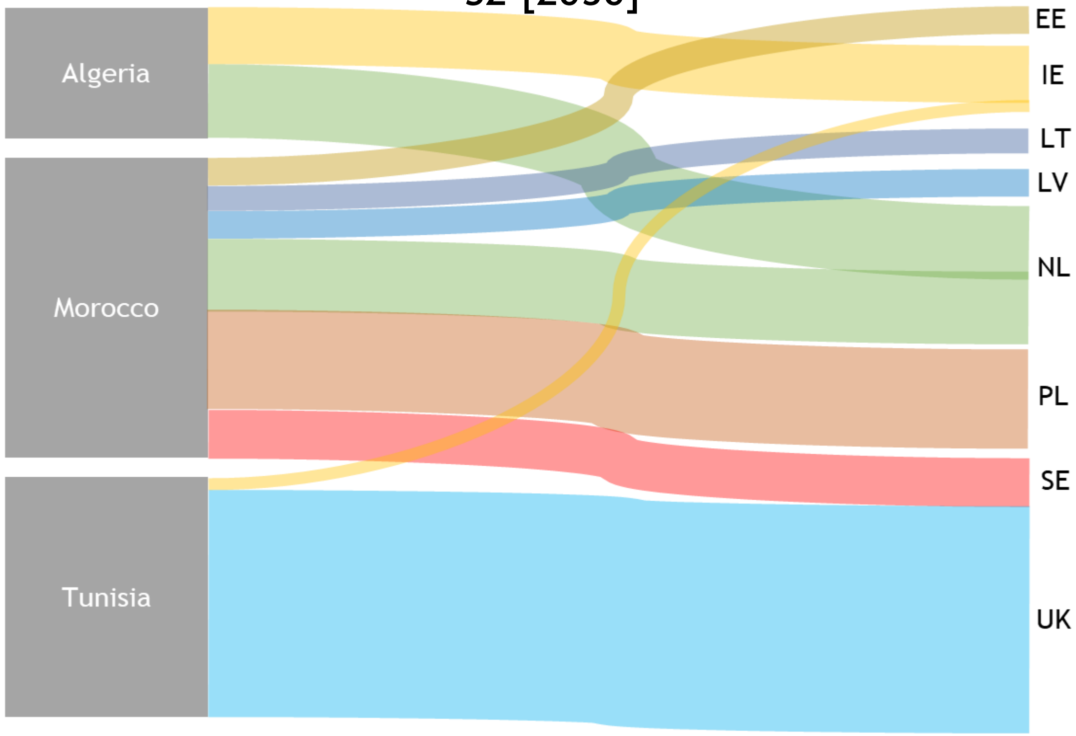
Q1 How much will Europe rely on H_2 trade from North Africa? How do the transport options affect the trade?

S1 [2050]



Production by WACC 3% and transport by pipelines at low costs case.

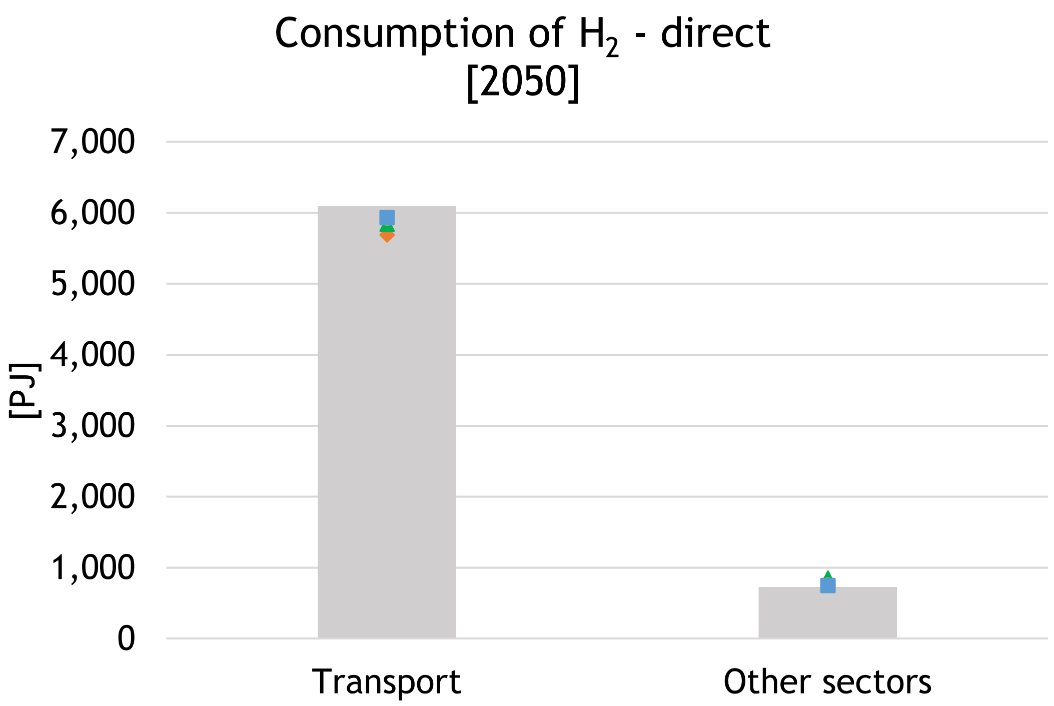
S2 [2050]

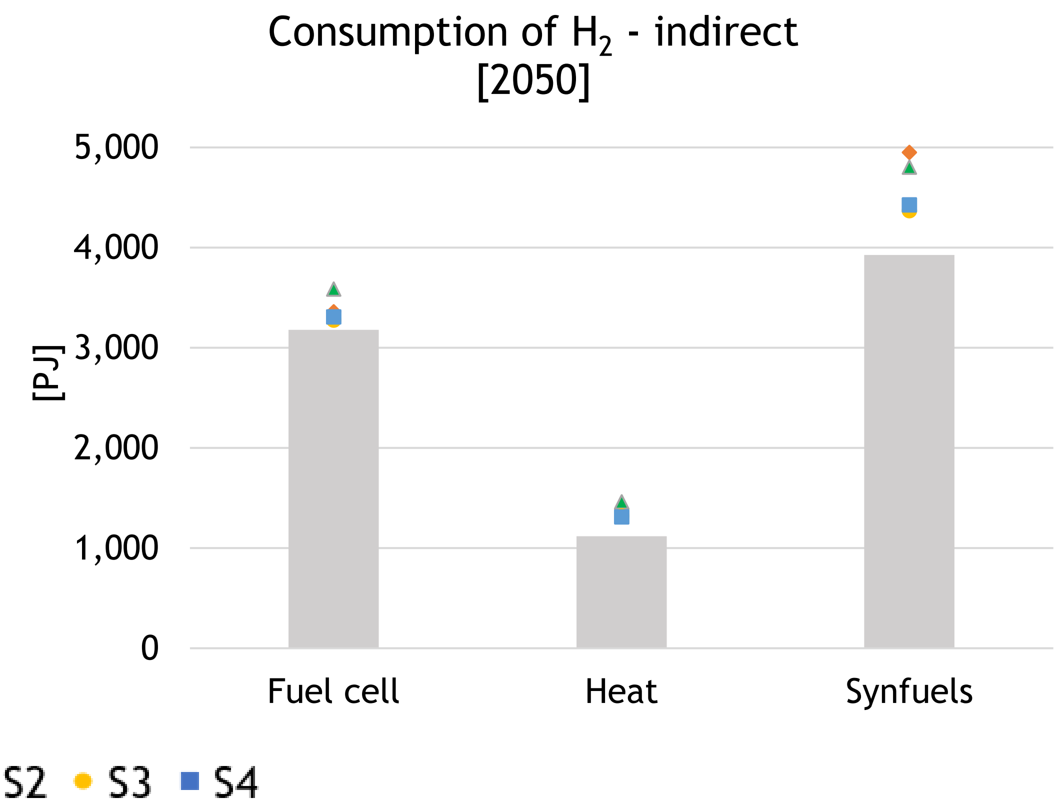


Production by WACC 3% and transport by LH2 shipping at low costs case.

Results and discussions

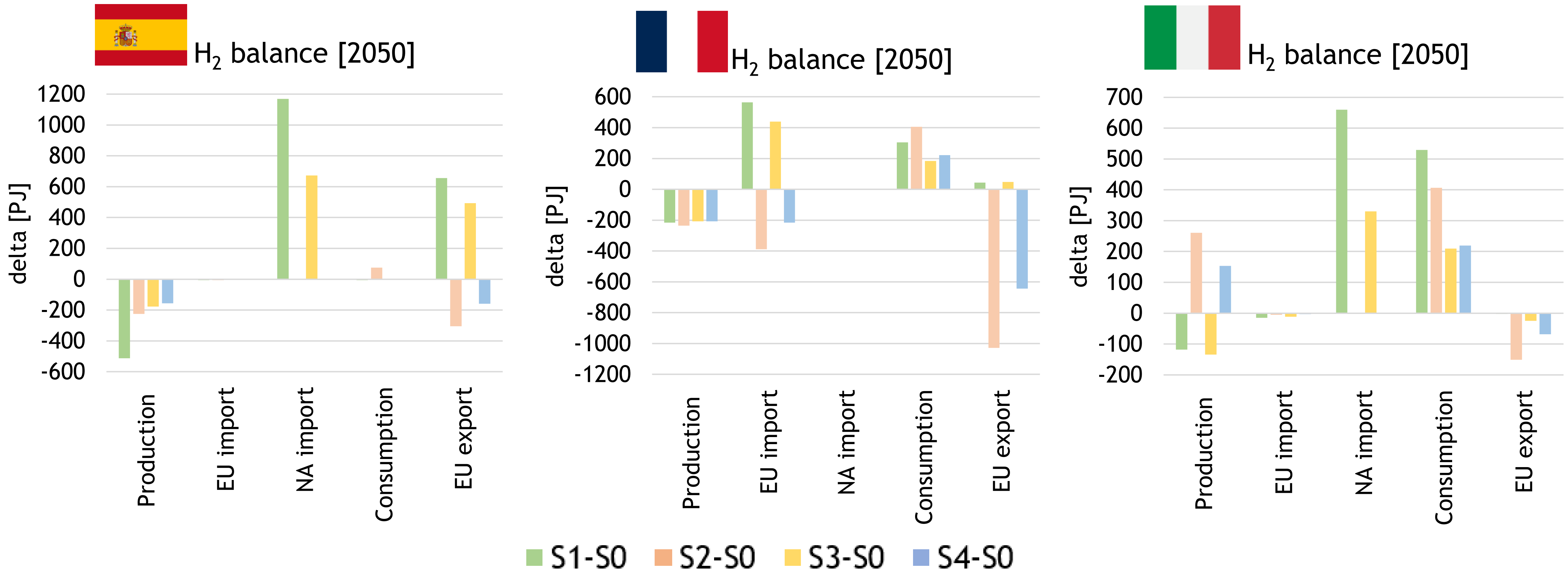
Q2 Which EU+ consumption sectors are affected by H_2 from North Africa?





Results and discussions

Q3 Which countries are impacted by H_2 trade from North Africa and how?



Main remarks and future work

we move

- All the importable hydrogen from North Africa is exploited by EU+ to reach the carbon-neutrality target by 2050, also in case of higher costs due to lower cooperation, market weakness and financial risks.
- In the short-term (2030) the only affordable option consist of pipelines for lower WACC, while in 2050 both transport options are cost-effective to support the EU+ decarbonization.
- Focusing on the consumption, the indirect use of hydrogen is the most affected by North Arica imports: consumption of synfuels in transport and of heat in industry increase up to 30%.
- Most impacted countries are Spain and Italy (for transport by pipeline) and the UK, the Netherlands and Poland (for shipping).
- Future work: (i) interplay of hydrogen and DAC for decarbonization purposes, (ii) focus on specific hard-to-abate sectors, (iii) include modelling of off-grid onshore wind plants to input electrolysers, (iv) evolution of electrolysers.

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Thank you for your attention

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