Group 4

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Agenda

- Results of Presentation 1
- Requirements
- Requirements > Criteria
- Candidate Solutions
- Uncertainty
- Risk Profile
- Decision Tree

Results of Presentation 1

Group	Stakeholder	Decision
4	Henkel AG & Co. KGaA	From which country should green hydrogen in the form of LOHC be imported?

Potential LOHC import countries

- **The EU and UK countries** : UK, Spain, Sweden, Norway, Denmark, Finland
- **The Middle East and North Africa (MENA) region countries** : Saudi Arabia, Oman, UAE, Morocco, Turkey, Algeria
- **Other countries** : Australia, Brazil, Canada, Chile, New Zealand, USA, Iceland

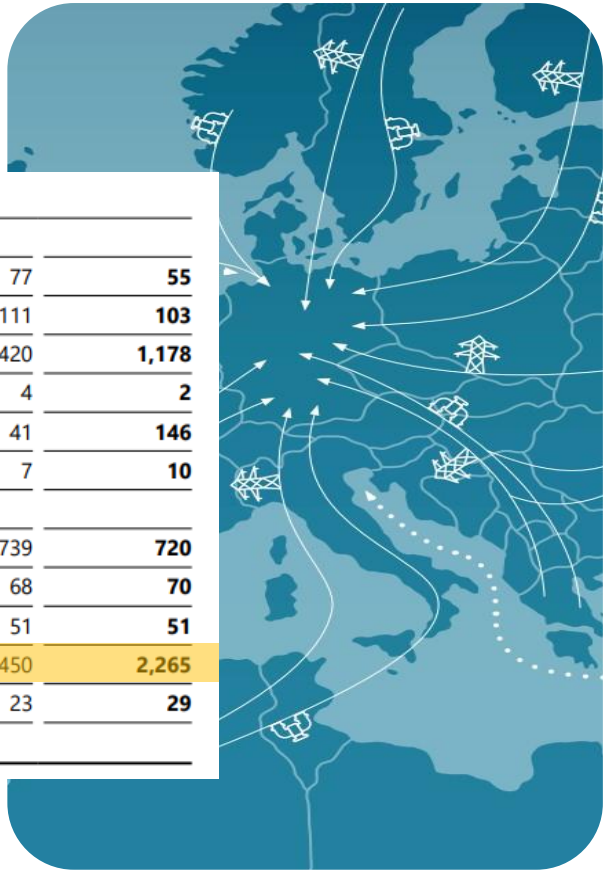
Requirements

- Strong/Slightly export-oriented country

ENERGY CONSUMPTION

Direct energy consumption						
Coal	1,000 MWh	89	84	82	77	**55**
Fuel oil	1,000 MWh	103	114	111	111	**103**
Gas	1,000 MWh	1,473	1,461	1,423	1,420	**1,178**
Other combustiles	1,000 MWh	20	7	4	4	**2**
Biofuels	1,000 MWh	0	0	0	41	**146**
Generated renewable energy[1]	1,000 MWh	3	2	4	7	**10**
Indirect energy consumption						
Bought-in electricity	1,000 MWh	780	769	752	739	**720**
Share of bought-in renewable electricity	%	11	11	48	68	**70**
Bought-in steam/heat	1,000 MWh	47	46	46	51	**51**
Total energy consumption	1,000 MWh	2,515	2,482	2,422	2,450	**2,265**
Share of renewable energy consumption	%	4	4	15	23	**29**

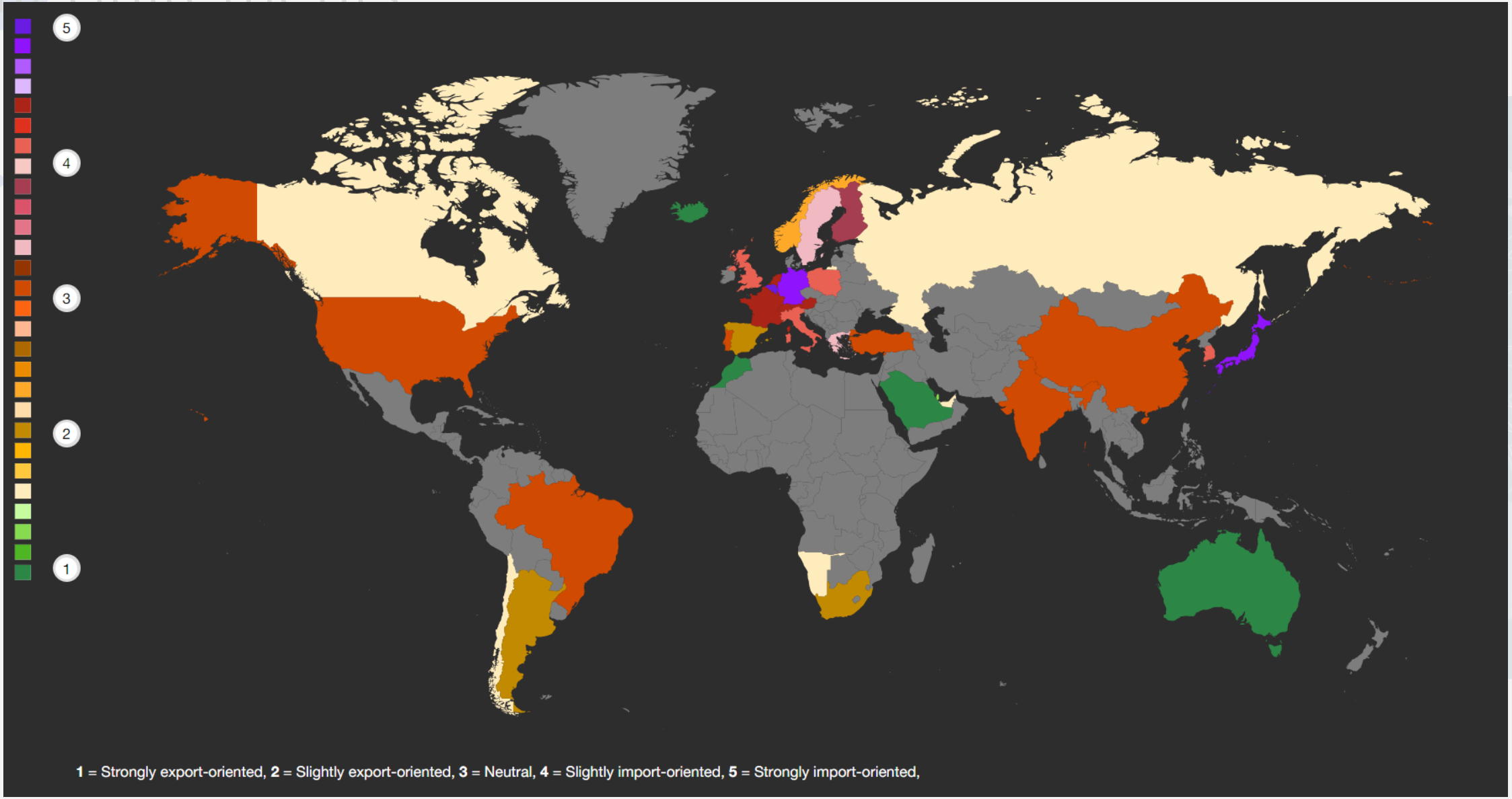
[1] "Generated renewable energy" is understood as electricity and thermal energy generated on-site using fuel-free sources such as wind and solar power.



Source: https://www.henkel.com/resource/blob/1804850/56551a2284bd7d2c9838410b8395a5dd/data/2022-sustainability-report.pdf

Image source: https://guidehouse.com/-/media/www/site/insights/energy/2022/transport-options-for-covering-germanys-green-hydrogen-demand.pdf

Requirements



Source: https://www.pwc.com/gx/en/industries/energy-utilities-resources/future-energy/green-hydrogen-cost.html

Image source: https://guidehouse.com/-/media/www/site/insights/energy/2022/transport-options-for-covering-germanys-green-hydrogen-demand.pdf

Requirements

- Strong/Slightly export-oriented country

Image source: https://guidehouse.com/-/media/www/site/insights/energy/2022/transport-options-for-covering-germanys-green-hydrogen-demand.pdf

Requirements

- Strong/Slightly export-oriented country
- Maximum production cost < 3,00€ by 2030

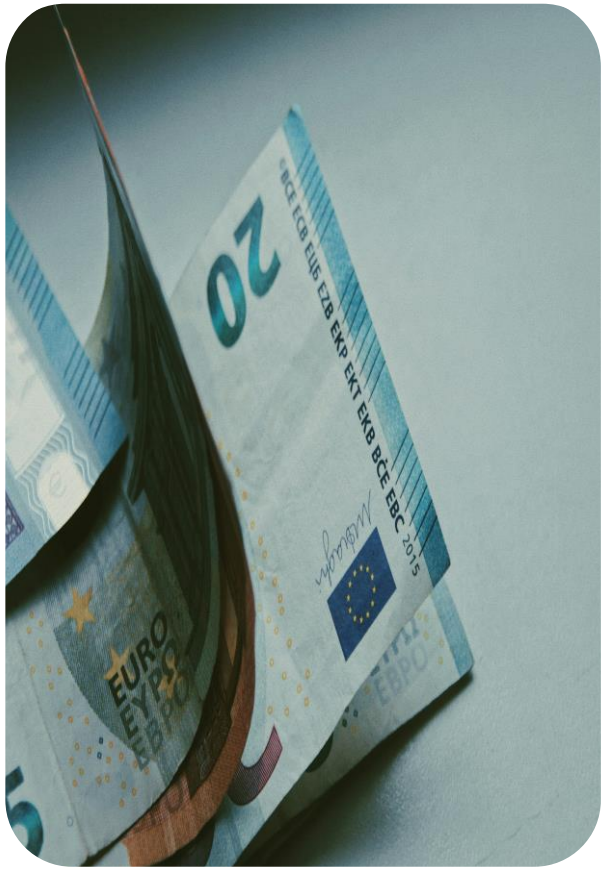
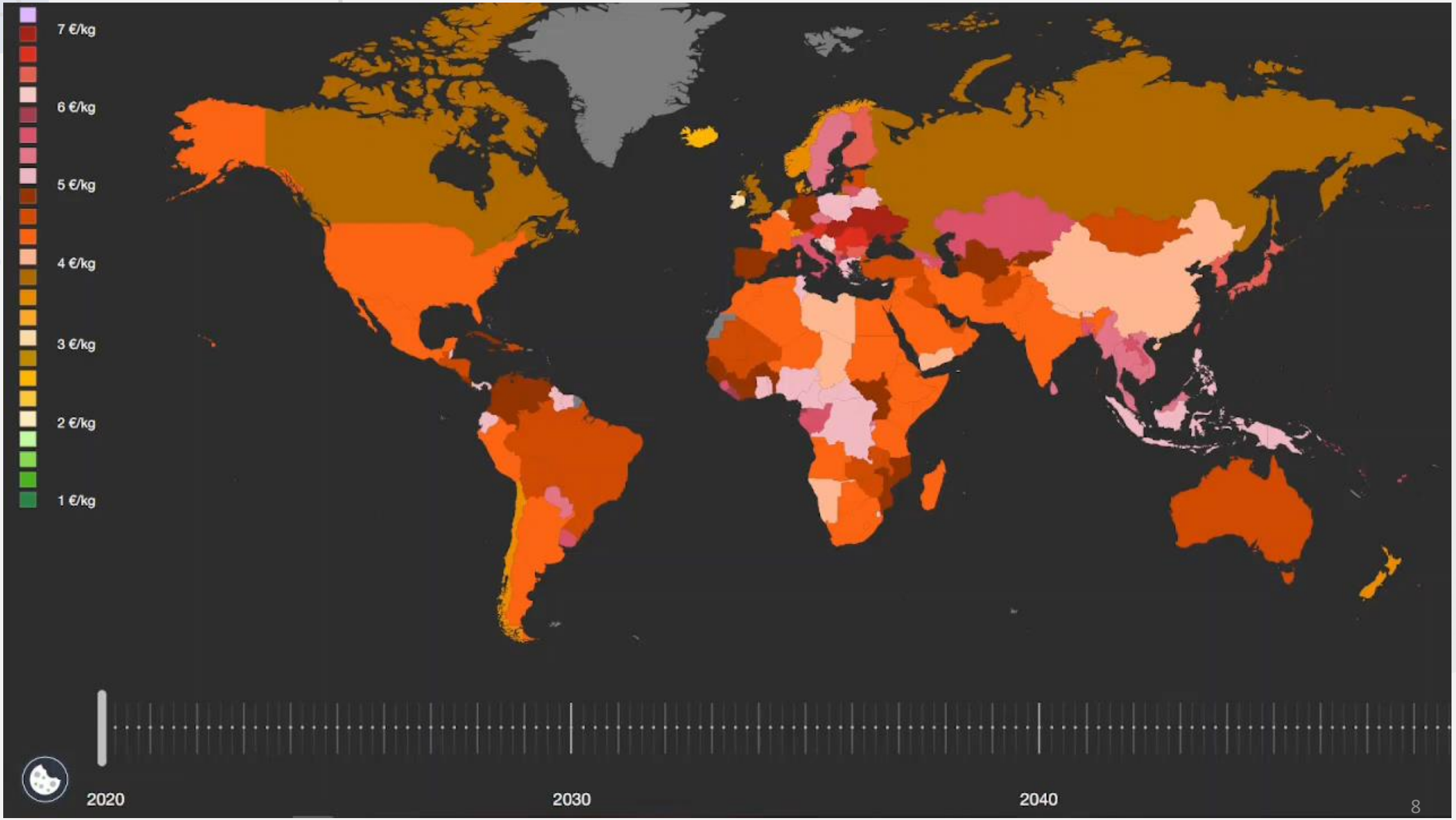


Image source: CAR GIRL on Unsplash



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Requirements

- Strong/Slightly export-oriented country
- Maximum production cost < 3,00€ by 2030

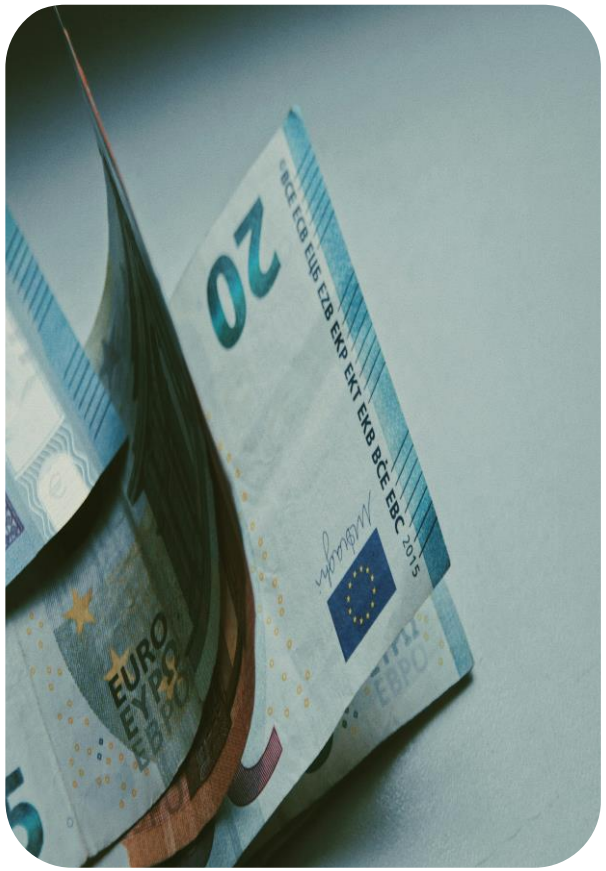


Image source: CAR GIRL on Unsplash

Requirements

- Strong/Slightly export-oriented country
- Maximum production cost < 3,00€ by 2030
- Transportation via ship or pipeline

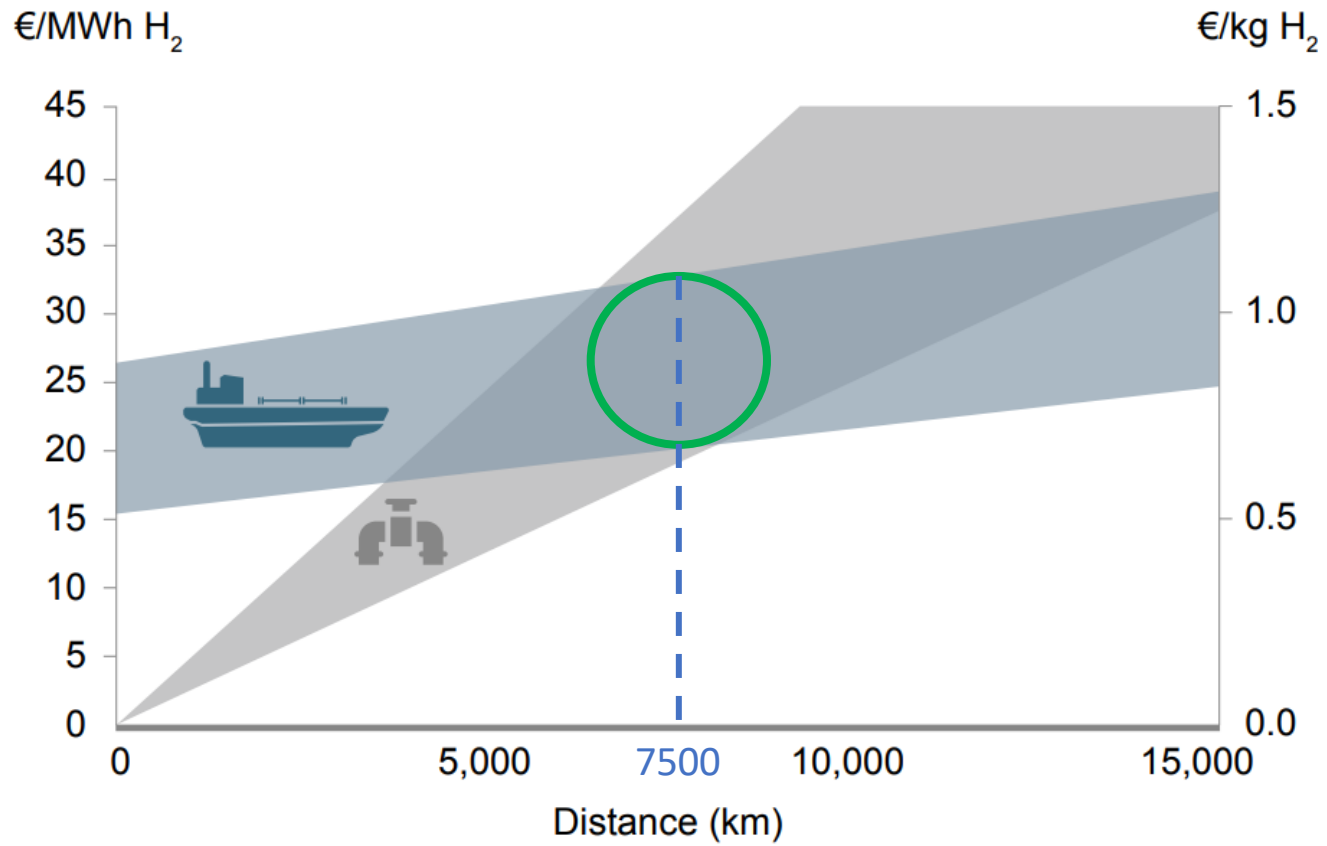
Image source: https://www.rolandberger.com/publications/publication_pdf/roland_berger_hydrogen_transport.pdf

Requirements

- Strong/Slightly export-oriented country
- Maximum production cost < 3,00€ by 2030
- Transportation via ship or pipeline
- Maximum distance < 7500 km

Image source: Photo by Emeric Deroubaix on Unsplash

Cost comparison of shipping and pipeline hydrogen transport routes



H_2 transport cost via ship (upper: liquefied H2, lower: LOHC)

H2 transport cost via pipeline (upper: 48 inch new, lower: 48 inch retrofitted)

Note: Pipeline transport assumes 48 inch (1,200 mm) in thickness, 12.7 GW and 80 bar for both new and repurposed pipelines.

Source: https://guidehouse.com/-/media/www/site/insights/energy/2022/transport-options-for-covering-germanys-green-hydrogen-demand.pdf

Image source: Photo by Emeric Deroubaix on Unsplash

Requirements

- Strong/Slightly export-oriented country
- Maximum production cost < 3,00€ by 2030
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Image source: Photo by Emeric Deroubaix on Unsplash

Requirements

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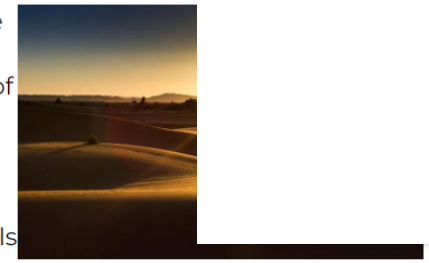
Other

Morocco, Germany to join work on green hydrogen production

The governments of Morocco and Germany have signed a pact that will facilitate the cooperation between the two countries in the development of green hydrogen projects.

The first two projects were outlined in the declaration of intent that was signed last week. One of them is the "Power-to-X" scheme that calls for the production of green hydrogen under a plan proposed by the Moroccan Solar Energy Agency (MASEN).



Sunset in the Sahara by Christopher L. on flickr.com CC BY 2.0

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Australia and Ger for joint hydrogen

Reuters

January 27, 2023 11:03 AM GMT+1 · Updated 10 mo

Jan 27 (Reuters) - Australia and Germany hav euros ($54.4 million), respectively, towards a Australian Minister for Climate Change and E

The two countries, which signed a bilateral al announced funding for four projects under th Incubator (HyGATE) initiative.

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Home / News / National / Chile and Germany Sign Agreement to Promote Green Hydrogen

Chile and Germany sign agreement to promote green hydrogen

29 Jun 2021

- Both countries agreed to strengthen cooperation on green hydrogen and announced the creation of a working group within the framework of the Chilean-German Energy Association to identify viable projects for the so-called "fuel of the future."

This morning, the **Minister of Energy, Juan Carlos Jobet, together with the Minister of Economy and Energy of Germany, Peter Altmaier,** signed a joint declaration to strengthen cooperation on green hydrogen and announced the creation of a working group within the framework of the Chilean-German Energy Association to identify viable green hydrogen projects.

https://iea.blob.core.windows.net/assets/5bd46d7b-906a-4429-abda-e9c507a62341/GlobalHydrogenReview2021.pdf

Requirements

- Strong/Slightly export-oriented country
- Maximum production cost < 3,00€ by 2030
- Transportation via ship or pipeline
- Maximum distance < 7500 km
- Existing bilateral agreements between governments on hydrogen development

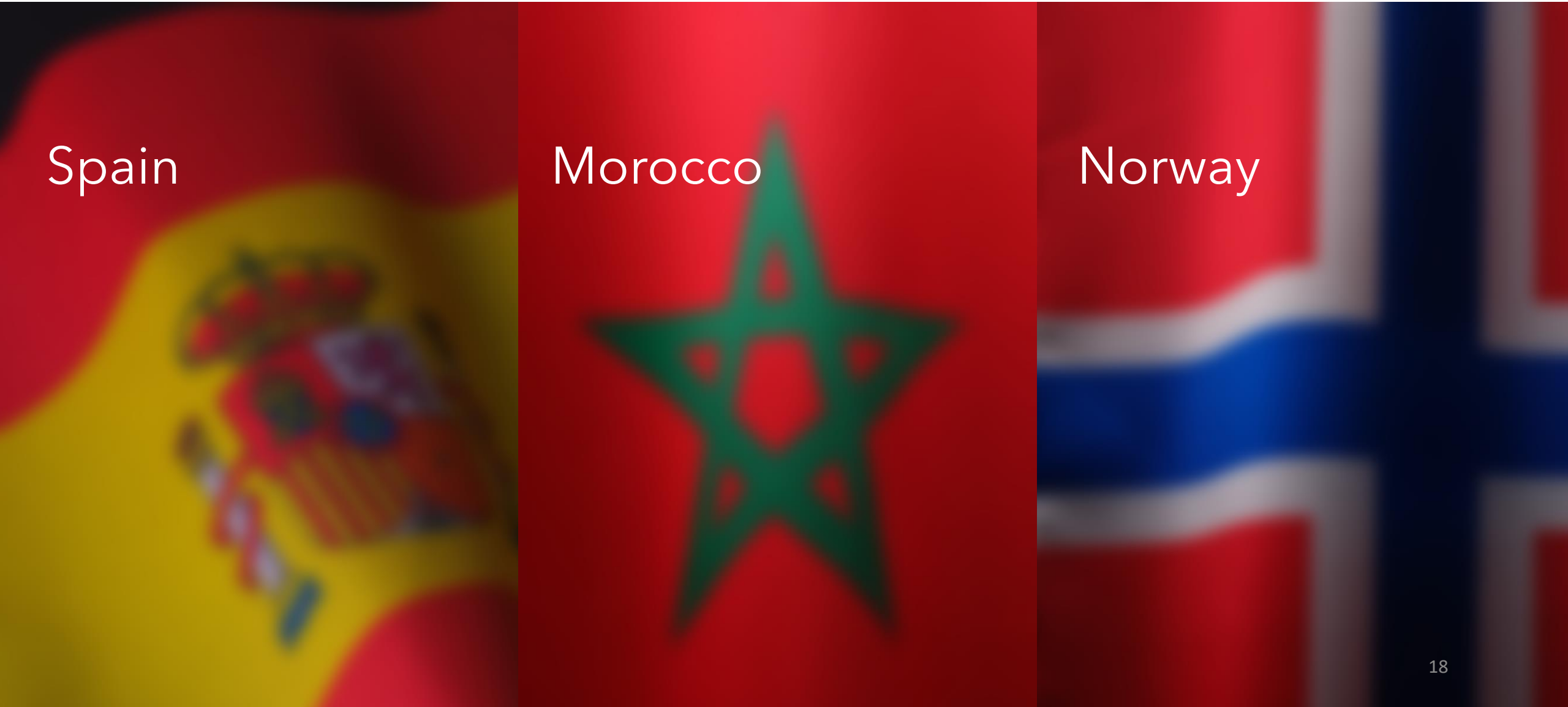
Requirements / Criteria

• Strong/Slightly export-oriented country	Exporting countries
• Maximum production cost < 3,00€ by 2030	Cost
• Transportation via ship or pipeline	Mode of transport
• Maximum distance < 7500 km	Transport distance
• Existing bilateral agreements between governments on hydrogen development	Geopolitics

Requirements / Criteria

Requirements	Criteria
Strong/Slightly export-oriented country	Exporting countries
Maximum production cost < 3,00€ by 2030	Cost
Transportation via ship or pipeline	Mode of transport
Maximum distance < 7500 km	Transport distance
Existing bilateral agreements between governments on hydrogen development	Geopolitics

Candidate Solutions



Method

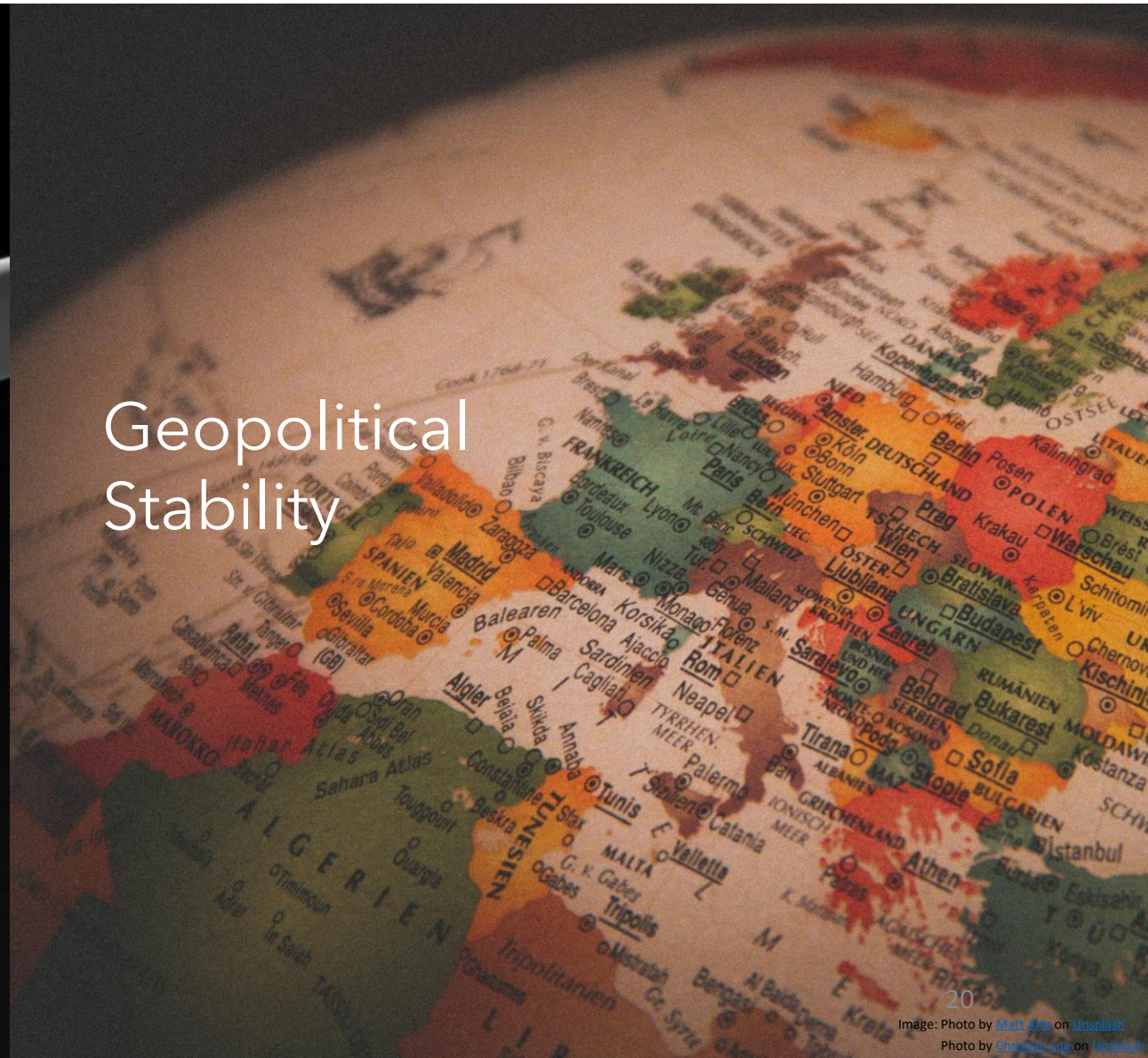
Reasons of choosing Decision Tree method -

- Honestly, we have limited expertise. Weighting each criterion necessitates in-depth knowledge and reliable sources
- All members of our group might not get common understating of scaling and weighting.
- Decision Tree works well both with qualitative and quantitative data.
- Decision trees are easy to interpret and understand, making them useful for communication with stakeholders, or even with our course mates.

Image source: https://www.freepik.com/free-vector/business-decisions-concept-illustration_11140496.htm#query=decision%20tree&position=47&from_view=search&track=ais&uuid=73e1cbc4-ed68-4f95-9514-4038ec9a951a

Uncertainty

Technological maturity



Geopolitical Stability

Risk Profile

Uncertainties
Technological maturity
Geopolitical Stability

Risk Profile

Uncertainties	Outcomes
Technological maturity	Developed (80%)
	Underdeveloped (20%)
Geopolitical Stability	Stable conditions (70%)
	Geopolitical tensions (30%)

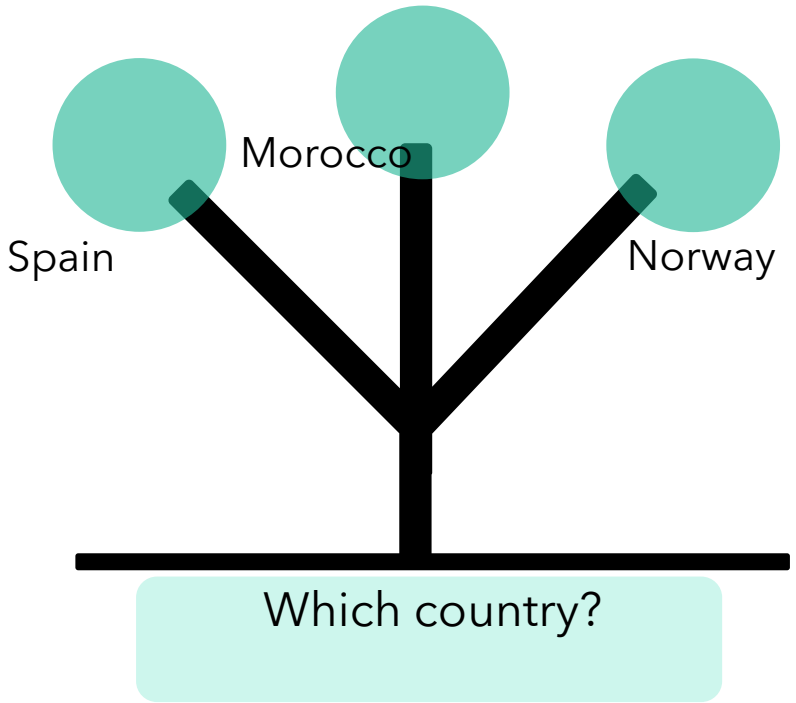
Risk Profile

Uncertainties	Outcomes	Consequences of Alternative Spain	Consequences of Alternative Morocco	Consequences of Alternative Norway
Technological maturity	Developed (80%)			
	Underdeveloped (20%)			
Geopolitical Stability	Stable conditions (70%)			
	Geopolitical tensions (30%)			

Risk Profile

Uncertainties	Outcomes	Consequences of Alternative Spain	Consequences of Alternative Morocco	Consequences of Alternative Norway
Technological maturity	Developed (80%)	Low cost Reliable transport	Low cost Higher generation Reliable transport	Low cost High generation Reliable transport
	Underdeveloped (20%)	Not having comparative low production cost Not Reliable transport	Not having comparative low production cost Not Reliable transport	Not having comparative low production cost Not Reliable transport
Geopolitical Stability	Stable conditions (70%)	Extension of H2Med could deliver a pipeline network Potential Reliable supply chain / transport	Repurposed pipeline network by 2030 Potential Reliable supply chain / transport	Potential Reliable supply chain / transport
	Geopolitical tensions (30%)	No pipeline network by 2030 Disruptions in supply chain	No repurposed pipeline by 2030 Disruptions in supply chain	Disruptions in supply chain

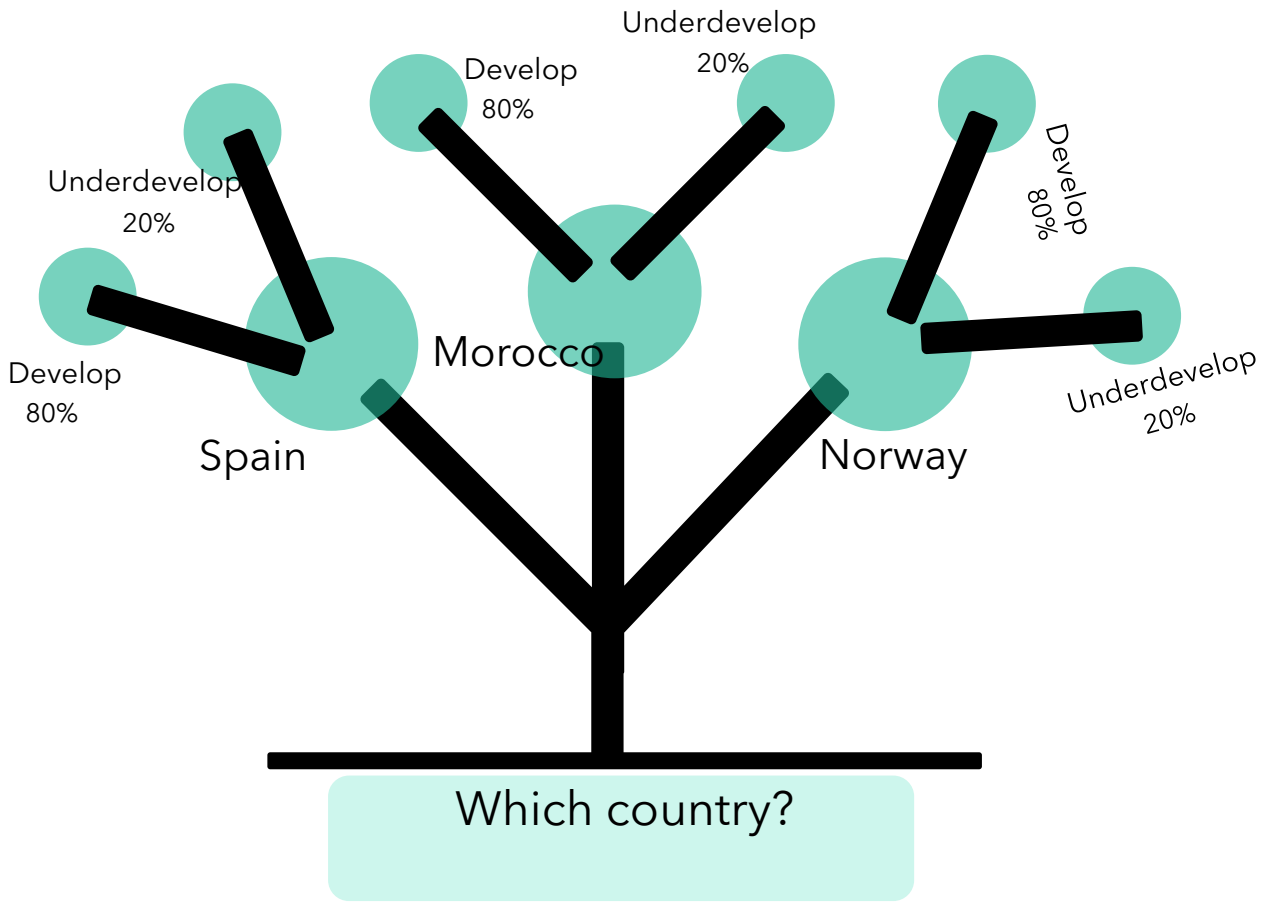
Decision Tree



Decision Node

Chance Node

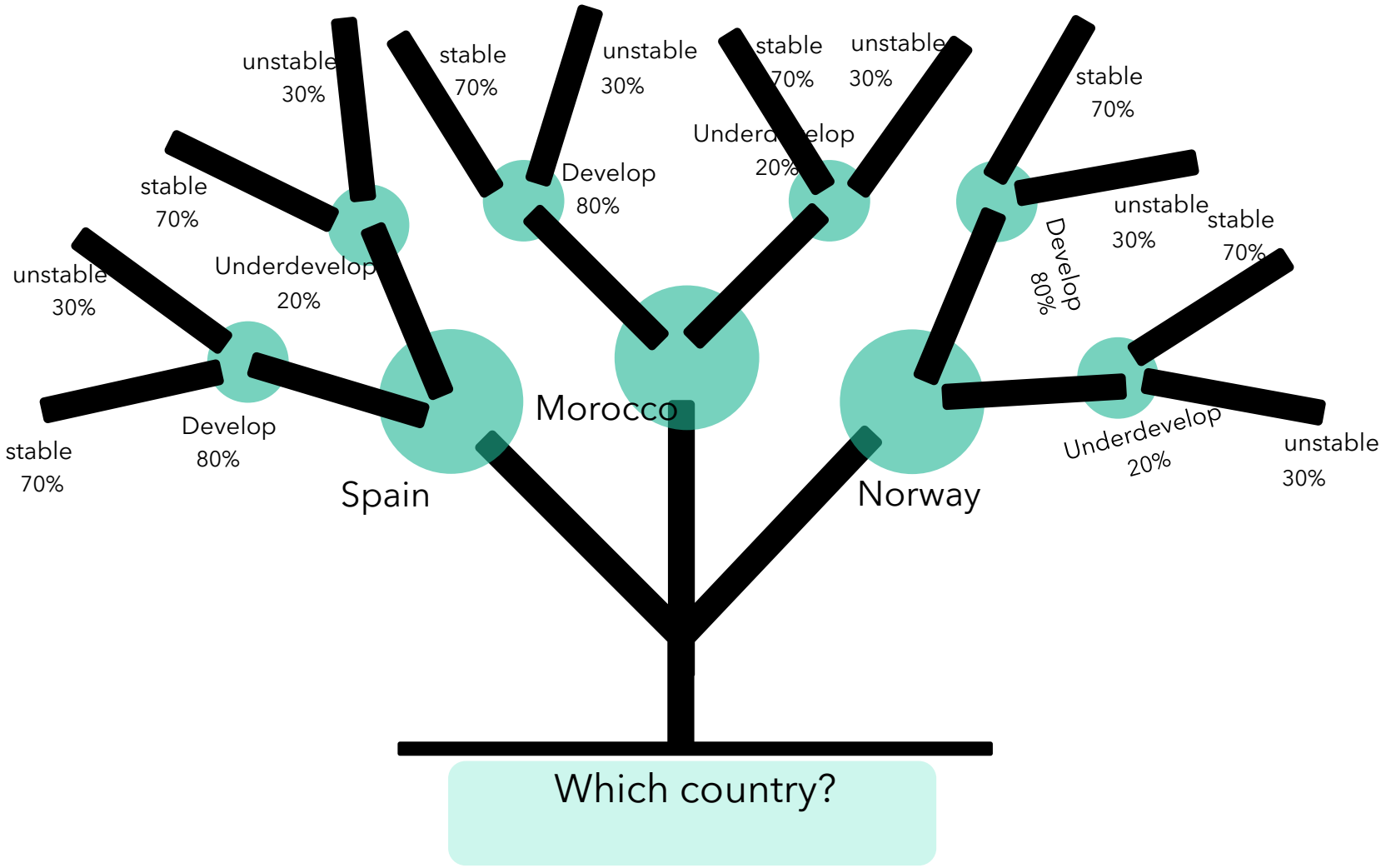
Decision Tree



Decision Node

Chance Node

Decision Tree



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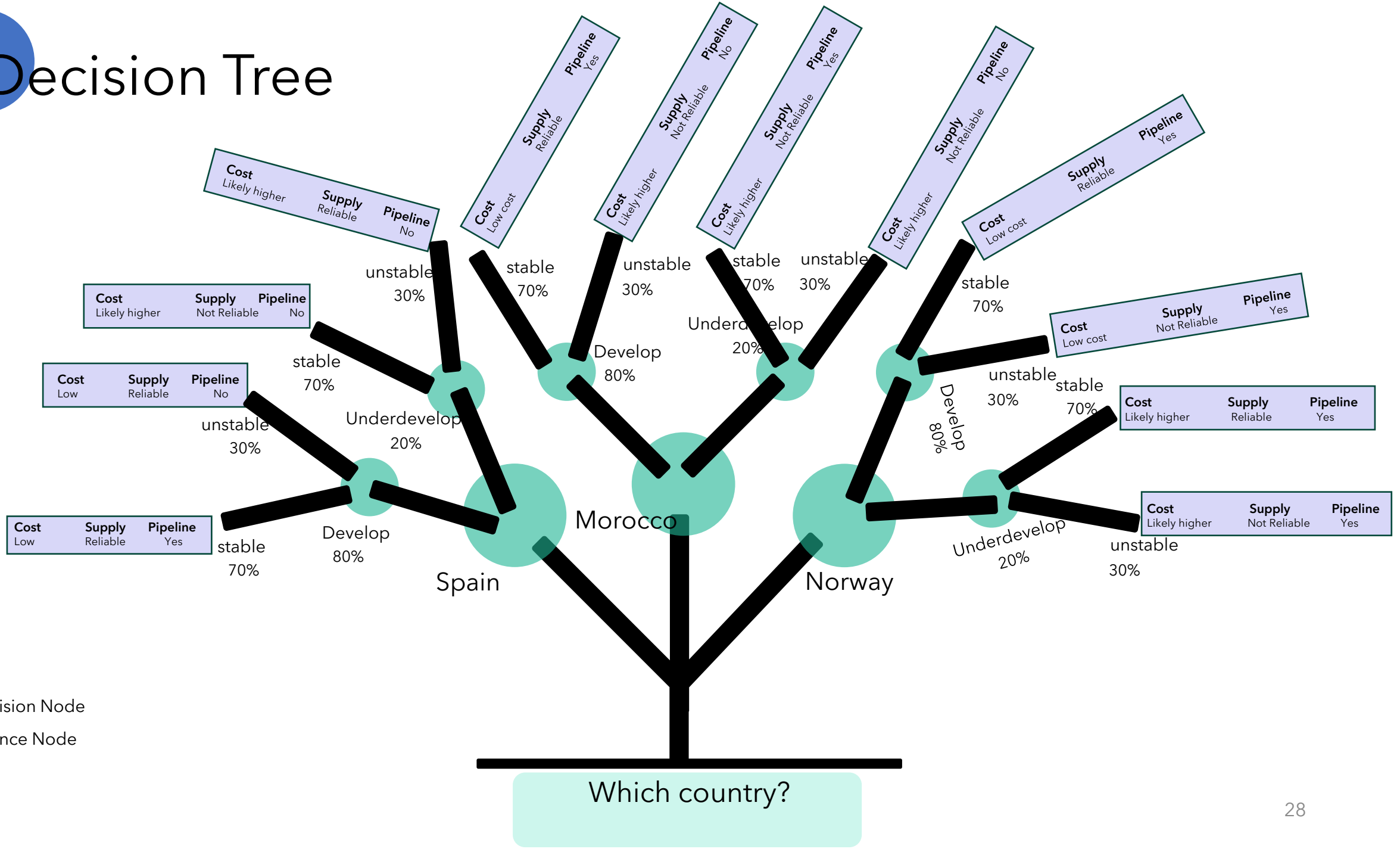

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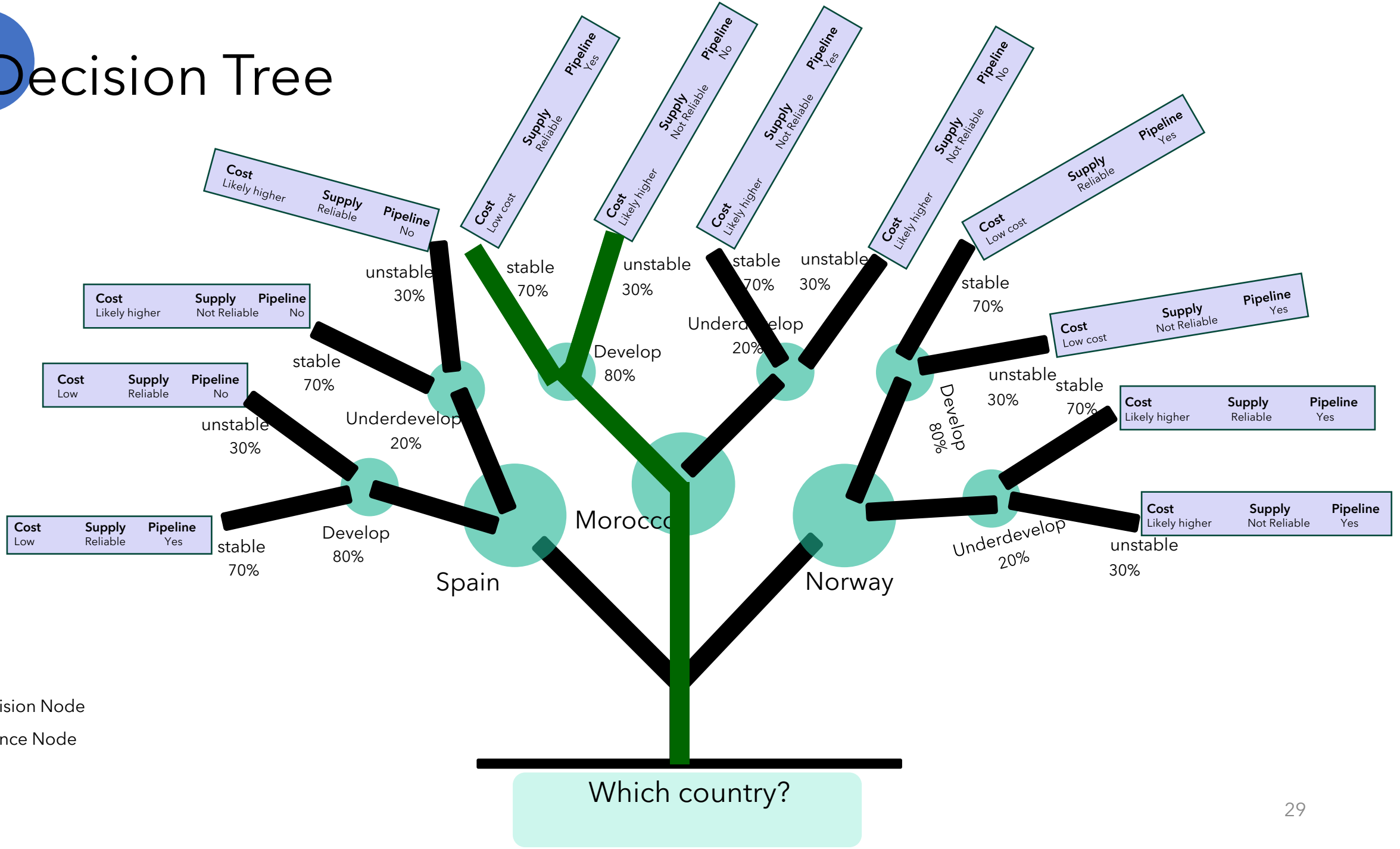

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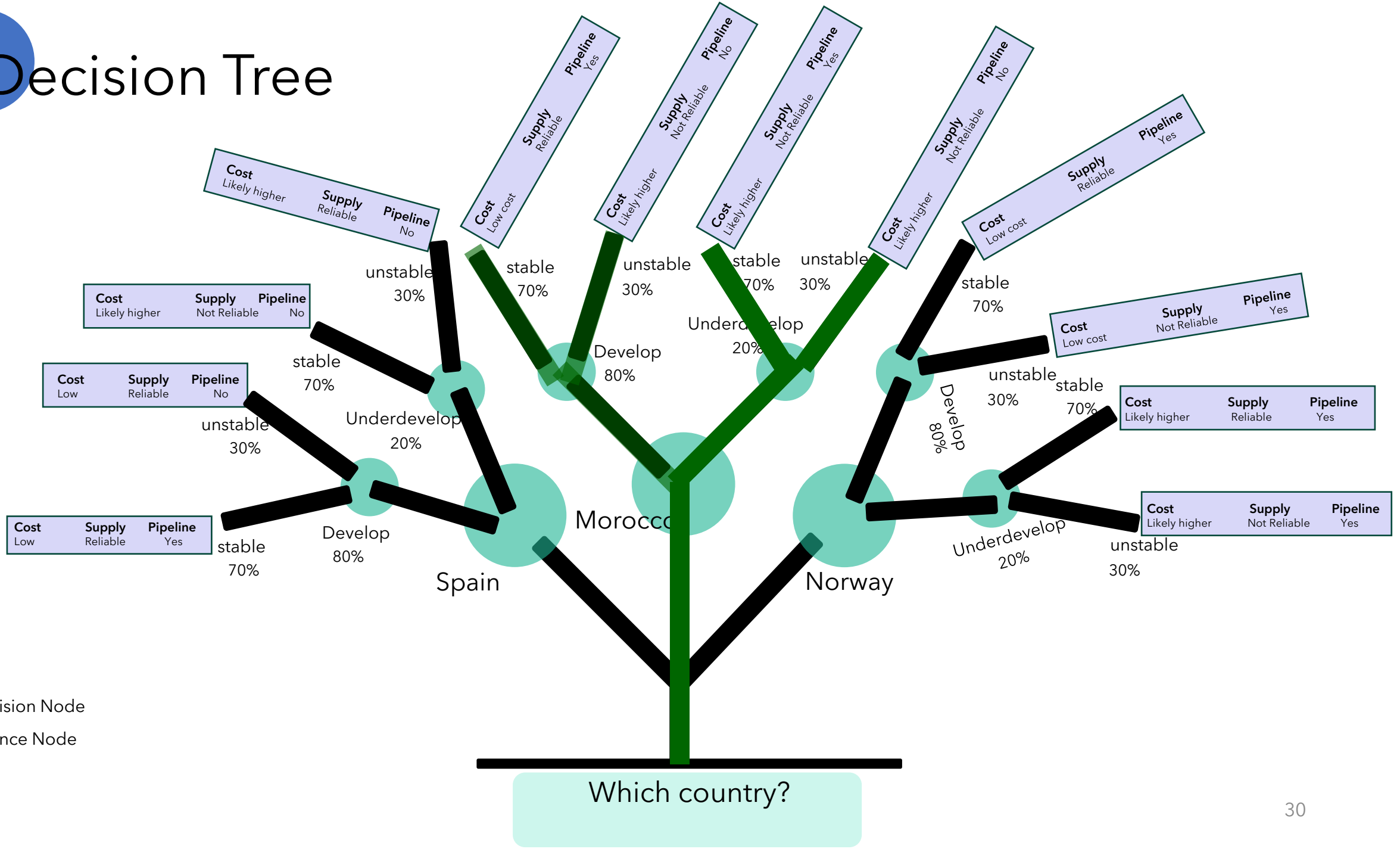

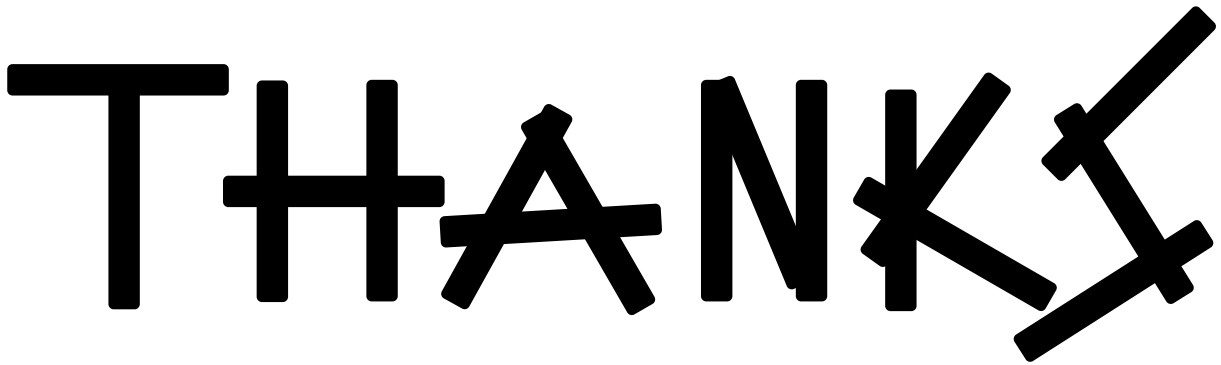
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