Decision Making Methods

Presentation 1

Group 4

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Agenda

- The Assignment
- Stakeholder Profile
- Liquid Organic Hydrogen Carriers (LOHC)
- Problem Analysis
- Key Decision Points
- Potential LOHC import countries

The Assignment

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

- Analyze the problem
- Describe the decision that has to be taken
- Find reasonable solution options

Stakeholder Profile

Henkel AG & Co. KGaA
is a globally recognized multinational corporation headquartered in Düsseldorf, Germany. Founded in 1876, Henkel is a leading producer of consumer and industrial products, with a strong focus on innovations and sustainability.

Source: Henkel AG & Co. KGaA, 2023, p. 6

Liquid Organic Hydrogen Carriers (LOHC)

Handling hydrogen as an oil

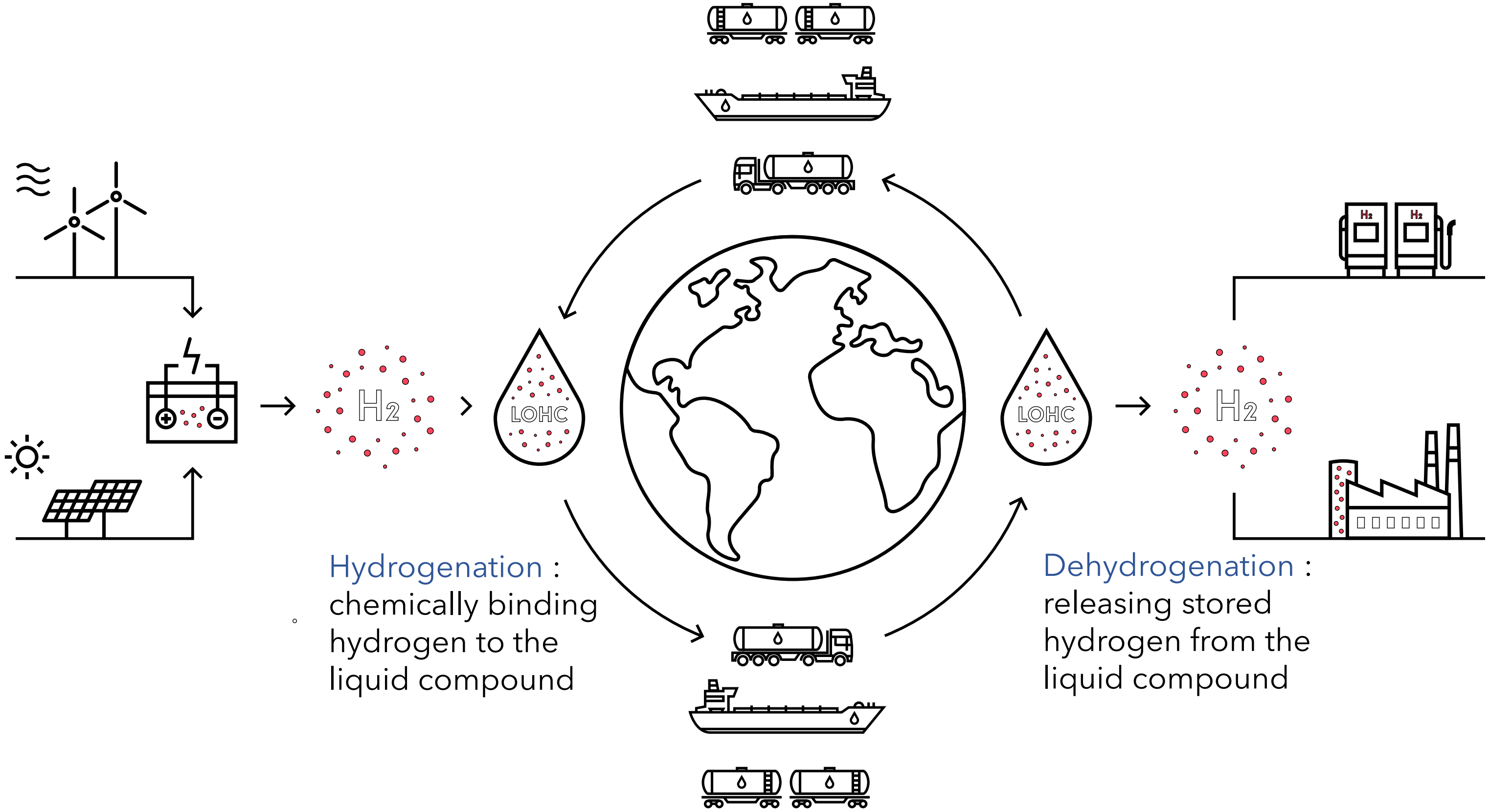
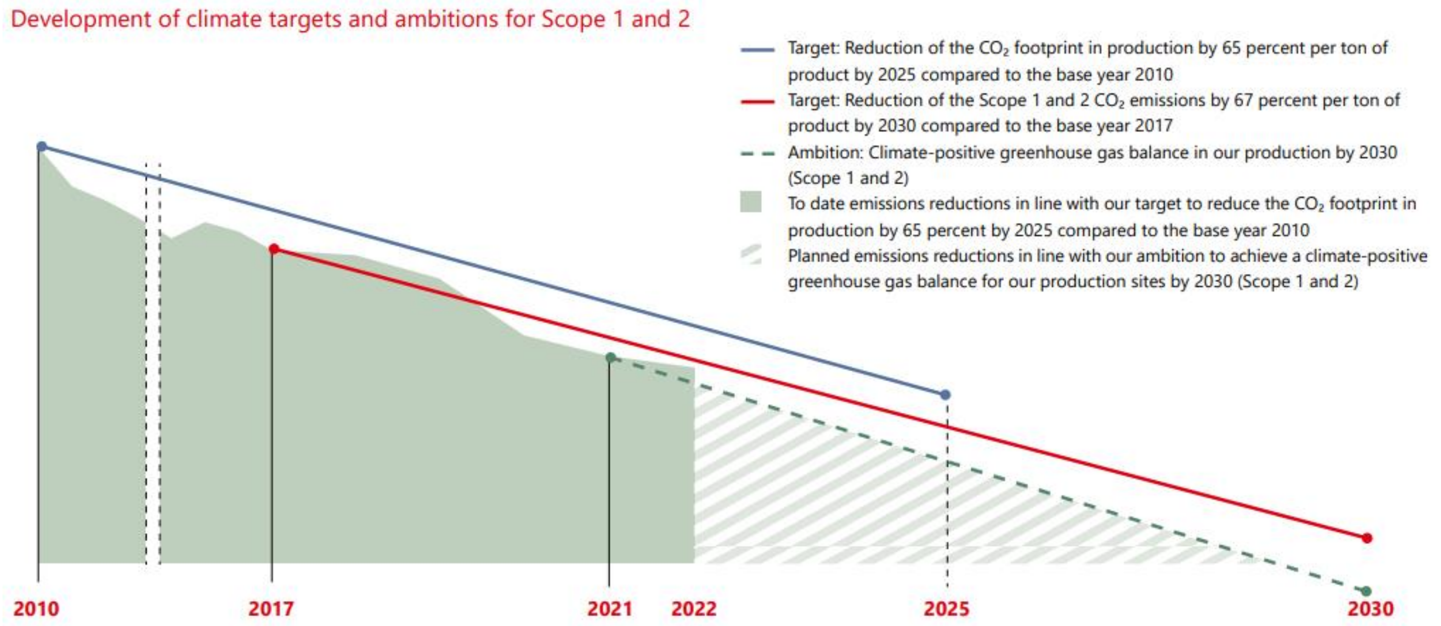


Image source: https://hydrogenious.net/how/ (accessed on 29.10.2023)

Problem Analysis

What are the long term targets and ambitions of Henkel regarding climate?



Topic	Targets and ambitions	Achieved 2022
Climate	Climate-positive operations (2030)	Ambition
	100 % of our electricity sourced from renewable sources (2030)	70 %
	– 65 % CO_2 emissions from our operations per ton of product (2025; vs. 2010)	– 55 %
	– 30 % CO_2 emissions from raw materials and packaging per ton of product (2030; vs. 2017)	– 15 % [3]
	– 100 million tons of CO_2 with customers, consumers and suppliers (2016–2025)	> 78 million

Source: Henkel AG & Co. KGaA, 2023, p. 16,39

Problem Analysis

Why not produce green hydrogen onsite?

- **High Energy Demand**: Electrolysis for hydrogen production requires massive amounts of green electricity.
- **Space Constraints**: Obtaining the necessary space for electrolysis and renewables is a challenge, especially in less favorable regions.
- **Infrastructure Complexities**: Expanding the electricity grid to transmit large volumes of renewable energy is a complex task

Focus

Roland Berger

Hydrogen transportation | The key to unlocking the clean hydrogen economy

Getting hydrogen from global production sites to end users at the lowest possible cost will be key to the success of the green economy. The potential for onsite green hydrogen production in European demand centers is limited. First, huge amounts of green electricity will be needed to power the hydrogen-producing electrolyzers. The conversion of the European steel industry to a more emission-friendly process by using hydrogen for the direct reduction of iron alone would require up to 10 m tons of hydrogen per year. Depending on the system efficiency, the production of green hydrogen for the steel industry would require roughly 60 GW of electrolysis capacity and 120-180 GW of renewable energy capacity. To put those numbers in perspective, Germany's total installed capacity of onshore and offshore wind power stands at 63 GW today. Second, the physical space required to achieve such capacities is substantial, especially in regions with less favorable conditions for renewables. Such space is rarely available. And third, the expansion of the electricity grid to transport such huge amounts of renewable energy is a difficult undertaking. Many ongoing high voltage grid projects face delays and those delays in fact hinder a faster renewable energy buildout in Europe.

Berger, R. (2021), p. 4

Problem Analysis

Why to import in the form of LOHC?

Main characteristics		Ammonia	Liquefied hydrogen	LOHC (benzyltoluene)
Storage density	Volum. [kg H_2/m^3 of carrier] Gravim. [kg H_2/t of carrier]	121.2[1] 177.5[1]	70.8 1,000	55.2 62.7
Energy needs	Conversion [MWh/t H_2] Reconversion [MWh/t H_2]	5.75 11.2	12.0 0.6	0.5 15.0
Technological and process maturity	Conversion – Small scale	■■■	■■■	■■□
	Conversion – Large scale	■■■	■□□	■□□
	Storage	■■■	■■■	■■■
	Transportation – Ship	■■■	■□□	■■■
	Transportation – Rail	■■■	■□□	■■■
	Transportation – Truck	■■■	■■■	■■■
	Reconversion	■□□	■■■	■■□
Operational value propositions	Advantages	• High storage capacity • Mature value chain, except for cracking process	• No reconversion required • High purity hydrogen	• Easy to store and transport (diesel-like liquid) • Use of existing infrastructure
	Disadvantages	• Additional purification step needed • High energy requirements for cracking process	• Boil-off losses along value chain • High energy requirements for liquefaction • Storage and transport complexity	• Number of cycles impact environmental footprint • High energy requirements for dehydrogenation
	Safety	• Acute toxicity, flammable, explosive under heat, toxic to aquatic life	• Highly flammable with no visible flame, can form explosive mixtures with air	• Low toxicity, non-explosive, hazardous to aquatic environment

[1] Properties of liquid ammonia ■■■ Proven & commercial ■■□ Prototype demonstrated ■□□ Technology validated or under development

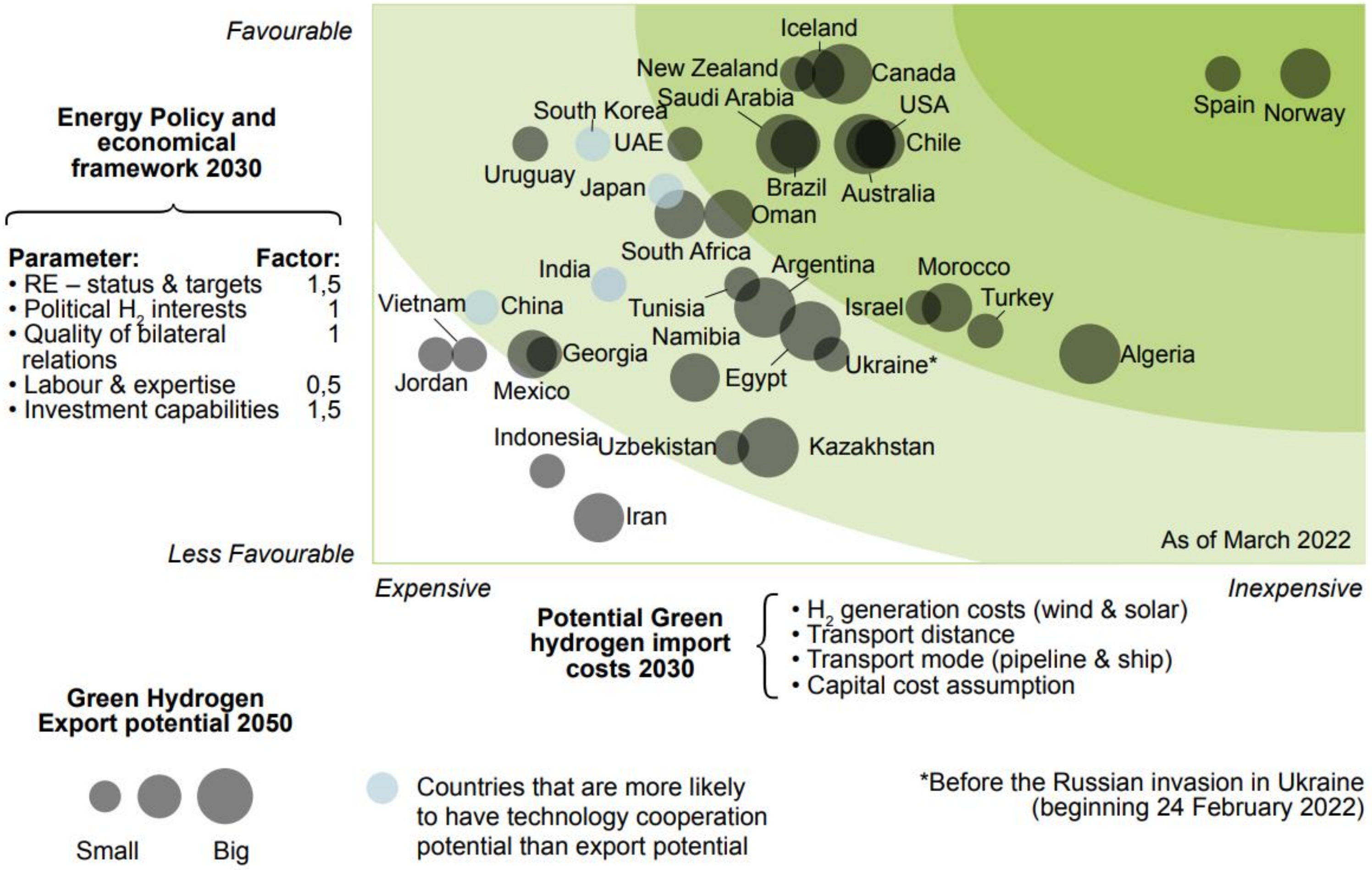
Berger, R. (2021), p. 12

Key Decision Points

- **Source Strategy**: Determine the origin(s) of LOHC imports.
  Decide whether to work with single supplier or multiple suppliers.
- **Supplier Selection**: Identify potential suppliers based on profile, reputation and product quality.
- **Demand and Price**: Identify market demand to ensure that import quantities align with Henkel's needs.
  Decide purchasing price/unit.
- **Quality Standards**: Establish quality standards and specifications for LOHC to ensure it meets Henkel's Sustainable Development Goals (SDGs).
- **Logistics and Transportation:** Choose the mode of transportation and logistics providers that meets low emissions logistics policies of Henkel.
  Determine shipping schedule, volume, and import terminals.
- **Storage and Handling**: Decide on storage and handling requirements.
- **Safety Measurements**: Define safety measures based on Safety, Health and Environment (SHE) Standards.
- **Infrastructure**: Required facilities for dehydrogenation process.

Potential LOHC import countries

International cooperation and export potential on green hydrogen with Germany



Dertinger A., et al. (n.d.), p. 18

Potential LOHC import countries

Guidehouse

Covering Germany's green hydrogen demand: Transport options for enabling imports

Germany plans to import hydrogen from UAE using 'liquid organic carrier' technology

Utility Uniper, start-up Hydrogenious LOHC and Jera Americas together with the Abu Dhabi National Oil Company (ADNOC) are eyeing up a plan to transport hydrogen fro[m] the United Arab Emirates (UAE) to Germany using so-called liquid organic hydrogen carrier (LOHC) technology.

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RENEWABLE HYDROGEN IMPORTS COULD COMPETE WITH EU PRODUCTION BY 203(

January 24, 2023

- Renewable hydrogen imports into the EU from Australia, Chile, and Morocco would be economically attra[ctive] 2030, supporting the bloc's goal of sourcing half of its hydrogen consumption from imports by 2030, Aur[ora] Research finds
- Imports of renewable hydrogen from Morocco, transported via ship in liquid form, would be the most com[petitive] supply source compared to domestic hydrogen production by 2030, assuming the end user is in Germany, modelling shows

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Wind

Project targets green hydrogen import from Sweden to Germany by 2026

Hydrogenious LOHC Technologies GmbH is planning to transport up to 8,000 tonnes of green hydrogen per year from Sweden to Germany and the Netherlands by 2026, using the liquid organic hydrogen carriers (LOHC) technology.

Canada, and Saudi Arabia.

Dertinger A., et al. (n.d.), p. 17
Tracey, M. (2023)
Ivanova, A. (2022)
Radowitz, B. (2022)

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

Potential LOHC import countries

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Thank You