

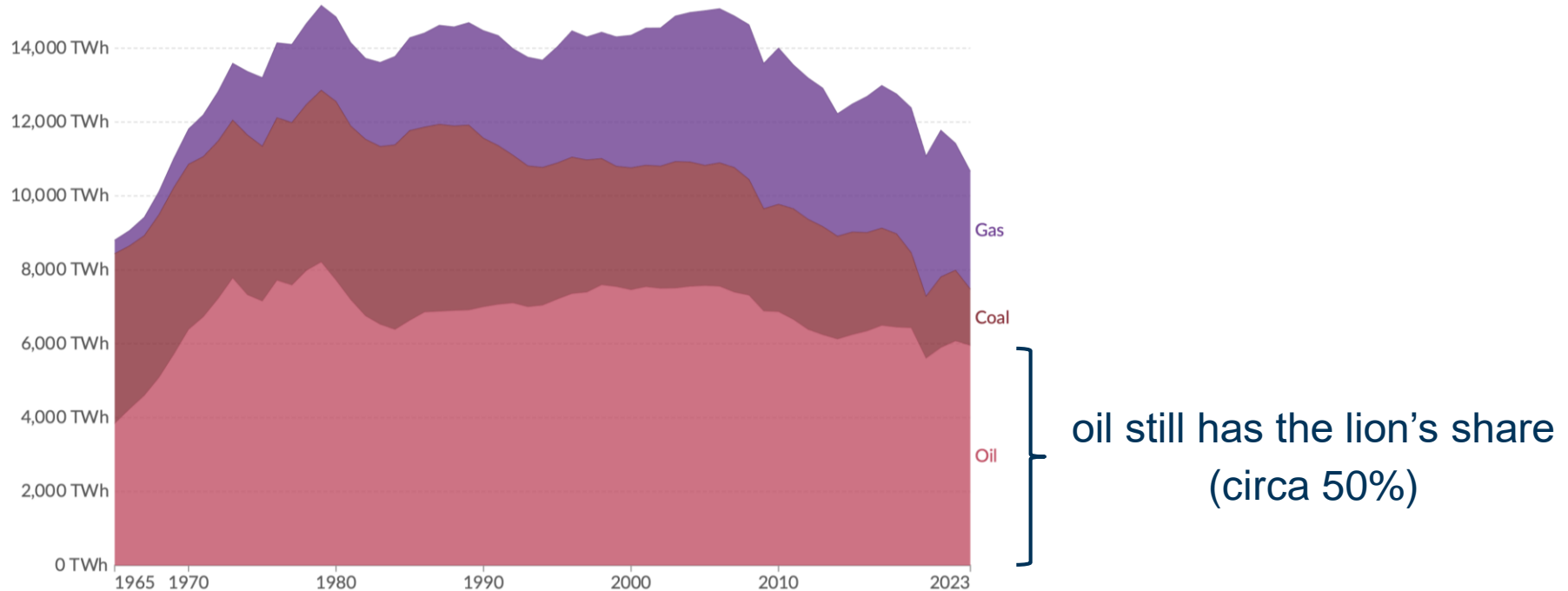
European decarbonisation and oil refineries: analysing the conditions for a profitable adoption of clean hydrogen

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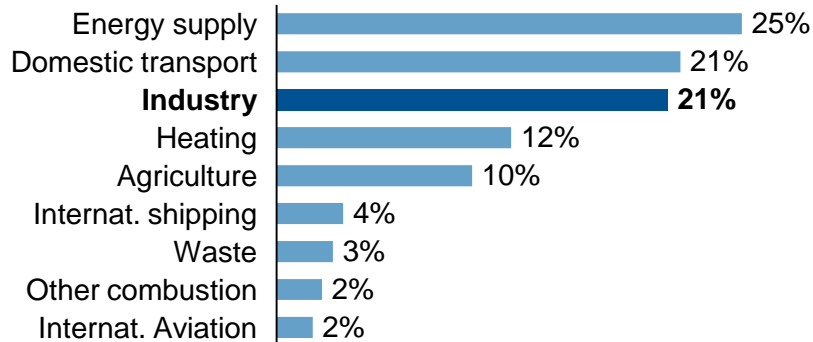


European economy substantially relies on fossil fuels



The decarbonisation is challenging, yet worth exploring

Hard-to-abate industries are a big hurdle within EU decarbonization



Source: EEA 2021 GHG emissions breakdown

Yet they are one of the basis of EU prosperity



c. 5 million
Employees in EU



25%
of the EU GDP



75%
of the EU exports

Source: E3G, Global CCS Institute

A competitive, future-proof, hard-to-abate industry is the key to European long-term prosperity. How it can do that, it is a topic worth investigating.

Research Questions

Can European oil refineries find the delicate equilibrium between sustainability (i.e., net-zero) and financial targets?

1

Is there a robust case behind the clean hydrogen as a decarbonization technology for the oil refineries in Europe?

2

What are the technological, societal and economic variables that have to be considered by oil refineries whilst navigating the decarbonization of the continent?

3

Is such an equilibrium reachable? Or the continent is doomed to deindustrialization?

European Decarbonization – Methodology

Foundational Database of Oil Refineries in Europe

<i>EU Countries</i>	<i>Carbon allowances</i>
<i>Time</i>	<i>Price of Output</i>
<i>Input & Output</i>	<i>Cost of input</i>



We rely on a database related to **European oil refineries** that entails as set of specific countries and over a selected period of time (1999-2018). **Energy input** are simplified in **oil, natural gas, electricity and heating**.

Estimation of production function through Model-based recursive partitioning



We employ **model-based recursive partitioning** to statistically estimate the **production function** in a **translog** fashion of the oil refineries.

Hydrogen demand via profit non-negativity condition



Based on a set of equation previously written (review ongoing) we derive the **hydrogen demand** as a **substitution technology of some fossil-fuel input**.

Simulations, results, insights and intuitions

Getting to some preliminary results by inserting **data-driven numbers in the set of equations**.

Foundational Model

1

Production Function

$$Y = f(\dots, q_i, \dots) \sim \sum_i q_i^{\alpha_i} = q_f^{\alpha_f} + q_h^{\alpha_h}$$

2

Revenue Function

$$R(q_f, q_h) = p_Y Y$$

3

Cost Function

$$C(q_f, q_h) = \sum_{i \in \{f, h\}} p_i q_i$$



Profit Function

$$\Pi(q_f, q_h) = R - C = p_Y (q_f^{\alpha_f} + q_h^{\alpha_h}) - q_f p_f - q_h p_h$$

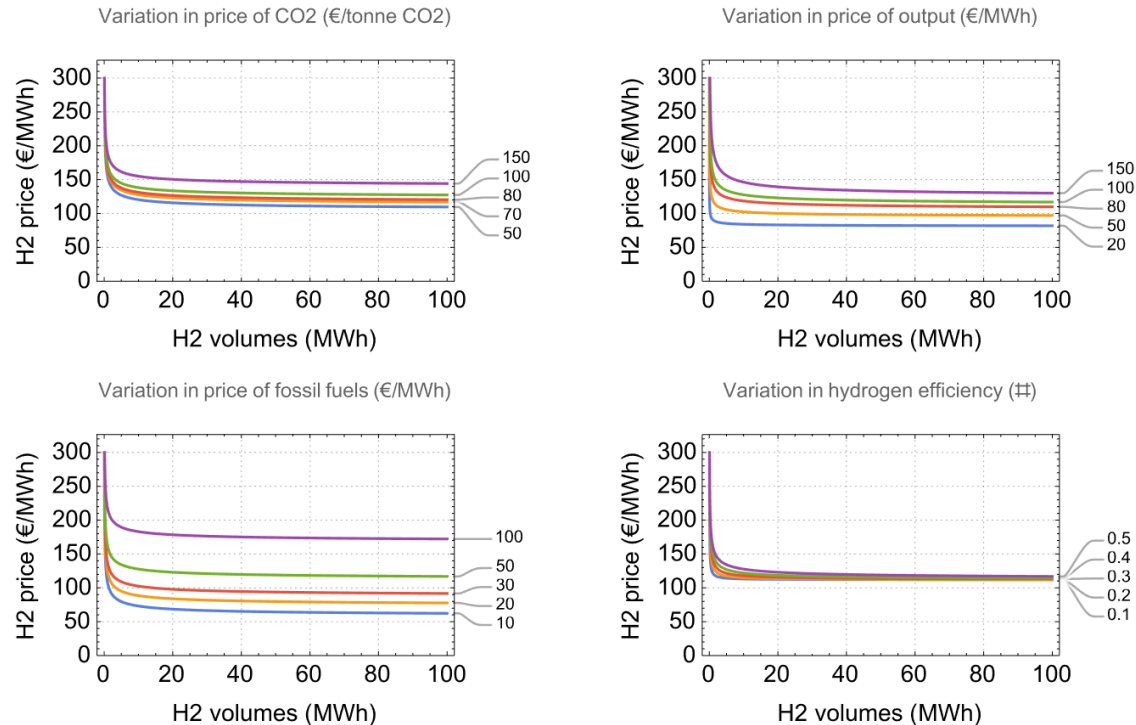
Mandated carbon market

$$p_h = \widehat{p}_f - \alpha_f \cdot p_Y \cdot \left(1 + \left(\frac{\alpha_f \cdot p_Y}{\widehat{p}_f} \right)^{\frac{1}{1-\alpha_f}} \right)^{\alpha_f - 1} + \frac{\alpha_h \cdot p_Y}{q_h^{1-\alpha_h}}$$

Voluntary Carbon Market

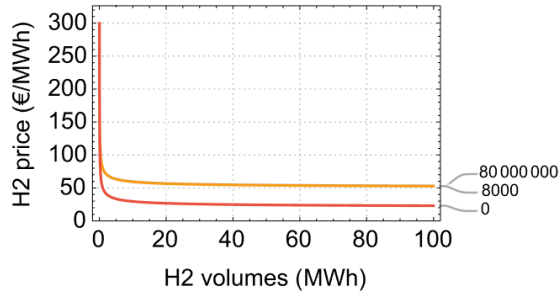
$$p_h = \alpha_h \cdot p_Y (q_h)^{\alpha_h - 1} - \alpha_f \cdot p_Y \left(\frac{E}{e_f} + 1 \right)^{\alpha_f - 1} + p_f$$

Willingness to pay for clean H2 – mandated market

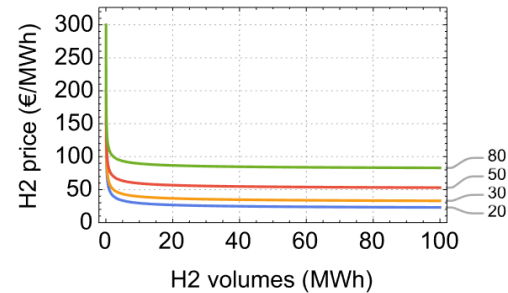


Willingness to pay for clean H2 – voluntary market

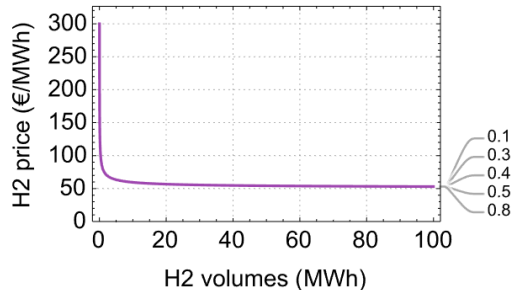
Variation in emission allowances (tonne CO2)



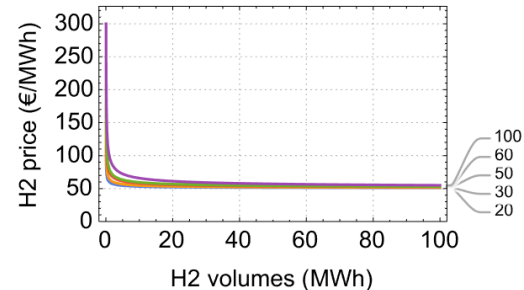
Variation in price of fossil fuels (€/MWh)



Variation in price of fossil fuels (€/MWh)



Variation in output price (€/MWh)



Next Steps

1 Simulation industries

The model has been plotted relying on a database that is specific to oil refineries in Europe. It would be extremely valuable performing similar simulations for other hard-to-abate industries.

2 Business Opportunity

After the focus on the European demand for hydrogen, it will be important to focus on large-scale production, particularly in countries that can be partners and have good RES (e.g., Saudi Arabia)

3 Geopolitical Perspective

Finally, the broader geopolitical standpoint must be considered. What is the implied value of decarbonized economies on a geopolitical standpoint? Is green a sovereign energy?

Thank you



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