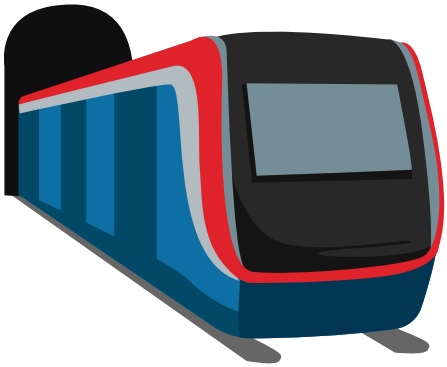
Energy Price Analysis and Total Cost of Ownership (TCO): A Comparative Study and Scenario Analysis

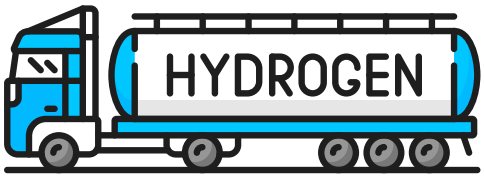
Rail market : When is the Optimal Time to Invest in Renewable Energy for Trains?

CONTEXT

The global concern over climate change has led to increased efforts to reduce carbon emissions and transition to sustainable energy sources. **Trains are a crucial part of Europe's transportation system but contribute significantly to greenhouse gas emissions, particularly through the use of offroad diesel.** To address this issue, alternative fuels such as hydrogen have gained attention as a cleaner option.

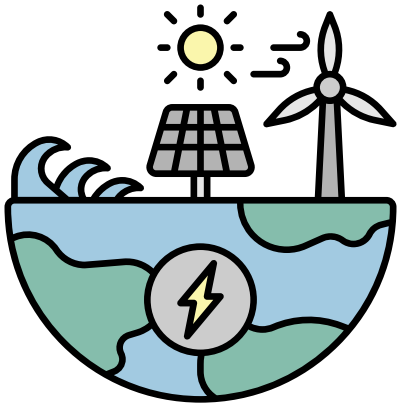


Hydrogen, especially green and blue hydrogen, offers the potential to power trains with zero or significantly reduced emissions when used in fuel cell systems. Unlike electrification, which may not be cost-effective or feasible for long-distance trains, hydrogen provides flexibility in transportation and storage, making it a viable and adaptable solution. Moreover, hydrogen can be produced from various renewable sources, ensuring a sustainable energy supply.



To make informed decisions, a **Total Cost of Ownership (TCO) analysis** is crucial. This TCO model considers upfront costs, transportation, storage, maintenance, and fuel expenses to evaluate the lifetime costs of different fuel options. By comparing **offroad diesel, electricity, and hydrogen fuels**, policymakers can identify the most economically viable and environmentally sustainable fuel option for Europe's trains, supporting the region's ambitious goal of achieving carbon neutrality.

METHODOLOGY AND DATA



Our study can be summarized into **three key steps**.

Firstly, we collected data from various **open-source platforms** such as the IEA database and OECD database. For indicators lacking verified sources, such as projected OPEX for electrolyzers and carbon capture storage devices, we made reasonable assumptions based on relevant reports.

Secondly, we conducted a detailed breakdown of the costs associated with each energy source. This analysis encompassed **capital expenditure (CAPEX), initial energy costs, operational expenditure (OPEX), transmission and storage costs, taxation, and subsidies.** Using available data and the assumptions made in the first step, we projected the costs for each category from **2020 to 2050** with either linear or inverted logistic models employed based on the available data and assumptions.

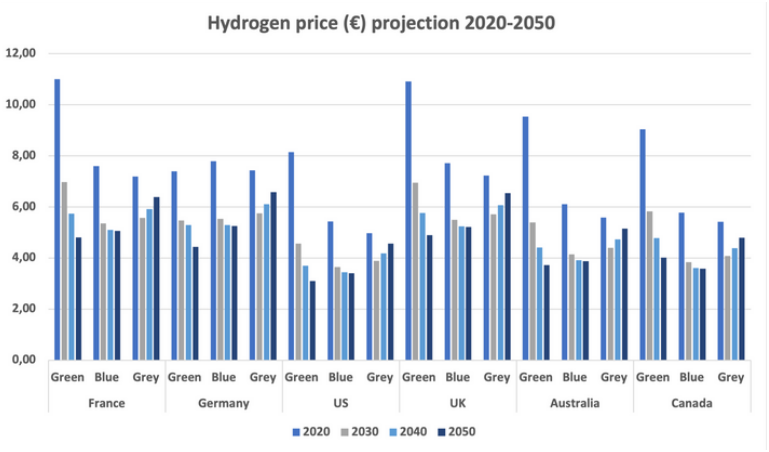
Thirdly, we utilized the projected costs to estimate the total cost of ownership (TCO) for both **regional and freight trains** powered by each energy source. The TCO calculations were performed over a **rolling period of 30 years**. Additionally, considering the opportunity cost associated with hydrogen trains, we developed an **optimal TCO model** to facilitate investment decision-making.

IEA OECD

ALSTOM

École des Ponts ParisTech

ENERGY COST FORECAST



According to our projections, the cost of blue and green hydrogen is expected to decrease significantly after **2030**. This reduction is attributed to **technological advancements, increased production scale, and improved efficiency**. As renewable energy becomes more prevalent, the costs of producing hydrogen from sustainable sources are anticipated to decline significantly.

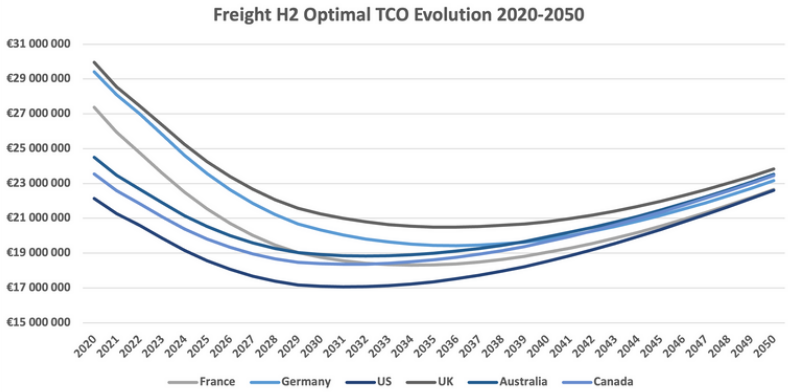
In contrast, the cost of grey hydrogen and conventional diesel is projected to rise due to **increased CO2 taxation and stricter environmental regulations**. These measures aim to discourage the use of carbon-intensive fuels and incentivize the adoption of cleaner alternatives. As a result, grey hydrogen and diesel are expected to become less economically viable compared to cleaner options like blue and green hydrogen.

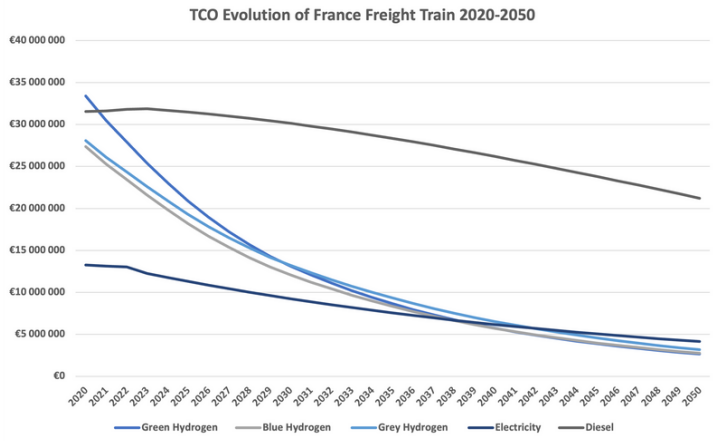
The cost of electricity, commonly used as an energy source for trains, is projected to **remain relatively stable**. However, it is essential to consider potential contingencies that may impact electricity prices, such as changes in market dynamics or disruptions to the electricity supply. While stability is anticipated, ongoing monitoring and assessment of the electricity market are necessary to identify any potential risks or fluctuations.

TCO EVOLUTION

In our TCO model analysis, we adopt a rolling basis of 30 years to examine the evolution of TCO. This approach considers key factors such as inflation rate, discount rate, and CO2 taxation to provide a comprehensive evaluation. **Currently, electrified trains are the primary choice in terms of TCO, followed by hydrogen trains, which are projected to become the dominant option around 2035.**

To enhance investment decision-making, we introduce the concept of optimal TCO. The optimal timing for investing in hydrogen trains varies based on the specific country, considering factors such as the local cost of natural gas and electricity. **Typically, the optimal investment time falls within the period of 2030 to 2038.**





In summary, our analysis suggests that a **energy price and TCO dynamics** is crucial for making informed investment decisions related to trains. By determining the optimal time for investment in hydrogen trains, stakeholders can make well-informed decisions considering favorable economic conditions and potential benefits offered by hydrogen as a fuel source. This analysis facilitates maximizing **cost-effectiveness and sustainability in train transportation**, aligning with the objective of achieving carbon neutrality and mitigating greenhouse gas emissions. It empowers decision-makers to seize the opportune moment for transitioning to hydrogen-powered trains, leveraging their economic and environmental advantages.