TRA-105 Fuel Cell Systems

# Limited Resources For Fuel Cell Expansion

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## Introduction

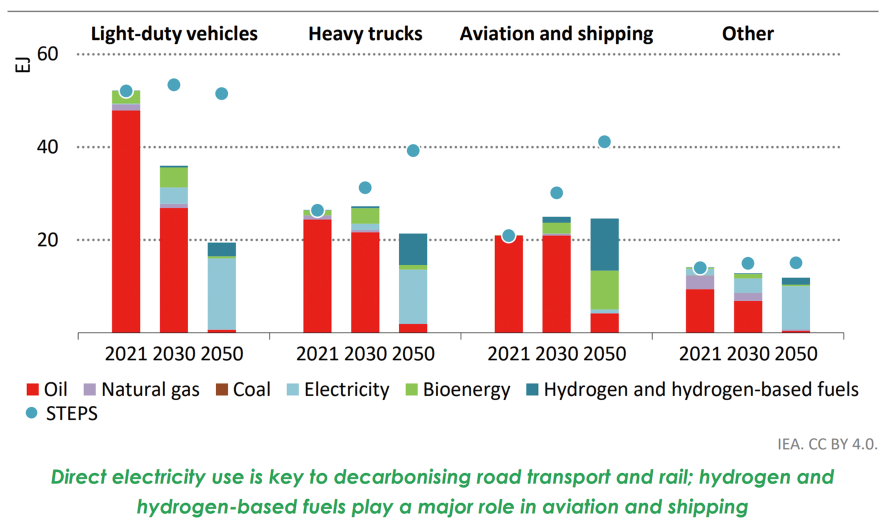
Figure 1. Hyundai N Vision 74 Hydrogen Fuel Cell Car.

This project investigates the future needs of materials related to fuel cells for PEM and SOFC used in road transport. We estimate the cumulative demand for fuel cell specific materials for a global scenario with high hydrogen use until 2050. We compare this estimate with global resource reserves to ınderstand supply chain bottlenecks.

## Objectives:

A global scenario with high hydrogen use until 2050.
How many (critical) raw materials that are needed for fuel cells if using PEM or SOFCs.
Relate the (critical) raw material use to the global hydrogen scenario and consider the cumulative use until 2050. Compare how the potential cumulative (critical) raw material use relate to the current production of the raw materials.

## A Global Scenario With High Hydrogen Use Until 2050



Note: Light-duty vehicles include passenger light-duty vehicles and light commercial vehicles. Other includes two/three-wheelers, buses, rail, pipeline and non-specified. STEPS = Stated Policies Scenario.

Figure 2. Final energy consumption in transport by source and mode in the NZE scenario, 2021-2050.

Globally, road vehicles emitted more CO2 than North America's energy - related carbon emissions in 2021, with oil products accounting for 90% of energy consumption. However, the NZE Scenario aims to decrease the share of oil products in road transport demand and end new sales of ICE vehicles by 2045, with EVs dominating in road transport by 2030. The electrification of heavy-duty vehicles and the rapid rollout of recharging infrastructure are crucial to achieving this goal, and by 2050, the road transport sector is almost entirely decarbonised.

| | 2021 | 2030 | 2050 |
|---|---|---|---|
| Oil products | 90 | 75 | 7 |
| Biofuels and nature | 9 | 10 | 0 |
| gas | | | |
| Electricity | 1 | 10 | 68 |
| Hydrogen | 0 | 5 | 25 |
| CO2 emission | 5.9Gt | | 200Mt |

Table 1. Road vehicles energy consuption (%)

Only the remaining ICE heavy duty trucks contributes to 200Mt of CO2 emission, 3% of 2021, hydrogen and hydrogen fuel cell produces over 25% of road transport energy.

Now

90% of energy consumption is made by oil products and electricity takes less than 1%, which produces 5.9 Gt CO2 emission.

2050

From: IEA 2022 Chapter 3

## PEM/ SOFCs Raw Materials

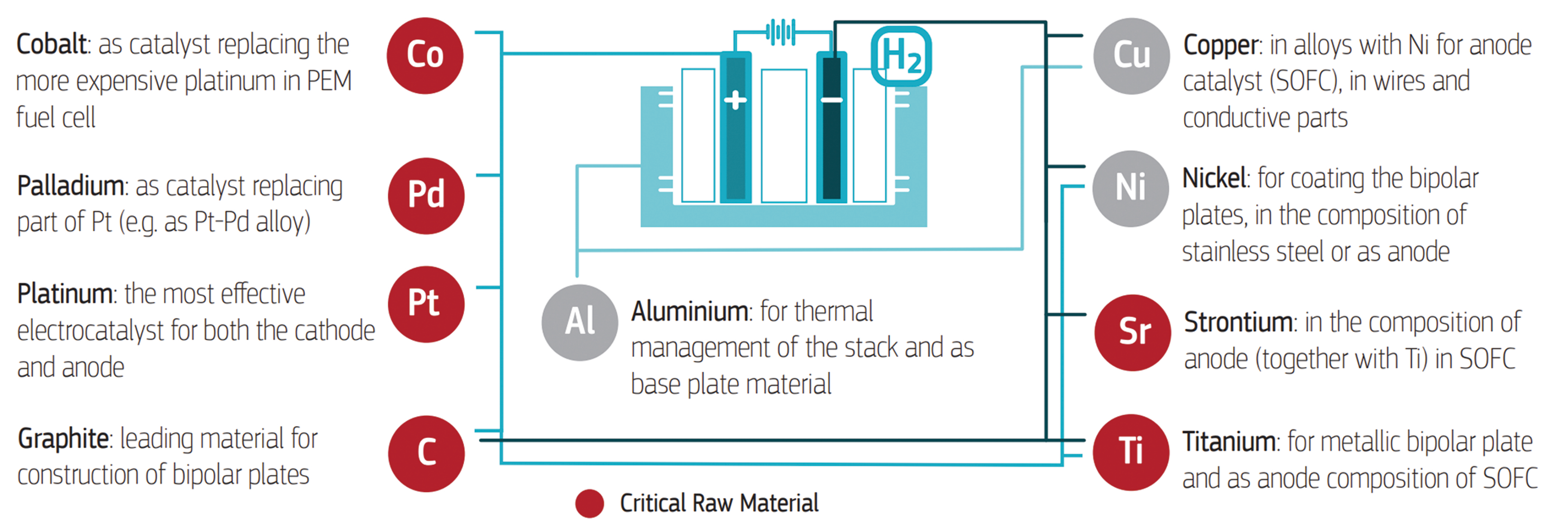



Figure 3. Relevant raw materials used in fuel cells (FCs)

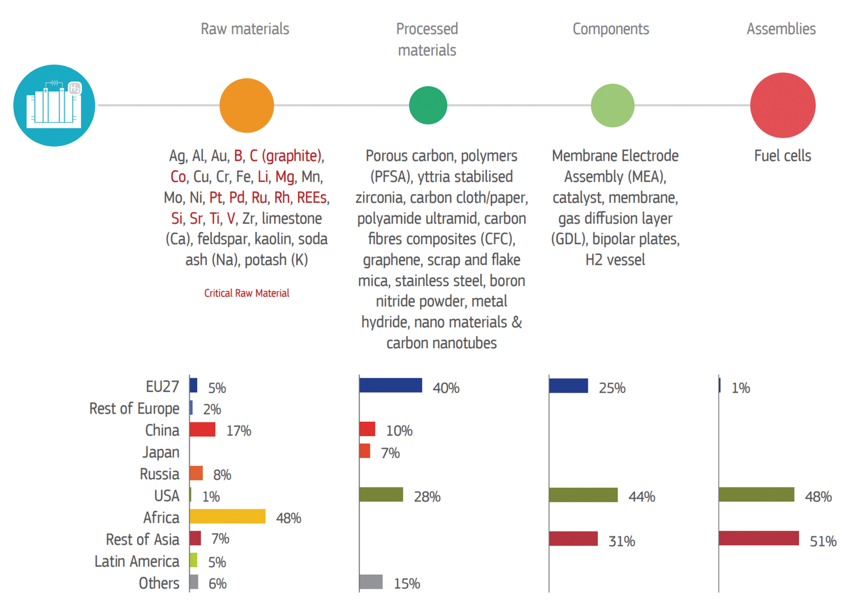


Figure 4. FCs and hydrogen technologies: an overview of supply risks, bottlenecks and key players along the supply chain

| | PEMFC | SOFC |
|---|---|---|
| Raw material | Aluminum<br>Copper<br>Nickel | Aluminum<br>Copper<br>Nickel |
| Critical raw material | Cobalt<br>Palladium<br>Platinum<br>Graphite<br>Strontium<br>Titanium<br>Magnesium<br>REEs<br>Borates<br>Silicon metal<br>Rhodium<br>Ruthenium<br>Lithium<br>Vanadium | Nickel<br>Copper<br>Strontium<br>Yttrium<br>Zirconium |

Table 2. Raw and critical raw materials used in PEMFC and SOFC

From: Critical Raw Materials for Strategic Technologies and Sectors in the EU

## Raw Material Consumption For FC-Vehicles of NZE 2050

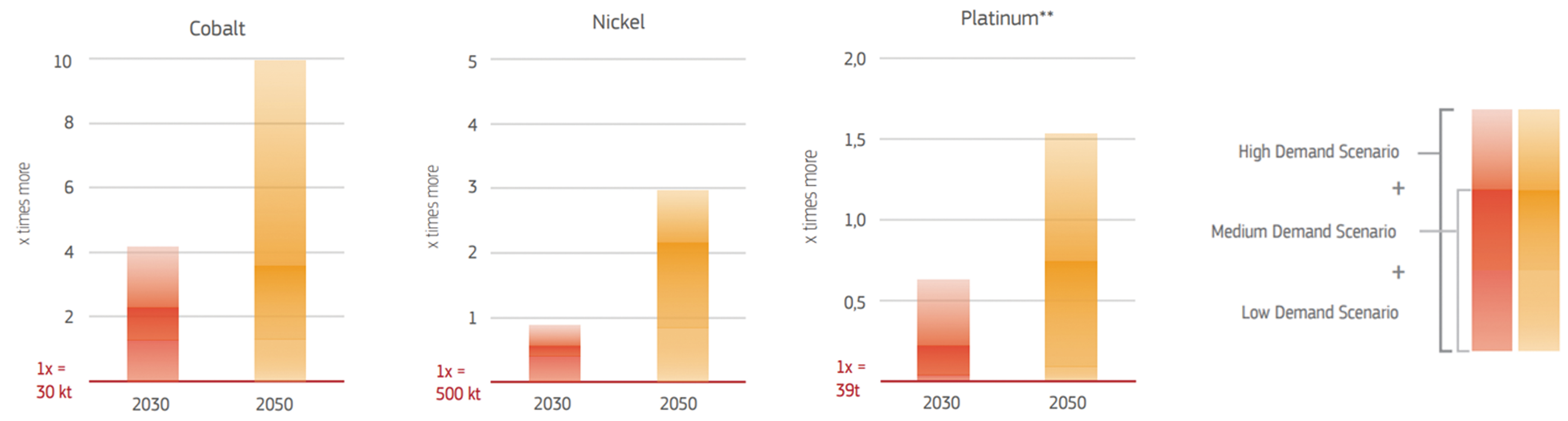


Figure 5. EU annual material demand for Cobalt, Nickel and Platinum in 2030 and 2050

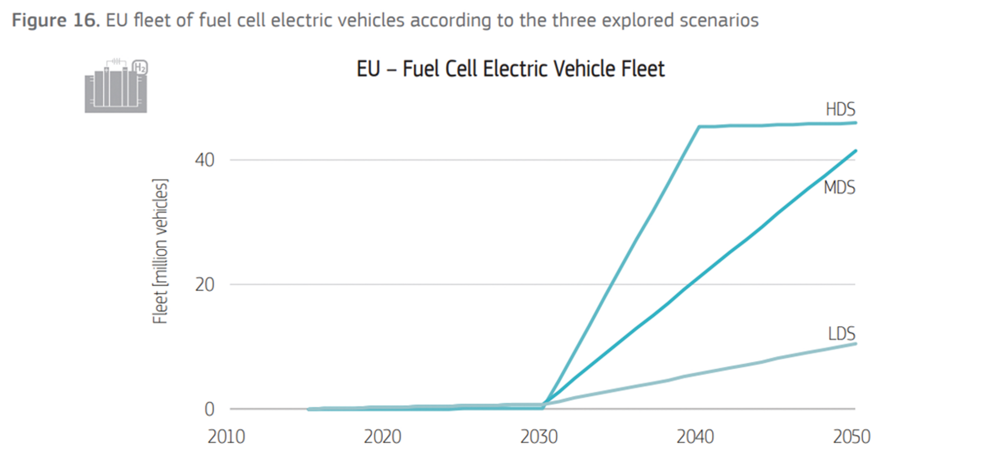



Figure 6. EU fleet of fuel cell electric vehicles according to the three explored scenarios
LDS – LTS Baseline: considers the EU legally binding targets by 2030 and targets a 64 % reduction of GHG emissions by 2050.
MDS – LTS 1.5° C Technical: considers the EU legally binding targets by 2030 (hence it is identical to the LTS Baseline until this date) and targets a 100 % reduction of GHG emissions by 2050. (the NZE 2050 scenario)
HDS – JRC-TIMES ZeroCarbon: almost complete decarbonisation by 2050 and stronger decarbonisation in 2030 than LTS in line with the 55 % objective depicted in the EU Green Deal (European Commission, 2019).

Platinum accounts for half of the cost of a fuel cell stack. Of the remaining materials, Nickel and Cobalt make up the majority of the remaining portion of the cost of the fuel cell.
Here we estimate the amount of these three raw materials used.We fit the three raw materials to the projected demand in 2030 and 2050 and integrate the fitted demand curves to obtain the total amount of raw materials we will need over the 20-year period.
The related CRMs: Platinum, Cobalt, Nickel.
Platinum:
7.8t in 2030, 29.25t in 2050. Total 2030-2050: 370.5t
Cobalt:
17.1kt in 2030, 45kt in 2050. Total 2030-2050: 621kt
Nickel:
450kt in 2030, 1450kt in 2050, total

## Current Production VS Future Demand

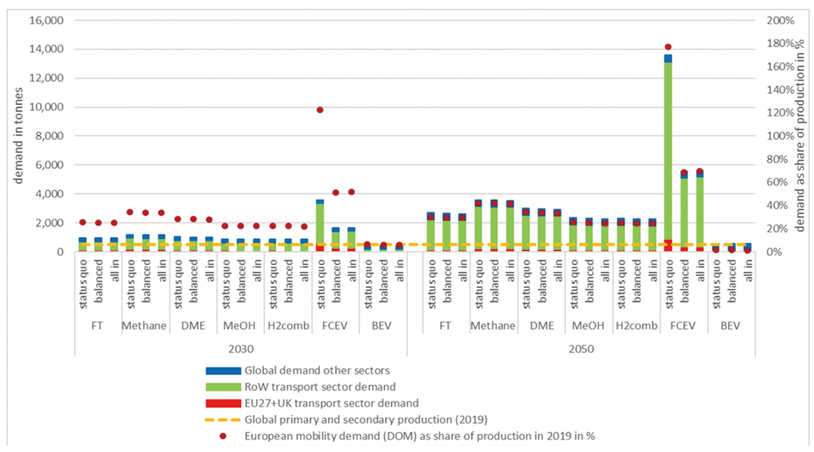


Figure 7: Total annual PGM demand in the 100% scenarios in 2030 (left) and 2050 (right).

| | | Li | Co | PGM | Cu | Ni | AG | REE | Silicon metal |
|---|---|---|---|---|---|---|---|---|---|
| Resources | *Million tonnes* | 86 (230,000*) | 25 (120*) | 0.1 | 2,100 | 130 | 0.797 | 478 | n.a. |
| Reserves | *Million tonnes* | 21 | 7.1 | 0.069 | 870 | 94 | 0.65 | 120 | n.a. |
| Global production 2019 | *Thousand tonnes* | 86 | 144 | 0.447 (Pt: 0.186; Pd: 0.227) | 20,400 | 2,610 | 26.5 | 220 (Nd: 30.7) | 3** |
| Dynamic of production | *Change 2019 versus 1994* | +1310% | +778% | Pt: +45 % Pd: +230% | +119 % | +288% | +191% | +341% | +400% |

*[Data source: (Boubault, 2019; USGS, 2021a; b; c; d; e; f; g) *resources in the oceans Li: Yang et al. (2018); Co: USGS (2021), ** (Boubault 2019)].*

Table 3: Resources, reserves and global production of selected raw materials

In Figure 7, we can see that the demand for PGMs will reach 180% in 2050. At the same time, FCEV demand for PGMs is the highest for different industrial uses. This means that for Europe, the demand for PGMs will be much higher than the range of its production capacity.
In Figue 8, we can see that FCEV's demand for cobalt is not really that high, and that even the production in 2019 can meet its demand for cobalt. However, it is worth noting that European mobility demand as share of production in 2019 reaches a staggering 300% by 2050. We see this as the mass production of BEVs placing a higher demand on cobalt production. In this environment, there could also be a situation where capacity does not meet the demand for FCEVs.
In Figure 9, the solid red line is Nickel's global resources, and the dotted black line is its global reserves. it is clear that with current production and stocks, there is no mismatch between production and demand for nickel.

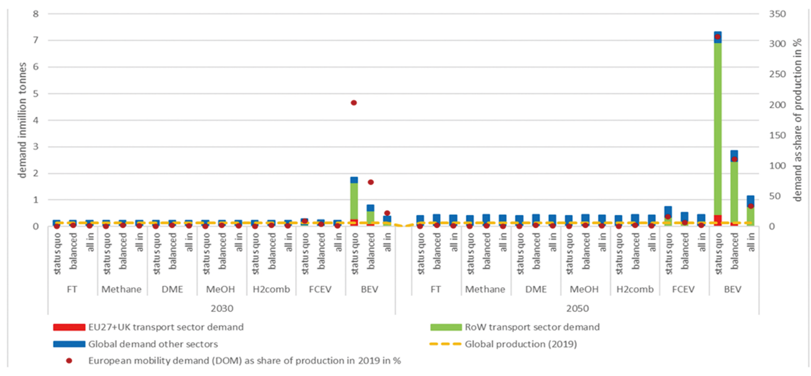


Figure 8: Total annual cobalt demand in the 100% scenarios in 2030 (top) and 2050 (bottom)

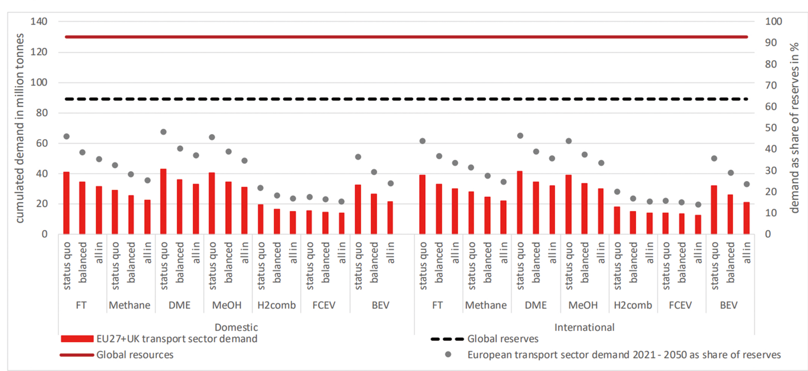


Figure 9: Cumulative primary nickel demand 2021-2050 associated with the EU27+UK transport sector in the 100% scenarios.

| | Recycling rate mobile sector | Source |
|---|---|---|
| Lithium | 85 % | European Commission (2020b) |
| Cobalt | 80 % | Dominish et al. (2021) |
| PGM | 55 % | European Commission (2020b); Hao et al. (2019) |
| Copper | 90 % | Schipper et al. (2018) |

Table 4: Applied recyling rates for selected materials.

From the table it could be seen that the recycle rate of raw materials like copper and lithium is considerable, almost fully recycled. But for critical ones, cobalt and PGM, especially PGM the rate is quite low. However, considering the rare resources, recycling critical raw materials as secondary production is still important.

## Conclusion

In this project, we analyze the global hydrogen usage by 2050. The production of raw materials for the production of PEM/SOFC was analyzed in relation to the production of raw materials and reserves in Europe.
According to the analysis of the data available so far, the amount of raw materials used for FC production in Europe is much lower than its known reserves at present. In other words, there will be a serious shortage of raw materials for FC production in Europe by 2050. To alleviate this shortage, the European region will need to rely on raw material imports from other countries and regions. Such imports will also depend on the logistics supply chain and the international political situation, which is a challenge for the development of FC in the European region. This challenge is not a technical one, but a risk when at a resource disadvantage.

## References

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