Road Freight Decabonisation

Pierre Chaufour

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RENAULT TRUCKS

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A significant role to play

Sources: EEA, EU27

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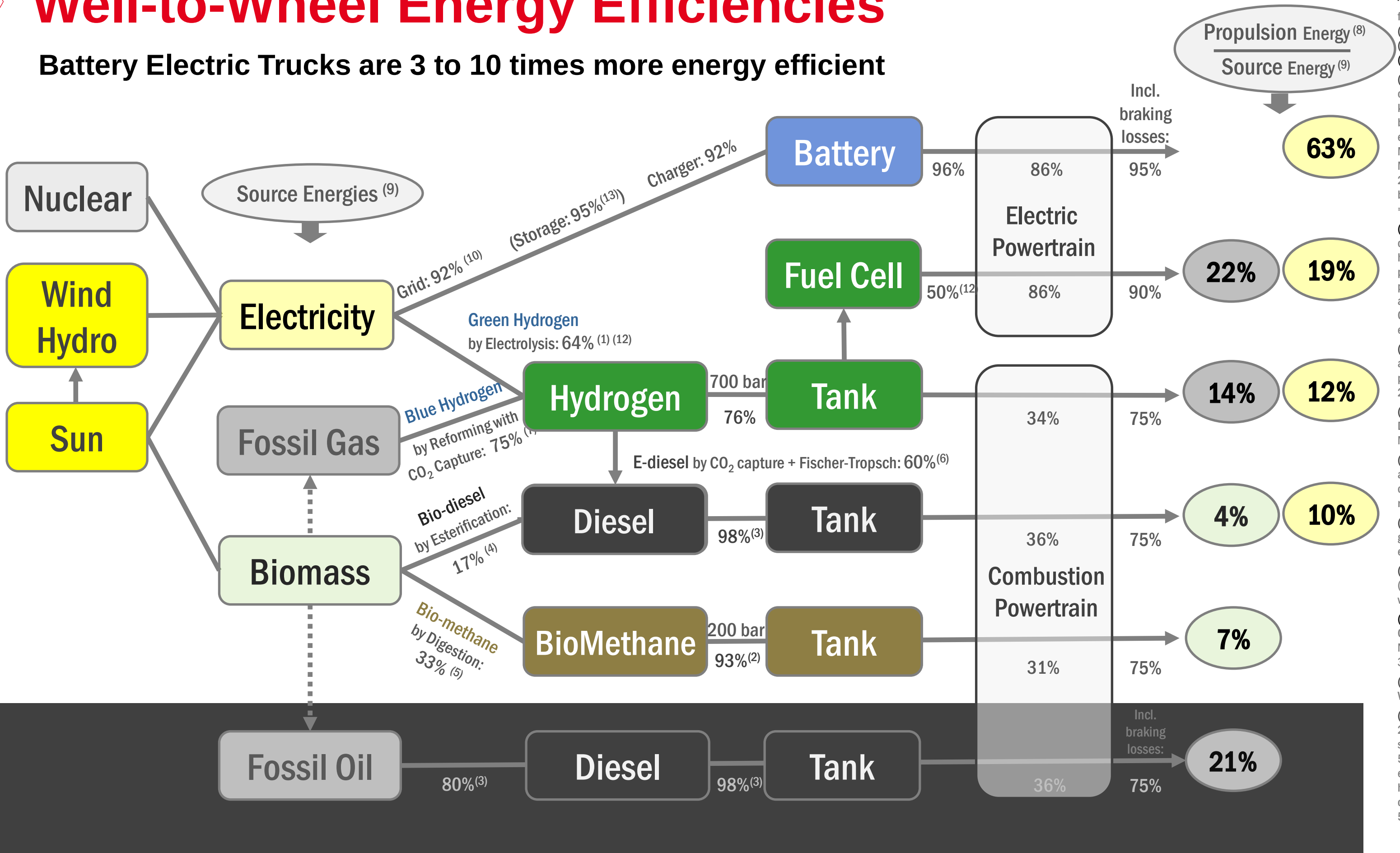
Well-to-Wheel Energy Efficiencies

Battery Electric Trucks are 3 to 10 times more energy efficient

For a 16-ton urban distribution truck



Average values over time

from JEC v5 2020 :
(1) EMEL1/CH2a
(2) OWCG4
(3) COD1

(4) Considered as example: in France, one hectare of rapeseed getting 1,300 kWh/m2/year as sun energy (65 MWh biomass with 0.5% sun to biomass efficiency) results in 1,500 l (13.6 MWh) of B100, and requires 15.1 MWh of additional primary energy (JEC 2020 ROFA1), hence a biomass to biodiesel efficiency of 13.6/(65+15.1) = 17%.

(5) Considered as example: in France, one kg of straw (14.5 MJ/kg at 10% humidity) results in 7.5 MJ biogas produced (France Stratégie 2021, page 132), and requires 8.5 MJ of additional primary energy (JEC 2020 OWCG4), hence a biomass to biogas efficiency of 7.5 / (14.5 + 8.5) = 33%.

(6) "E-Fuels: A techno economic assessment of European domestic production and imports towards 2050", CONCAWE, 2022

(7) « Techno-economic Evaluation of Deploying CCS in SMR Based Merchant H_2 Production", IEA, 2017

(8) The "propulsion" energy is the one available at truck wheel to compensate for air drag and rolling resistance

(9) The "Source" energy can be oil, gas, biomass, or renewable/nuclear electricity

(10) 2.2 % in high-voltage network (source : RTE), 6% in medium and low voltage network

(11) "Performance and Costs of CO_2 Capture at Gas Fired Power Plants", Neil Smith et al. / Energy Procedia 37 (2013) 2443 – 2452

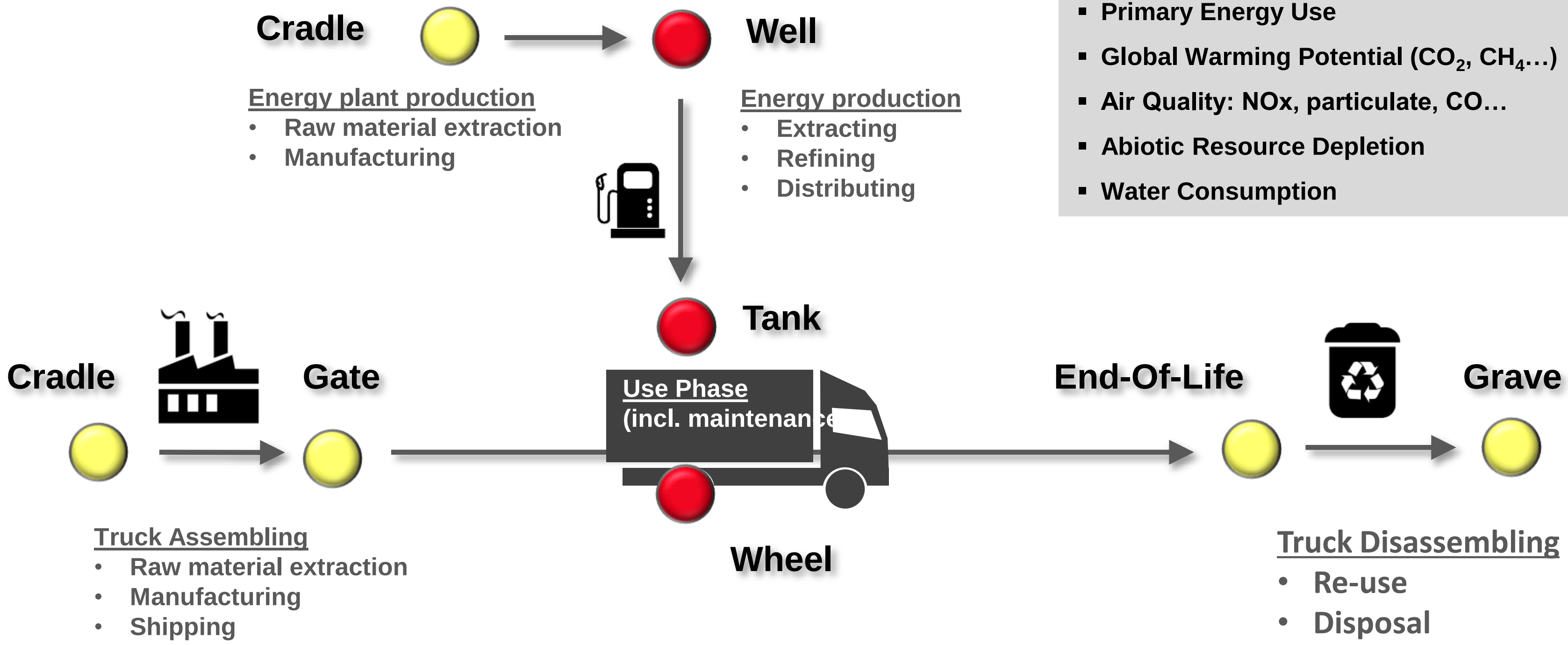
(12) Based on Hydrogen Low Heating Value (120 MJ/kg)

(13) Considered as example: "Target 2050: 100% renewable energy supply", UBA, 2010, figure 5, link : 52.8 TWh/y stored with an average efficiency of 70% (batteries, dams, hydrogen), hence 23 TWh/y losses out of a consumption of 506 TWh/y, hence 5% losses.

Life Cycle Analysis

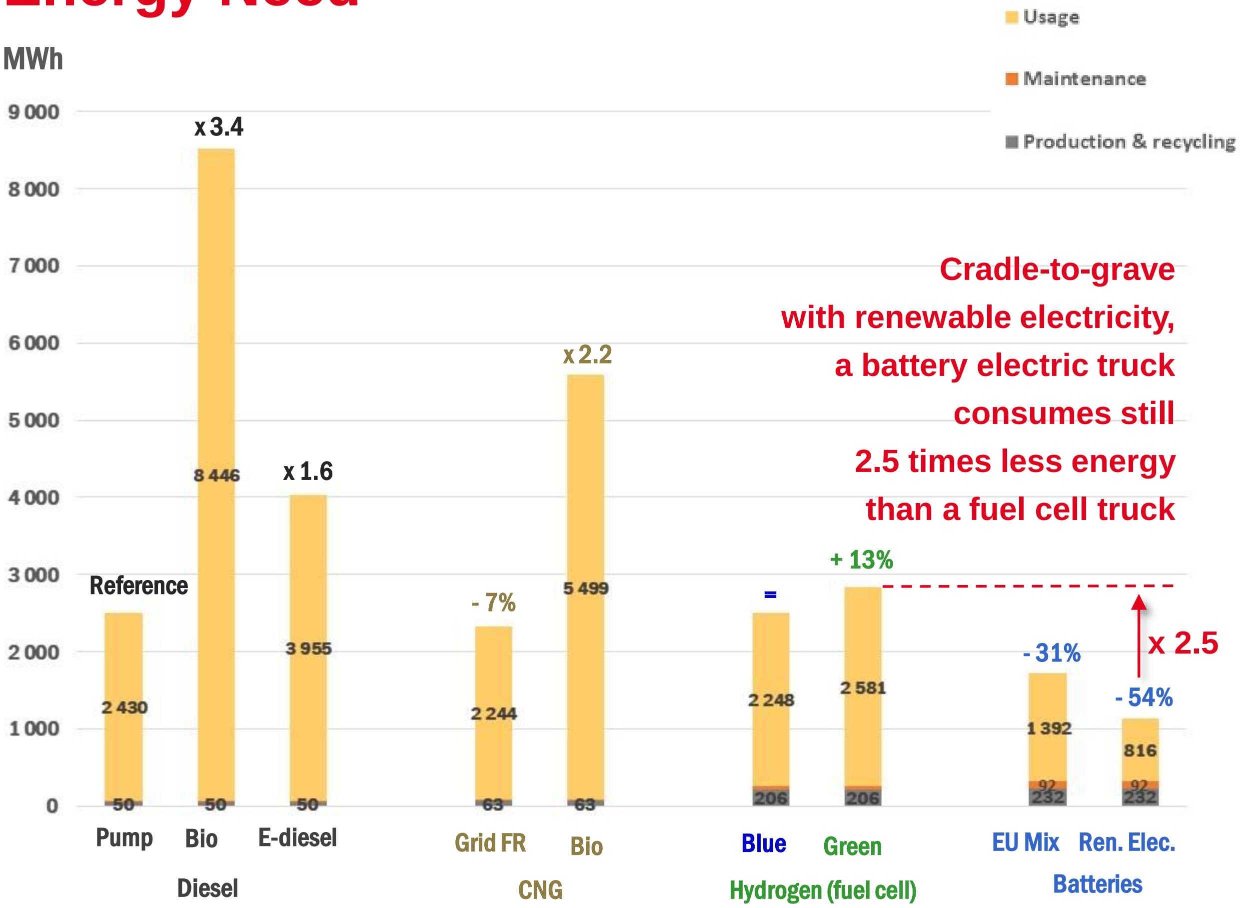
A Life Cycle Analysis is the evaluation of potential environmental impacts of a product through its lifecycle (ISO 14040). For trucks, the impacts considered include:

- **Primary Energy Use**
- **Global Warming Potential (CO_2, CH_4…)**
- **Air Quality: NOx, particulate, CO…**
- **Abiotic Resource Depletion**
- **Water Consumption**



Energy Need

For a 16-ton urban distribution truck



The energy considered here are renewable electricity, biomass, oil, and gas.

D 16-ton running 560 000 km over 14 years (2024-2037)

Production & recycling & maintenance : Volvo internal LCA, scaled for hydrogen and gas based on CO_2 emissions. Battery, fuel cell and hydrogen tank second life and recycling not taken into account yet.

Multiplicators to get primary energy:

Pump Diesel: x 1.58 in 2020 up to **1.72** in 2030 and afterwards (JEC 2020 COD 1 for the fossil part (x1.26), 7% bio in 2020, 10% in 2030 and afterwards).

Bio-diesel: (B100): x 5.88 (17% energy efficiency of converting biomass into B100)

E-diesel: x 2.83 in 2020, down to **2.62** in 2050

Grid-CNG: x 1.16 in 2020 up to **1.24** in 2030 and afterwards (JEC 2020 CMCCG1 for the fossil part, 0% bio-methane content in 2020, up to 5% in 2030 and afterwards).

Bio-methane: x 3.03 (33% energy efficiency of converting biomass into bio-methane)

Blue Hydrogen: x 1.84 (JEC 2020 GPCH2bc)

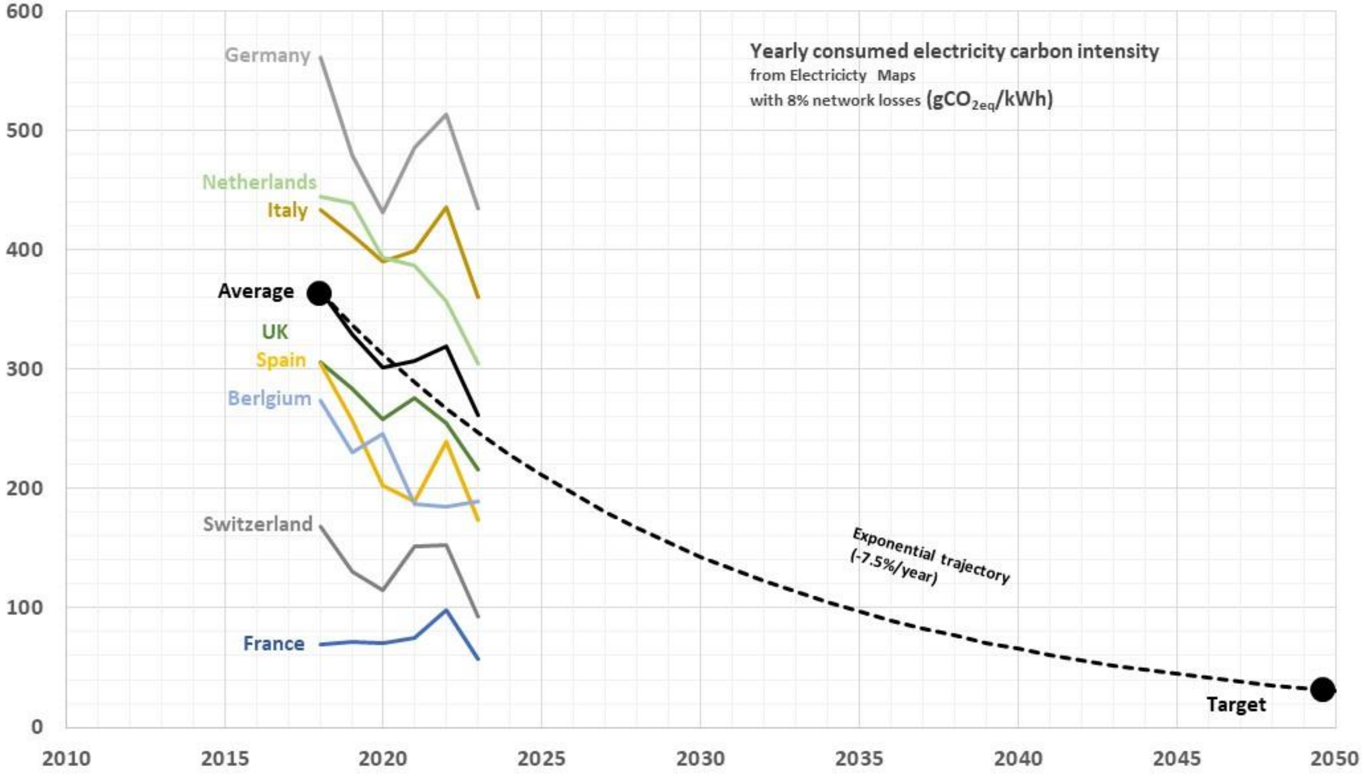
Green Hydrogen: x 2.14 in 2020, down to **x 1.97** in 2050

European grid electricity : x 2.83 in 2020 (JEC 2020 EMEL), down to **x 1.17** in 2050 (renewable electricity with 8% network losses and 7% storage losses)

Renewable electricity : x 1.09 in 2020 (i.e. 8% network losses), up to **x 1.17** in 2050 (8% network losses and 7% storage losses), plus the energy for one set of batteries for the storage.

Batteries: 134 kWh grid per kWh of battery. Replacement after 7 years as maintenance.

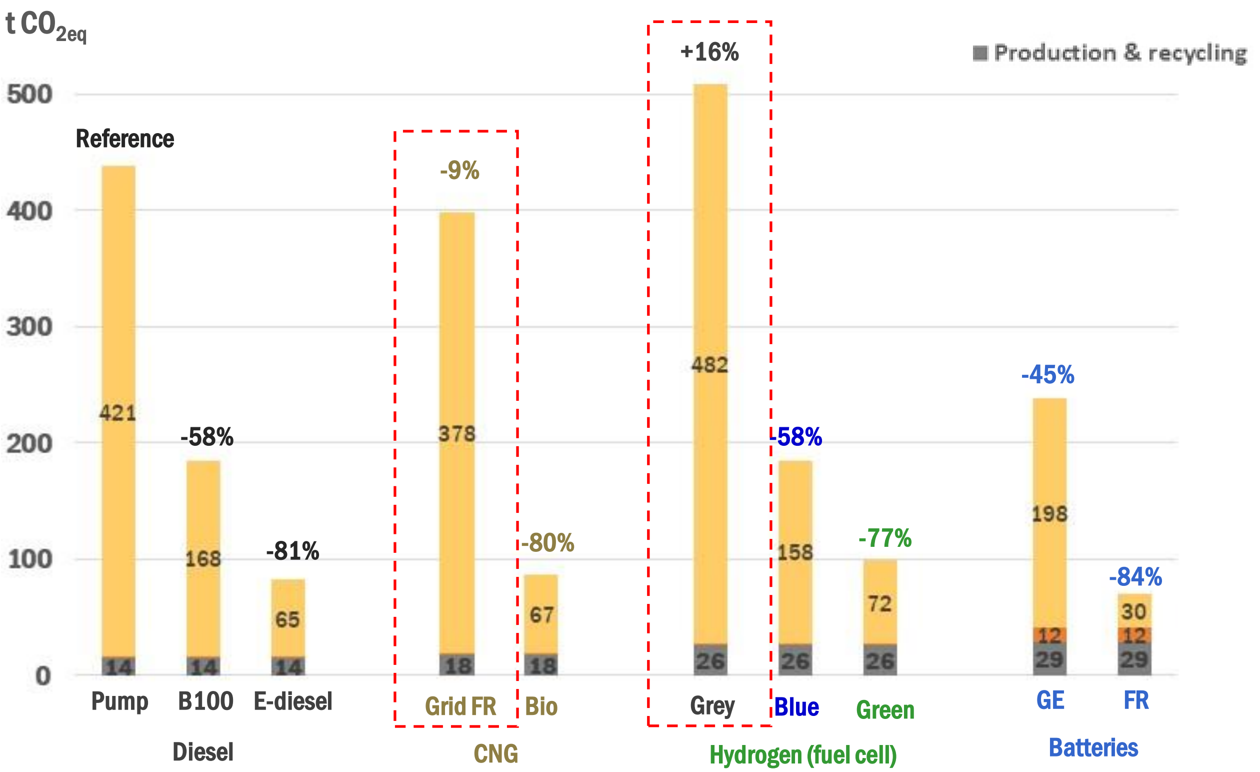
Electricity decarbonisation started



Global Warming Potential

For a 16-ton urban distribution truck

All considered energy options do decarbonise road freight, except grid gas and grey hydrogen



D 16-ton running 560 000 km over 14 years (2024-2037)

Production & recycling & maintenance : Volvo internal LCA for diesel and BEV in 2020, scaled for the other cases with Ricardo ED11344 report. For batteries, assuming that 40% of accolated storage energy is left at SOH=80% for the second life, and that recycling saves 30% of the carbon footprint of a new battery.

CO_2 emission coefficients:

Pump Diesel: 3.09 kgCO_2eq/l in 2020 (7% bio) decreasing linearly to 2.85 kgCO_2eq/l in 2030 (17% bio), and constant afterwards

B100: 1.14 kgCO_2eq/l in 2022 (ADEME), decreasing linearly to 1/3 of this value in 2050

E-diesel: 0.57 kgCO_2eq/l in 2020, decreasing to 0.17 kgCO_2eq/l in 2050.

Grid-CNG: fossil (3.35 kgCO_2eq/kgCH4 (ADEME), for France 1% bio-CNG in 2022, increasing to 7% in 2030 and 30% in 2050.

Bio-CNG: 0.66 kgCO_2eq/kgCH4 in 2020 (ADEME), decreasing linearly to at 1/3 of this value in 2050.

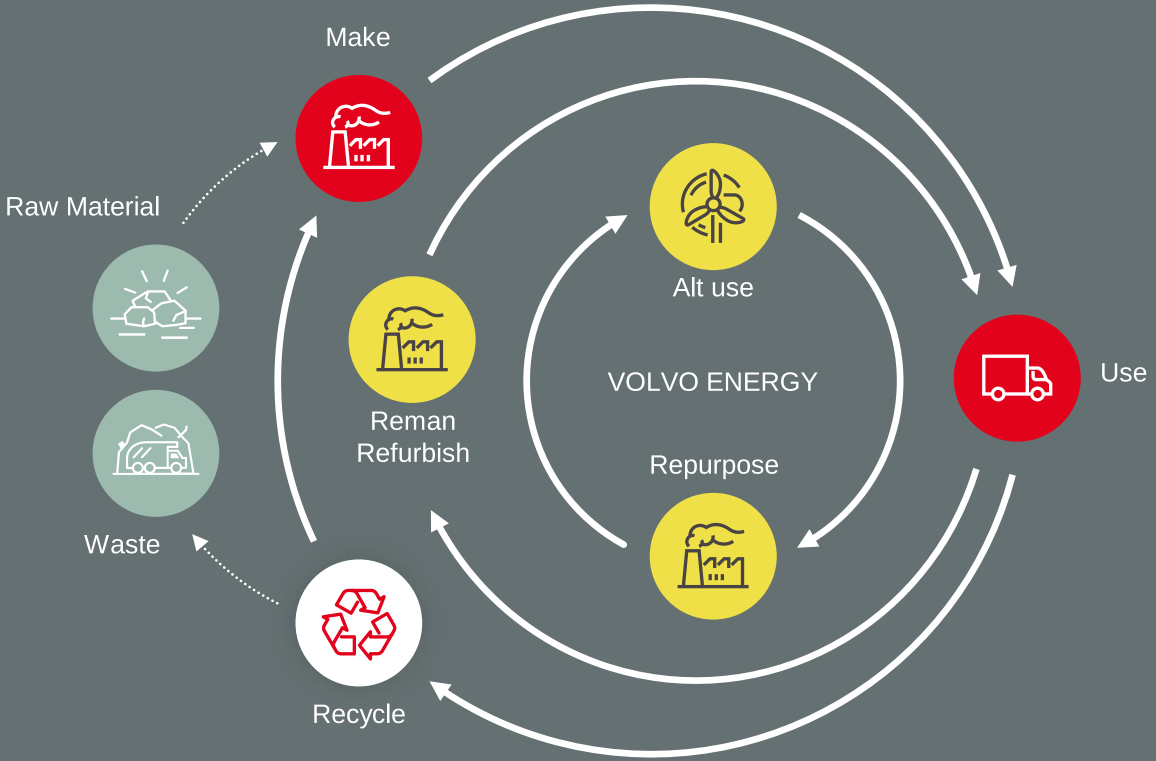
Grey Hydrogen: 13.1 kgCO_2eq/kgH2 (JEC GMCH1)

Blue Hydrogen: 4.8 kgCO_2eq/kgH2 (JEC GPCH2bC) in 2020, decreasing to 3.5 kgCO_2eq/kgH2 in 2050.

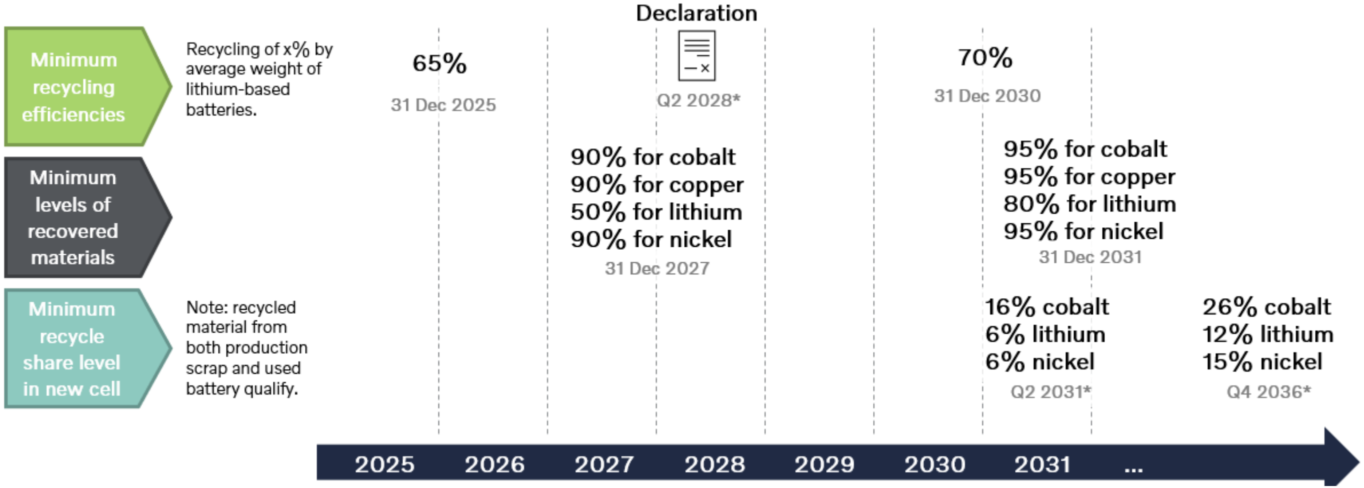
Green Hydrogen: 2.7 kgCO_2eq/kgH2 in 2020, decreasing to 1.5 kgCO_2eq/kgH2 in 2050

Grid electricity : 57 gCO_2eq/kWh in 2021 in France (ADEME), 505 gCO2eq/kWh in 2018 in Germany (IEA), decreasing linearly to 30 gCO_2eq/kWh in 2050.

Battery Circular Economy



Recycling and regionalization at the heart of new regulatory frameworks



Critical mineral act

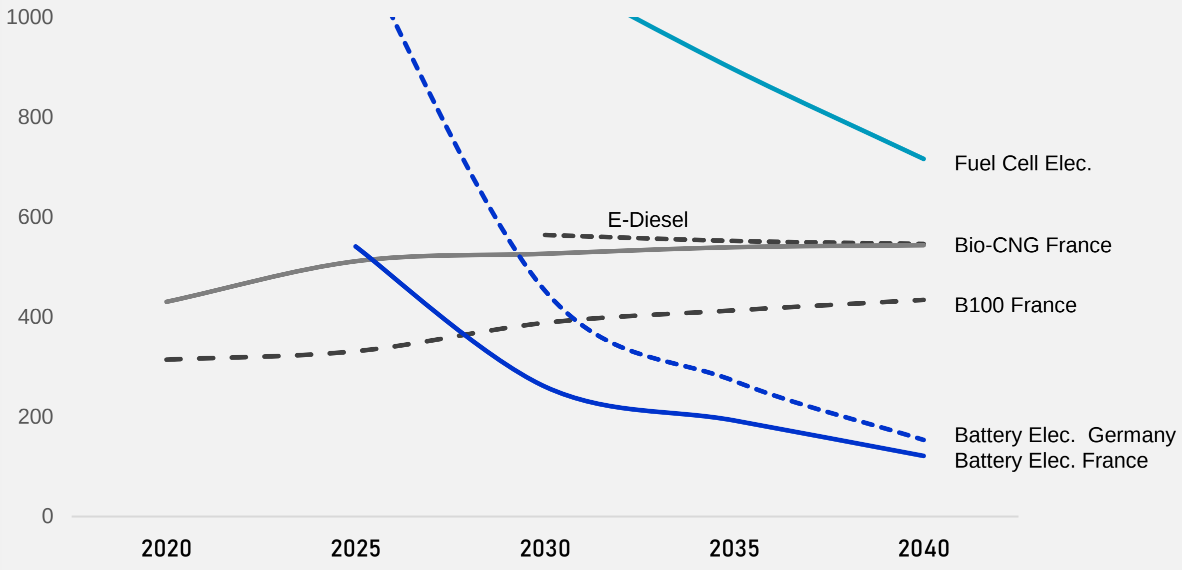
- *Critical and strategic minerals: Ni, Li, Co, Graphite*
- *Extraction*: 10% of EU consumption
- *Processing*: 40% of EU consumption
- *Import diversification*: by 2030

Life Cycle Analysis

- Global Warming Potential
- Energy Consumption
- Energy Availability
- NO_x Emission
- Noise Emission
- Mineral Resource Depletion
- **Decarbonisation Cost**

LIFECYCLE DECARBONISATION COST COMPARED TO DIESEL ($€_{2023}/TONCO_{2EQ}$)

Without tax and incentive



Battery Electric trucks will have the lowest decarbonisation cost

40-ton regional-haul tractor operating over 800,000 km

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