

Various Pathways for Decarbonizing the Road Transport Sector

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- ✓ Analysis of powertrains by country/region
 - ✓ LCA emissions
 - ✓ Critical minerals used in each powertrain
 - ✓ Total cost of ownership

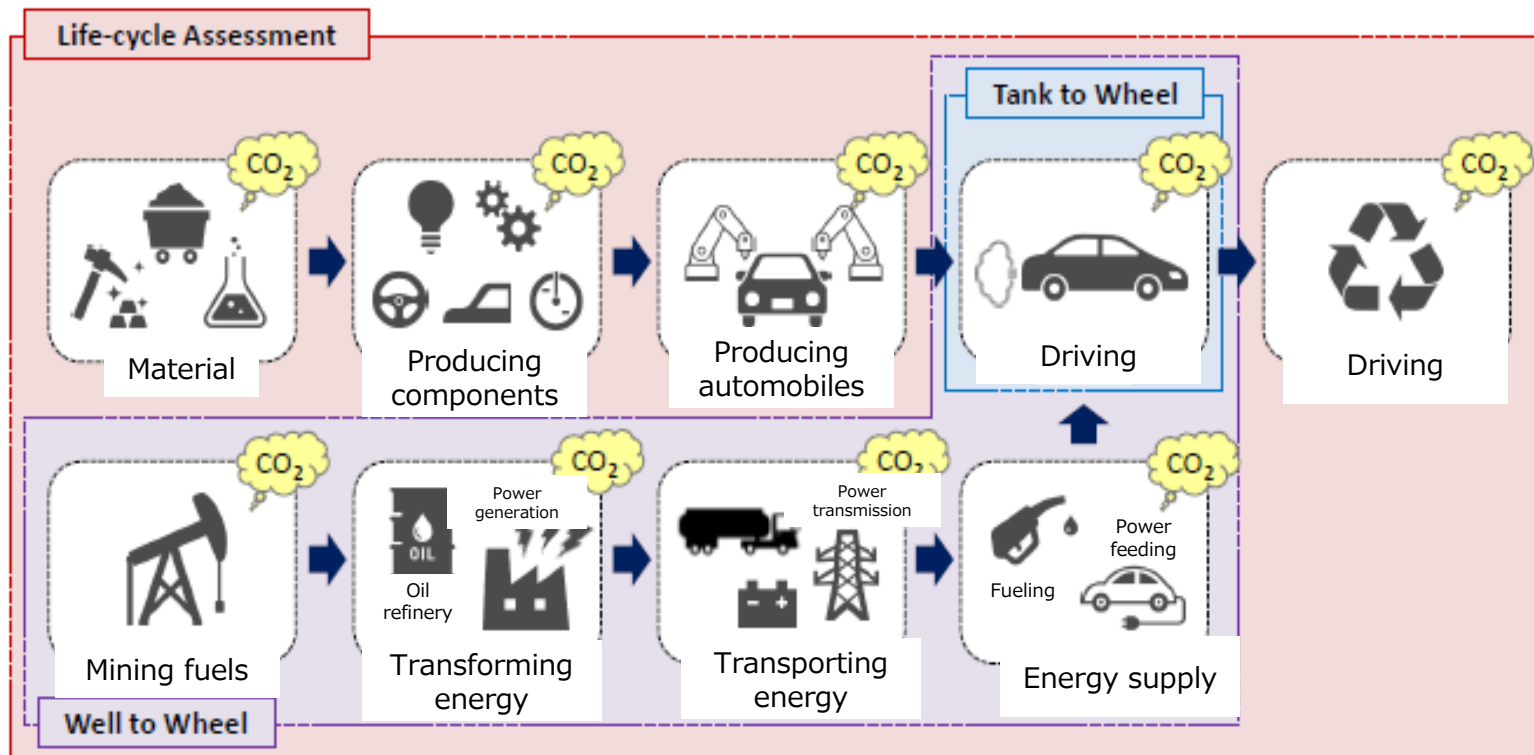
- ✓ Analysis of nation-wide emissions
 - ✓ Assumption on stocks by powertrain
 - ✓ Total LCA emissions: OECD Europe and Brazil

- ✓ Policies in Global South

- ✓ Conclusions

LCA analysis for automobiles

- In estimating the **GHG emissions from automobiles**, **Life Cycle Assessment (LCA)** can offer a fair evaluation including the emissions from production/manufacturing, fuel supply, energy use and end of life/recycling.
- Since the availability of CN fuel, power supply mix, energy infrastructure, and social conditions vary greatly depending on the country and region, LCA analysis can offer **country/region specific different perspectives for the GHG emissions from automobiles**.



Source : Ministry of Environment, The second review meeting on greening of whole tax system (Nov, 2020)

Cases of LCA analysis for automobiles

- Toward reducing the GHG emissions from automobiles, it is important to consider the two key factors:
 - Carbon neutral fuels
 - Zero emissions vehicle + low carbon electricity, and fuel efficiency

	CN fuel ratio (Biofuel+e-fuel)	Power generation mix, fuel prices, fuel efficiencies, etc.	Powertrain share
CN Fuel Promotion Scenario (CNF)	Advanced Technologies	Reference	Reference
Advanced Technologies Scenario (ATS)	Advanced Technologies	Advanced Technologies	Advanced Technologies

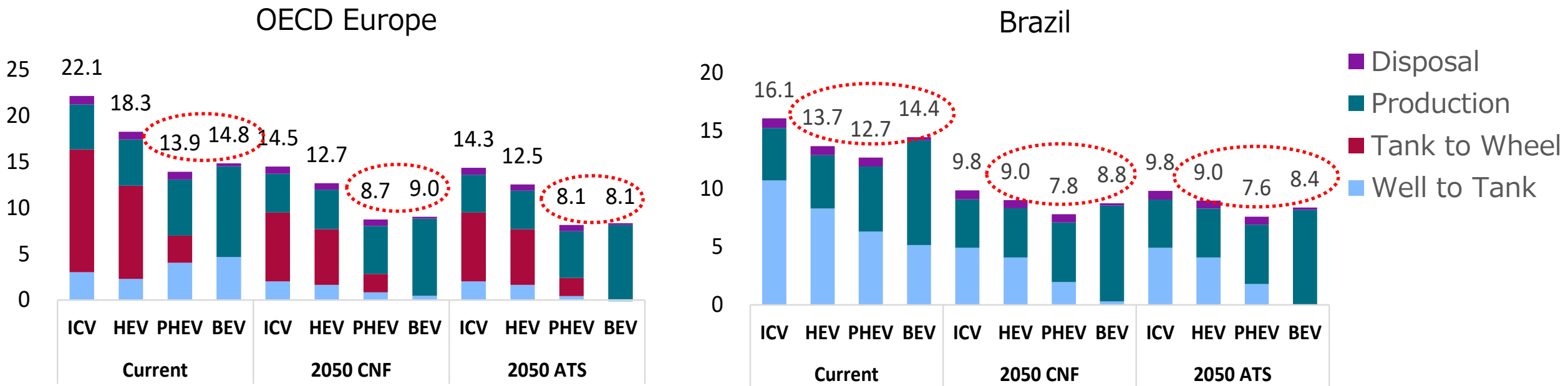
Note:

- **Reference: continuation of current trends** (IEEJ Outlook 2025)
- **Advanced Technologies: maximum implementation of policies with technologies deployed to maximum extent** (IEEJ Outlook 2025)

GHG emissions vary by country/region

- **OECD Europe** : Currently PHEV's life cycle emissions represents the lowest level, followed closely by that of BEV. This relationship will continue toward 2050.
- **Brazil** : **Currently HEVs and PHEVs with E100 represents the lower GHG emissions on lifecycle basis compared with BEVs. Even in 2050** when the power sector is projected to be fully decarbonized, **the life cycle emissions of HEVs and PHEVs are expected to be almost equivalent to and lower than BEVs.**

Life cycle GHG emissions per a passenger vehicle (tCO₂eq/Vehicle Lifetime)

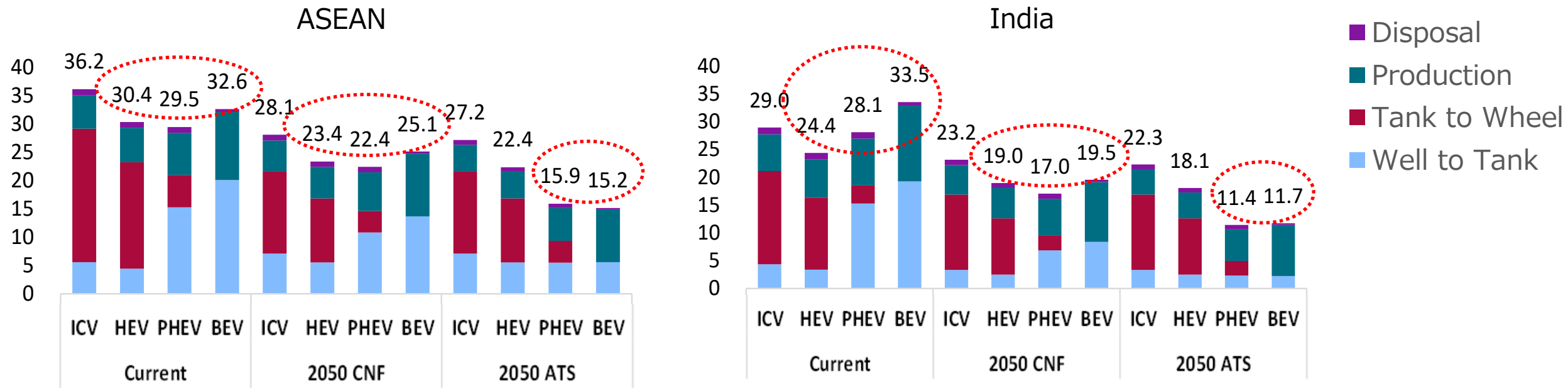


※Well to Tank does not include GHG emitted by transporting fuels.
A passenger vehicle is assumed to be produced and disposed domestically.

Combining HEVs/PHEVs with CN fuels: key in ASEAN and India

- **India and ASEAN** : Currently HEVs/PHEVs outperform BEVs in terms of life cycle GHG emissions (The speed of decarbonizing the power sector is slower compared with developed countries).
- If the CN fuels such as biofuels become more widely utilized, this trend will continue toward 2050.
- Even when the decarbonization of the power sector is accelerated in the future, **PHEVs' life cycle emissions will be lower than or almost equivalent to BEV's** in 2050. (Advanced Tech Case).

Life cycle GHG emissions per a passenger vehicle (tCO₂eq/Vehicle Lifetime)

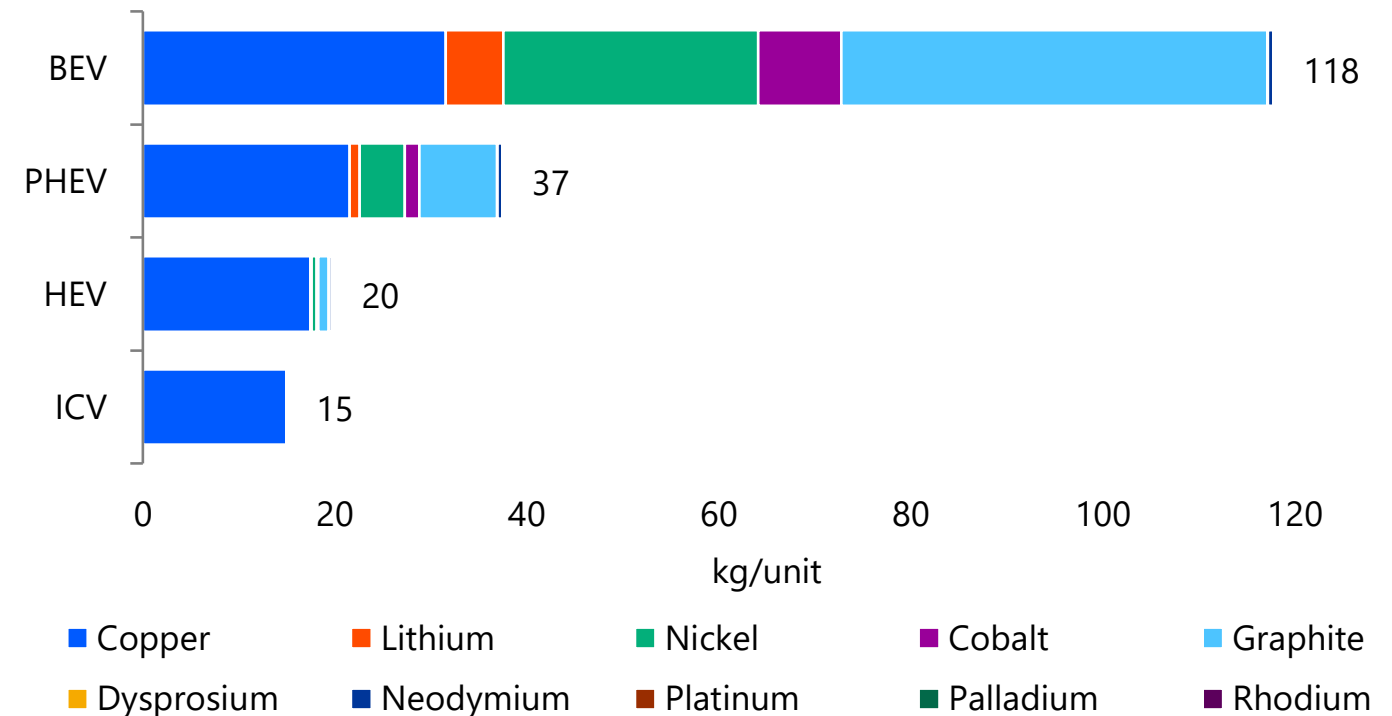


※Well to Tank does not include GHG emitted by transporting fuels.
A passenger vehicle is assumed to be produced and disposed domestically.

Critical minerals used in BEVs are approximately 6 times and 3 times that of HEV and PHEV respectively

- The combination of powertrains such as HEV/PHEV and sustainable fuels will greatly reduce the demand for critical minerals, contributing to enhancing national security.
- When BEVs are diffused, supply and demand balance of critical mineral can be an issue and costs of BEVs have a risk to rise.

Amount of critical minerals used in each powertrain(kg/unit)

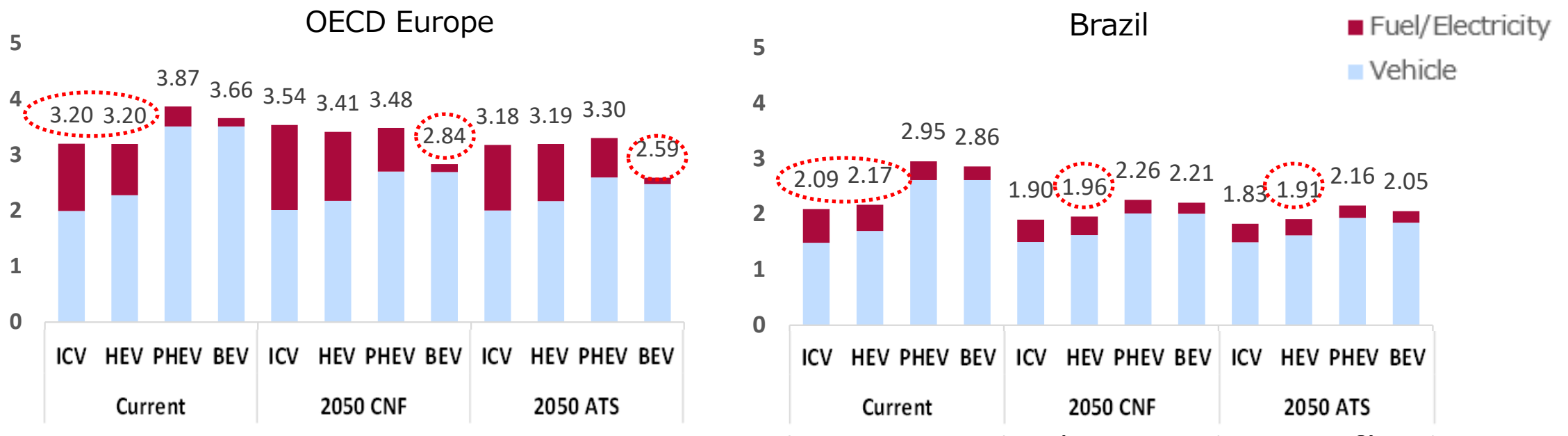


Source: Japan Organization for Metals and Energy Security (2022)
"Critical minerals supply and demand toward achieving carbon neutral" (in Japanese)

Total Cost of Ownership also varies by country/region

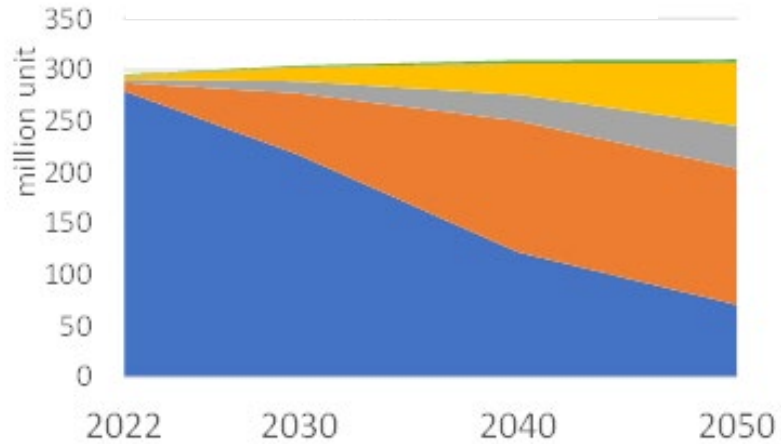
- Aside from the cost of vehicles, **energy prices (electricity and fuel)** are the important factors affecting the cost of vehicle ownership.
- **OECD Europe** : Total Cost of Ownership (TCO) of ICVs and HEVs are lower than PHEVs and BEVs now. BEVs become the lowest in 2050 because oil prices become relatively higher than electricity prices in addition to expected decline of BEV prices.
- **Brazil** : **HEV's TCO is expected to continue to be lower than BEV** until 2050, assuming the continued provisions of economic incentives for ethanol.

Total Cost of Ownership of a passenger vehicle (USD 1,000/year)

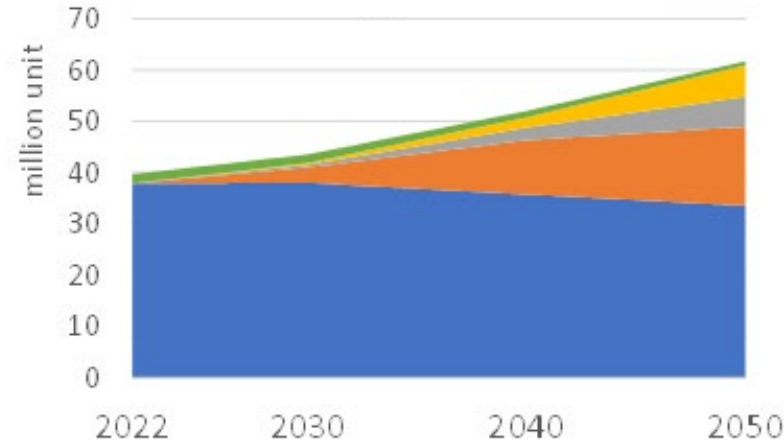


Assumptions on stocks by powertrain

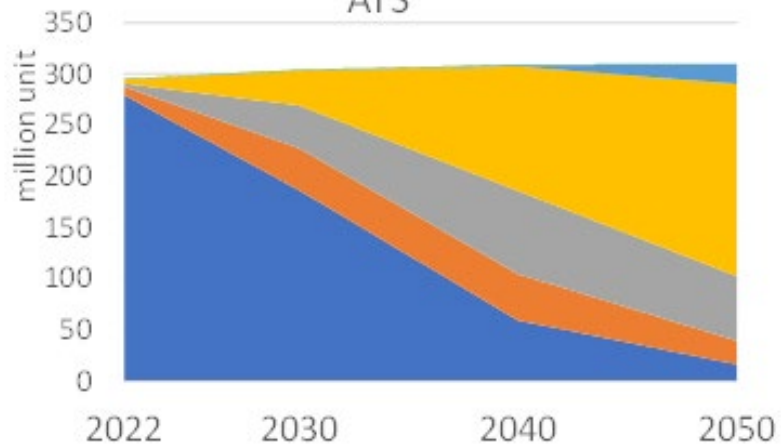
OECD Europe
REF/CNF



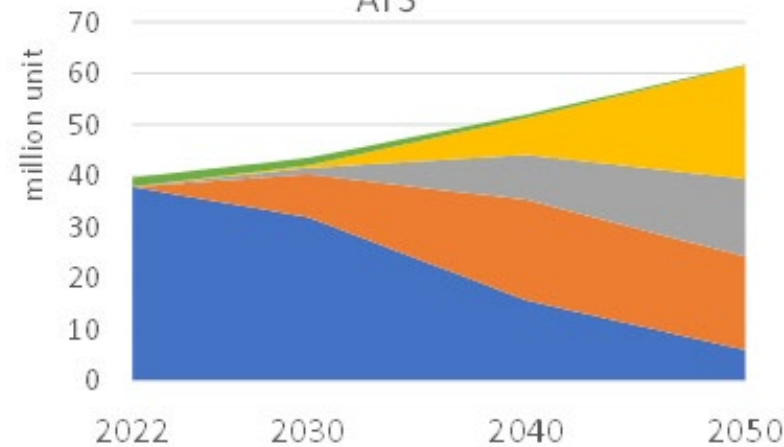
Brazil
REF/CNF



ATS

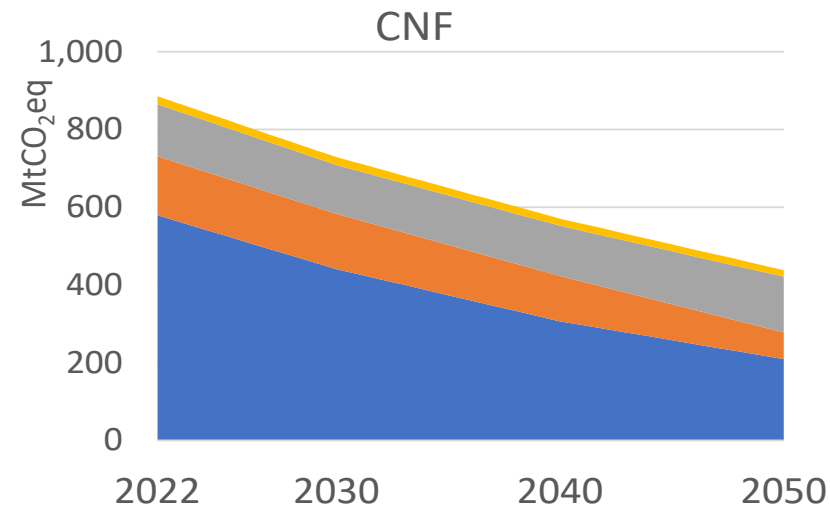
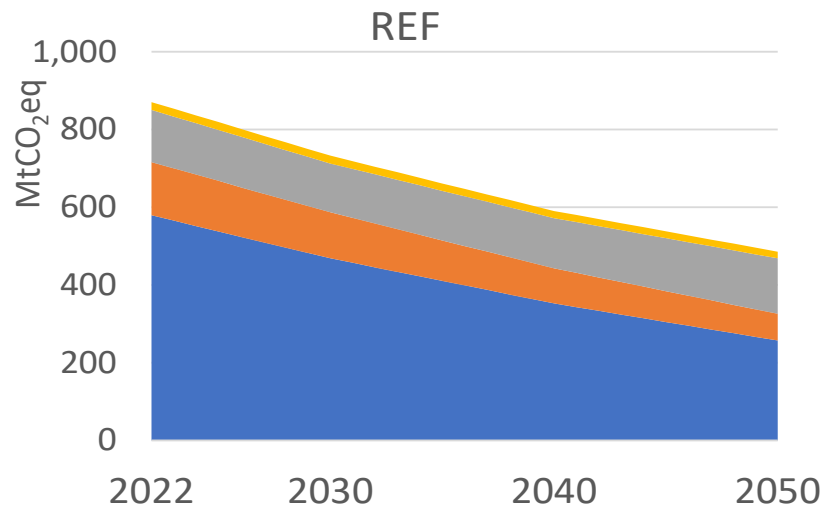


ATS

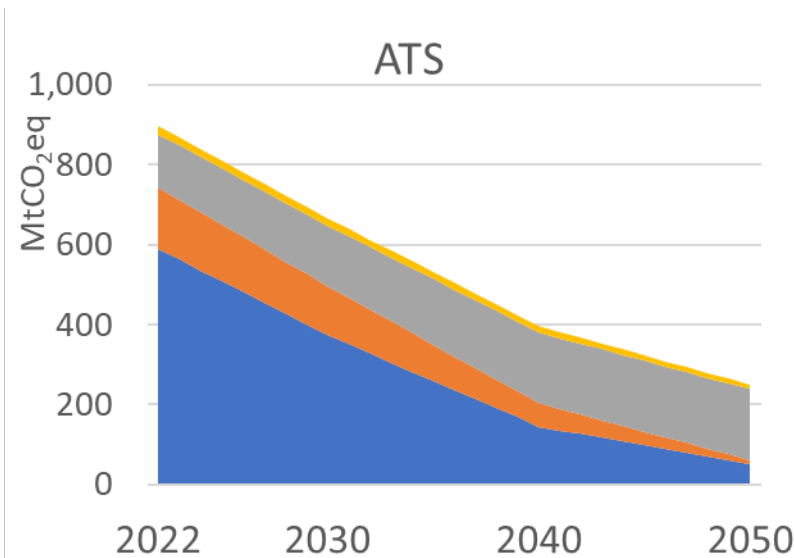


- NGV
- FCV
- BEV
- PHEV
- HEV
- ICV

Total GHG emissions of LCA (OECD Europe)



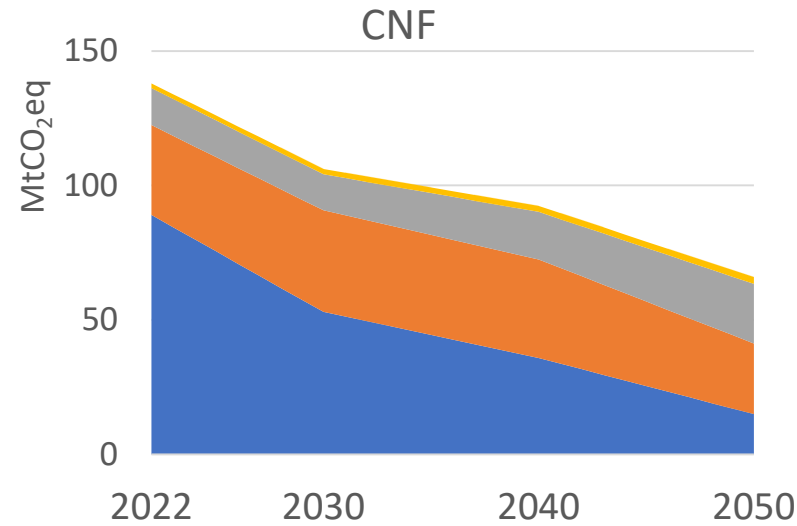
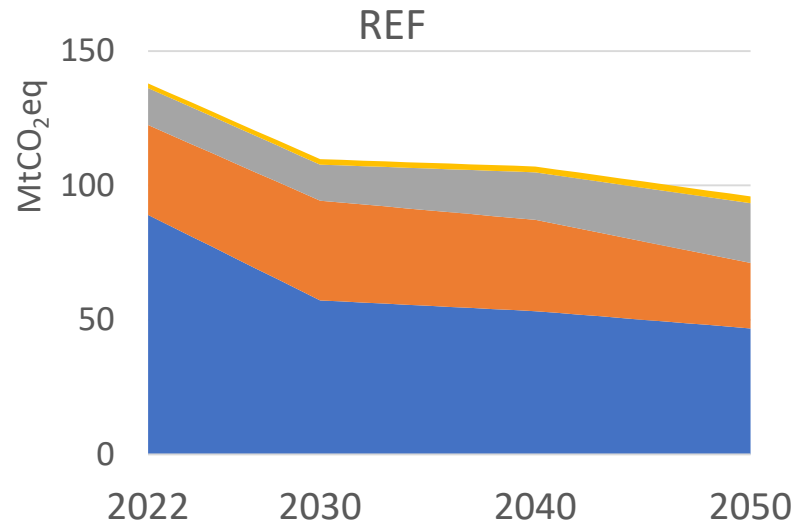
- Disposal
- Production
- WtT
- TtW



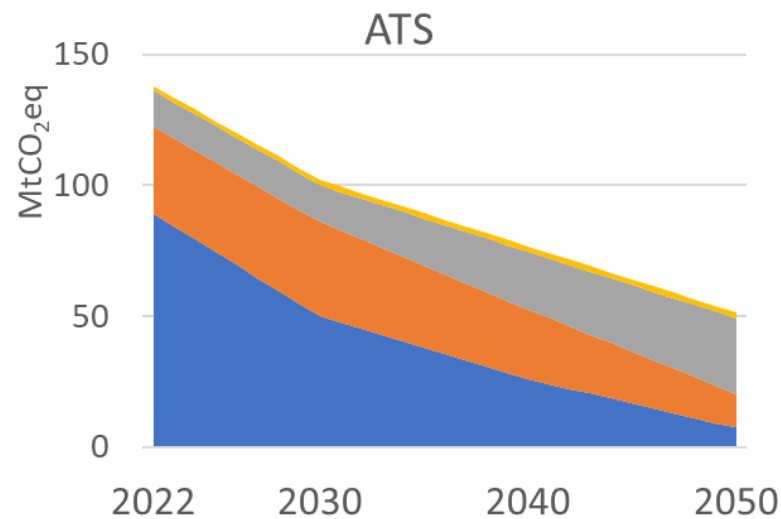
In OECD Europe, due to limited supply potential of CN fuels, the difference between REF and CNF is marginal.

The wide-spread BEVs and decarbonized electricity will reduce the WtW emissions significantly, but the GHG emissions from manufacturing BEVs will increase.

Total GHG emissions of LCA (Brazil)



- Disposal
- Production
- WtT
- TtW



Brazil has sufficient supply potential of CN fuels; the land used for ethanol production in Brazil is just 1% of its total national land area.

Accordingly, CN fuels alone will significantly contribute to the GHG emissions reduction.

Automobile Decarbonization Policies of the Selected Countries

	Policies
Brazil	<ul style="list-style-type: none"> • Blending targets; E27.5 (2024) to E30 (2025), and B14 (2024) to B15 (2025) • Mover (National Green Mobility and Innovation Program); introduced WtW standard for calculating CO2 emissions, and plan to introduce LCA after 2027.
India	<ul style="list-style-type: none"> • Blending targets; E20 (2025-26). Guaranteed pricing, long-term ethanol contracts, and technical standards and codes. • Set a goal of new car sales share of EV at 30% by 2030. Various incentives under FAME II (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India), spurring the growth trends of both two-wheelers and three-wheelers.
Indonesia	<ul style="list-style-type: none"> • Blending targets; E5/E10(2024) to E20(2025), and B35 (2024) to B40 (2025). The Government subsidizes the price gap between biofuels and gasoline or diesel. • Prohibit the sale of gasoline-powered two-wheelers by 2040 and plan the ban on the sale of internal combustion engine vehicles (ICV) by 2045.
Thailand	<ul style="list-style-type: none"> • Blending; E10, E20 and E85 are available at petrol stations. • Set a target to raise the EV share in domestic vehicle production to at least 30% by 2030 (EV 30@30 Policy). EV 3.5 program provides subsidies, excise tax reductions, and import tariff reductions to manufactures on conditions that they produce domestically at least twice the number of imported EVs from 2026, and if production begins in 2027, at least three times that number.

Conclusions

- In the pathways toward decarbonizing the road transport sector, sustainable fuels such as biofuels and e-fuels could play the roles as important as BEVs and fuel efficiency.
- The pathways for decarbonizing the road transport sector vary depending on national/regional circumstances.
- In countries like Brazil with high supply potential of CN fuels, CN fuels can contribute greatly to reducing LCA emissions on a powertrain basis as well as in the nation-wide transport sector.
- It is worth noting that as the battery production is the most electricity intensive process in the entire BEV manufacturing, how to decarbonize the electricity source at the site of battery production is critically important to lower LCA emissions.
- Through deepening this LCA analysis on the road transport sector, the IEEJ would like to contribute to the discussions on sustainable fuels toward COP30.