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IEEJ Outlook 2025
LCA analysis for automobiles
:Selection of appropriate powertrain for each country and region

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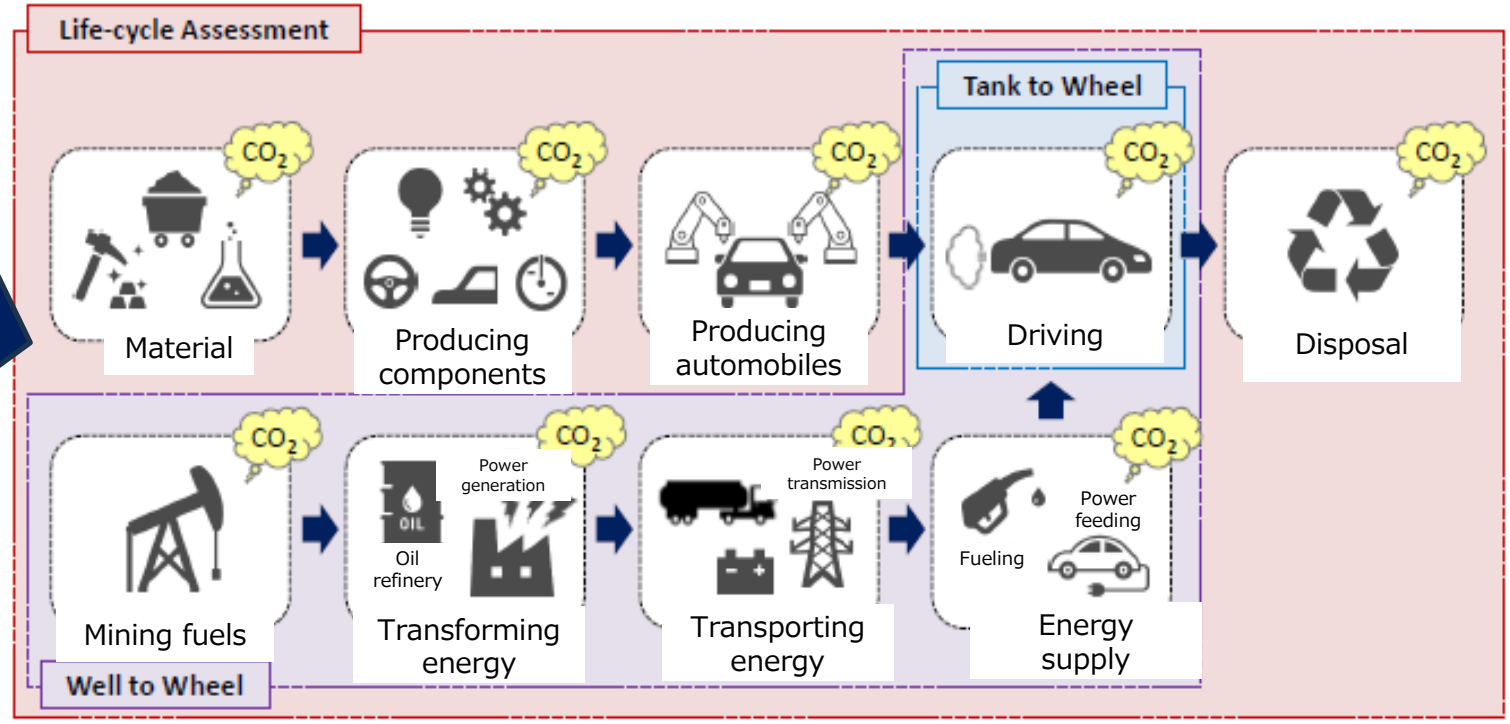
LCA analysis for automobiles by powertrain type

- In estimating the GHG emissions from automobiles by powertrain type, Life-Cycle Assessment (LCA) can offer a fair evaluation including indirect emissions.
- LCA analysis can offer country/region specific different perspectives for the GHG emissions from automobiles by powertrain.

Powertrain type

1. ICV (Internal Combustion engine Vehicles)
2. HEV (Hybrid Electric Vehicles)
3. PHEV (Plug-in Hybrid Electric Vehicles)
4. BEV (Battery Electric Vehicles)



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

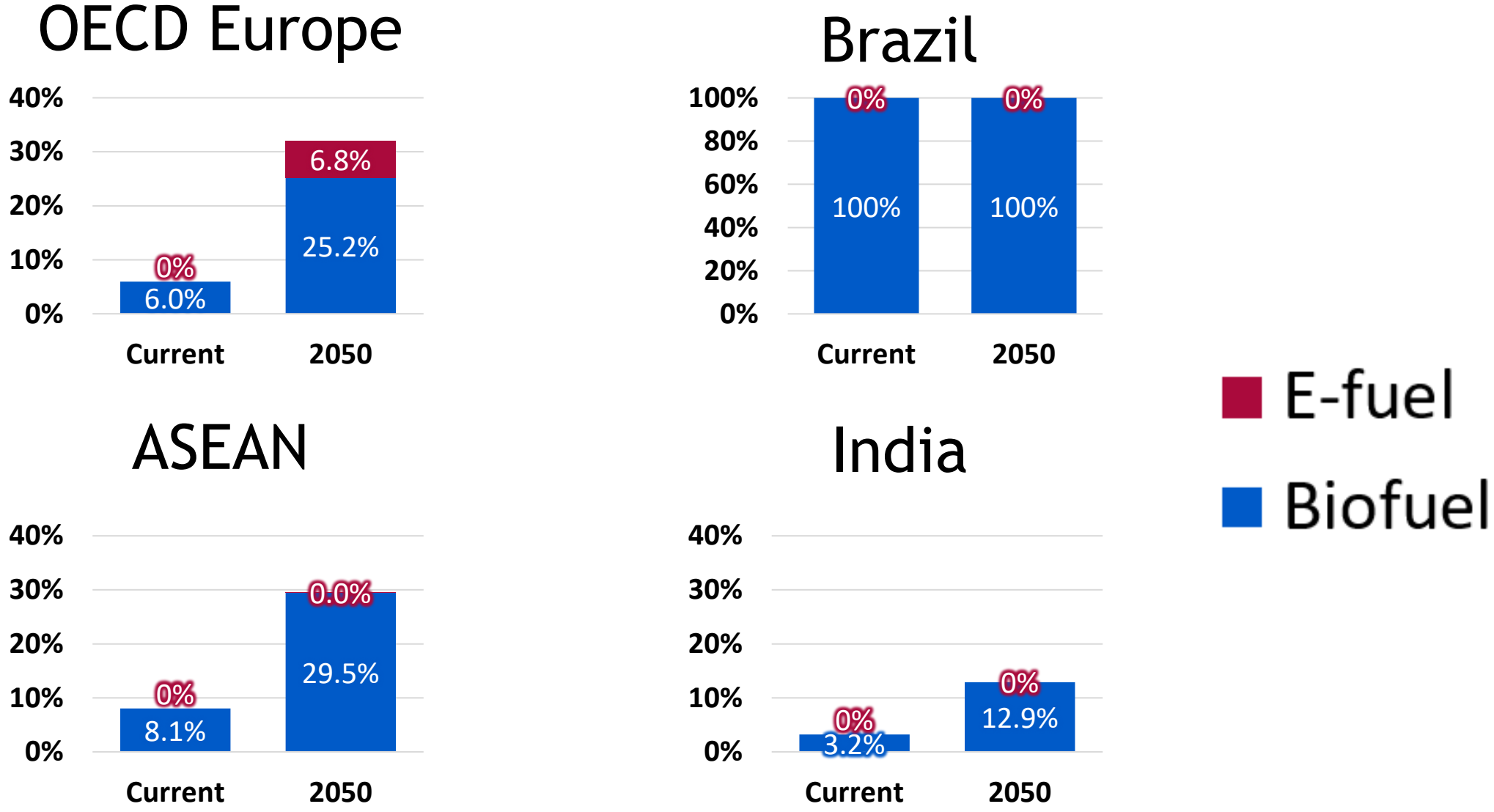
Cases of LCA analysis for automobiles

- Two key factors toward reducing the GHG emissions from automobiles
  - Carbon neutral (CN) fuels blending ratio
  - Zero emissions vehicle + low carbon electricity

IEEJ Outlook 2025	Reference Scenario (Ref)	Advanced Technologies Scenario (ATS)
	Reflects past trends with technology progress and current energy policies, without any aggressive policies for low-carbon measures	Assumes introduction of powerful policies to address energy security and climate change issues with the utmost penetration of low-carbon technologies

LCA analysis for each powertrain type	CN fuel blending ratio (Biofuel+e-fuel)	Power generation, fuel prices, etc.
CN Fuel Promotion (CNF)	ATS	Ref
Advanced Technologies (ATS)	ATS	ATS

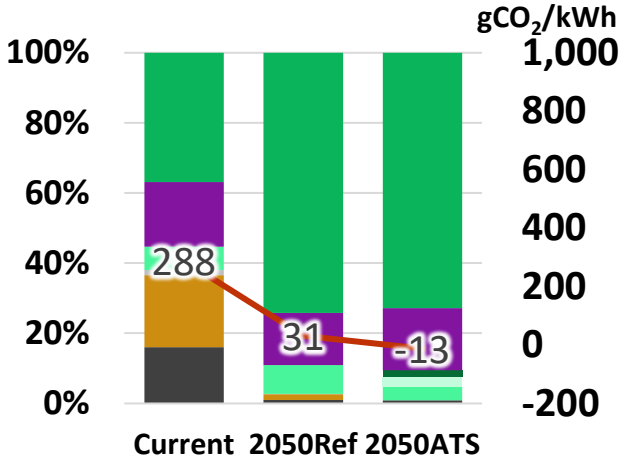
Assumption of CN fuels blending ratio



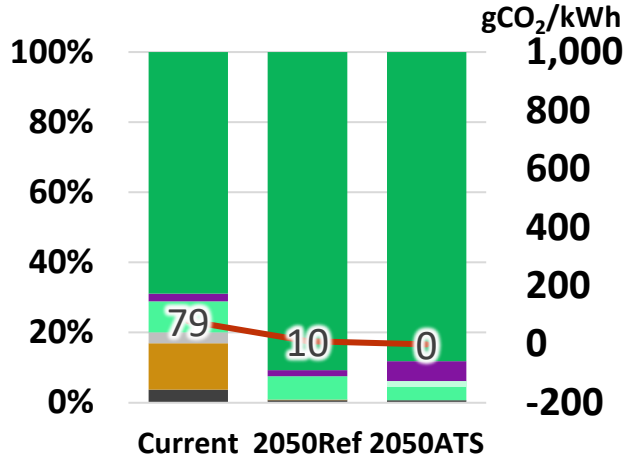
※The CN fuels blending ratio is calculated CN fuel consumption divided by liquid fuel consumption in road sector
※CN fuels blending ratio is assumed E100 in case of Brazil

Assumption of power generation mix and CO_2 coefficient for electricity

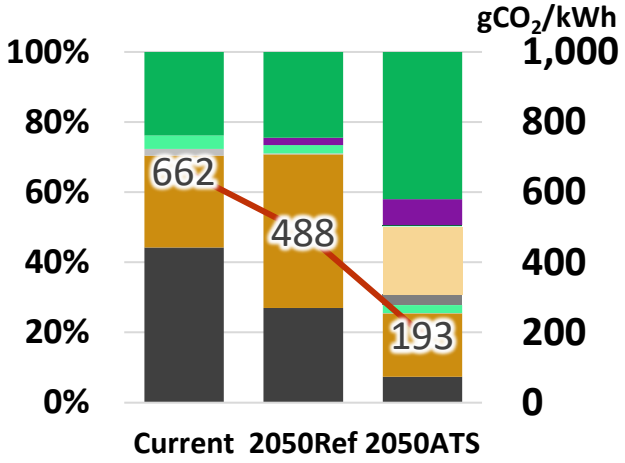
OECD Europe



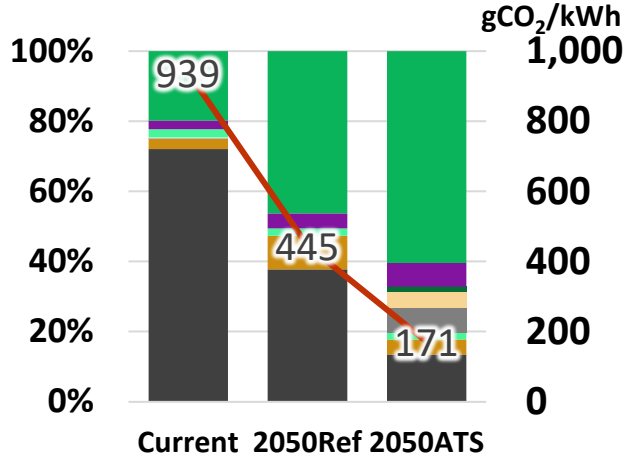
Brazil

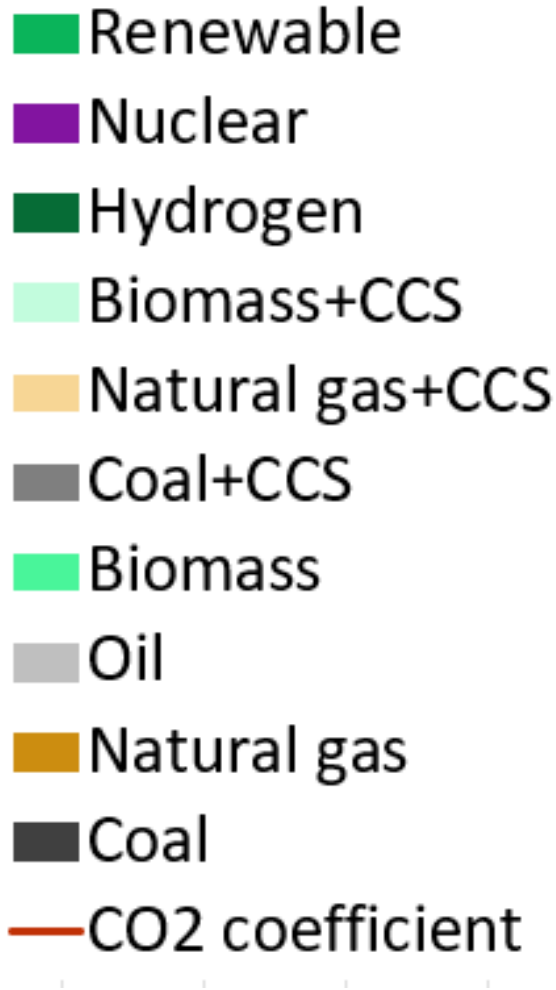


ASEAN



India

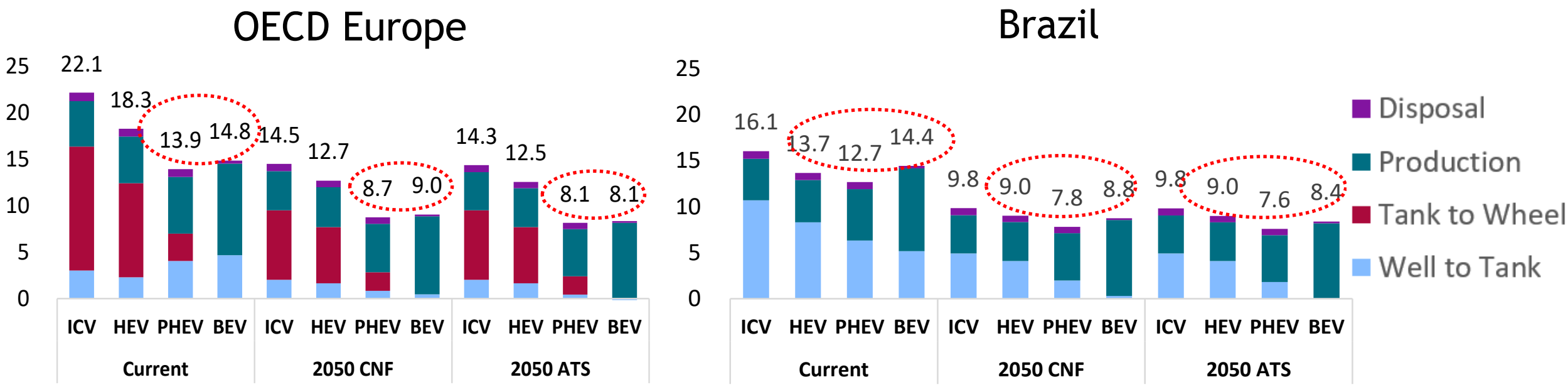




GHG emissions vary by country/region

- In OECD Europe, PHEV's life cycle emissions represent the lowest level, followed closely by that of BEV.
- In Brazil, the life cycle emissions of HEVs and PHEVs are expected to be almost equivalent to and lower than BEVs in 2050.

Life cycle GHG emissions per a passenger vehicle (tCO_2eq/Vehicle Lifetime)

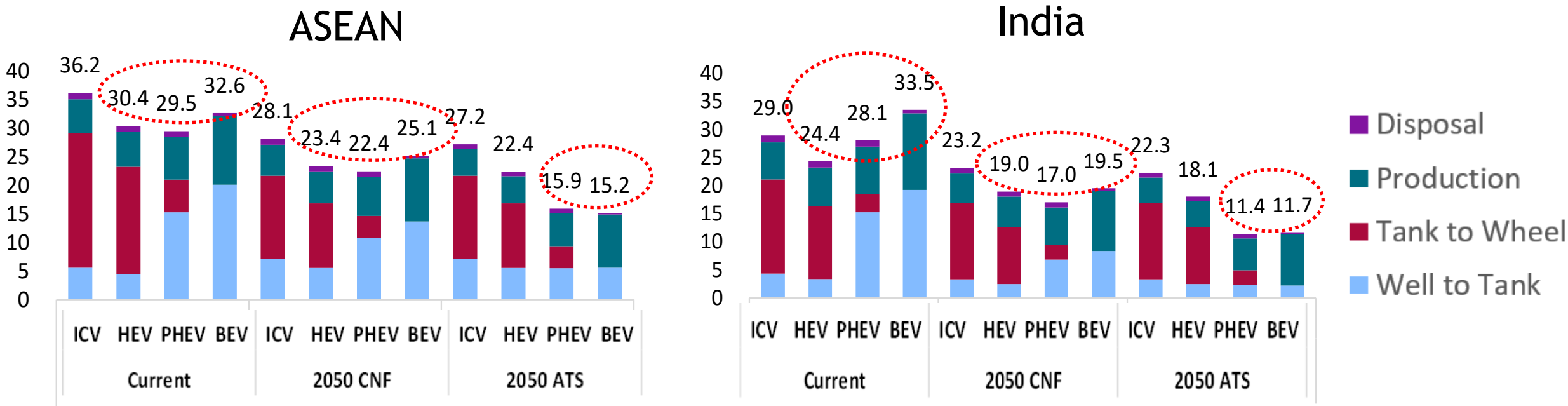


※Well to Tank does not include GHG emitted by transporting fuels.
For production and disposal, Greet model 2021ver. is referred. For electricity consumption, CO_2 intensity in the power generation of country is applied.as a passenger vehicle is assumed to be produced and disposed domestically.

Combing HEVs/PHEVs with CN fuels is a key option in ASEAN and India

- In ASEAN and India, life cycle emissions of HEVs/PHEVs are lower than BEVs in 2050 CNF.
- PHEVs' life cycle emissions will be almost equivalent to BEVs' in 2050 ATS.

Life cycle GHG emissions per a passenger vehicle (tCO_2eq/Vehicle Lifetime)



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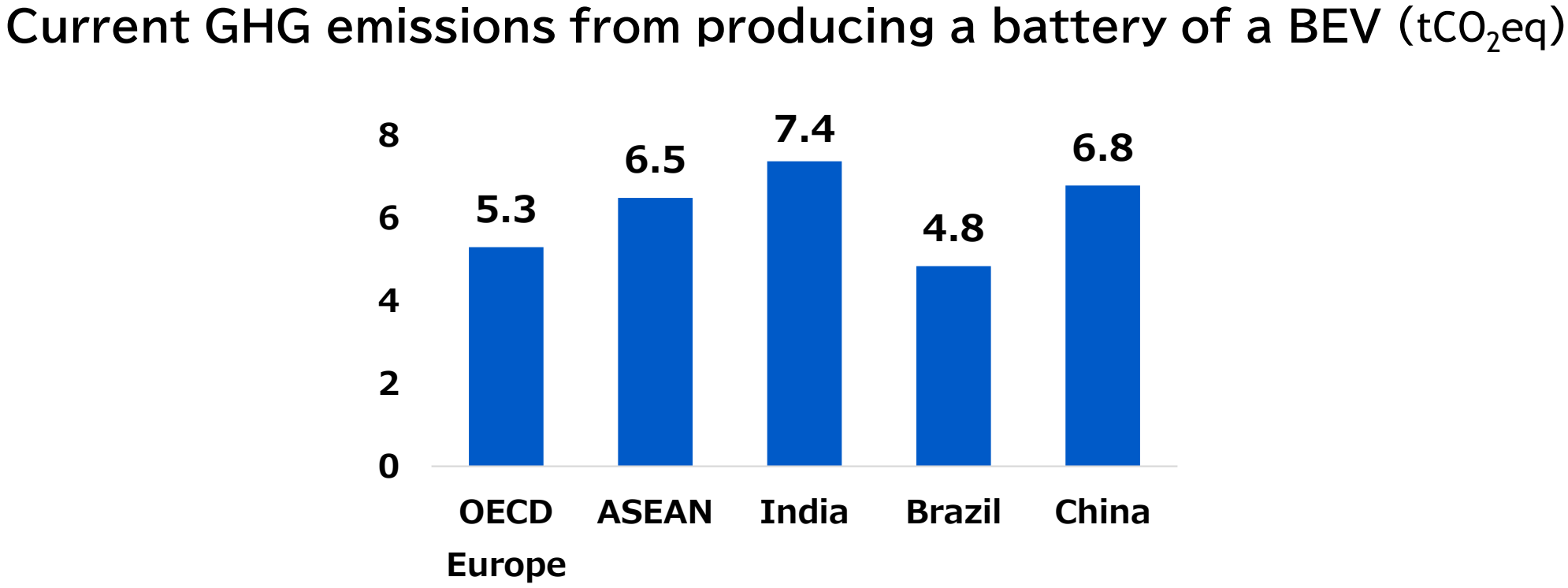
GHG Emissions vary depending on where a battery of BEV is produced

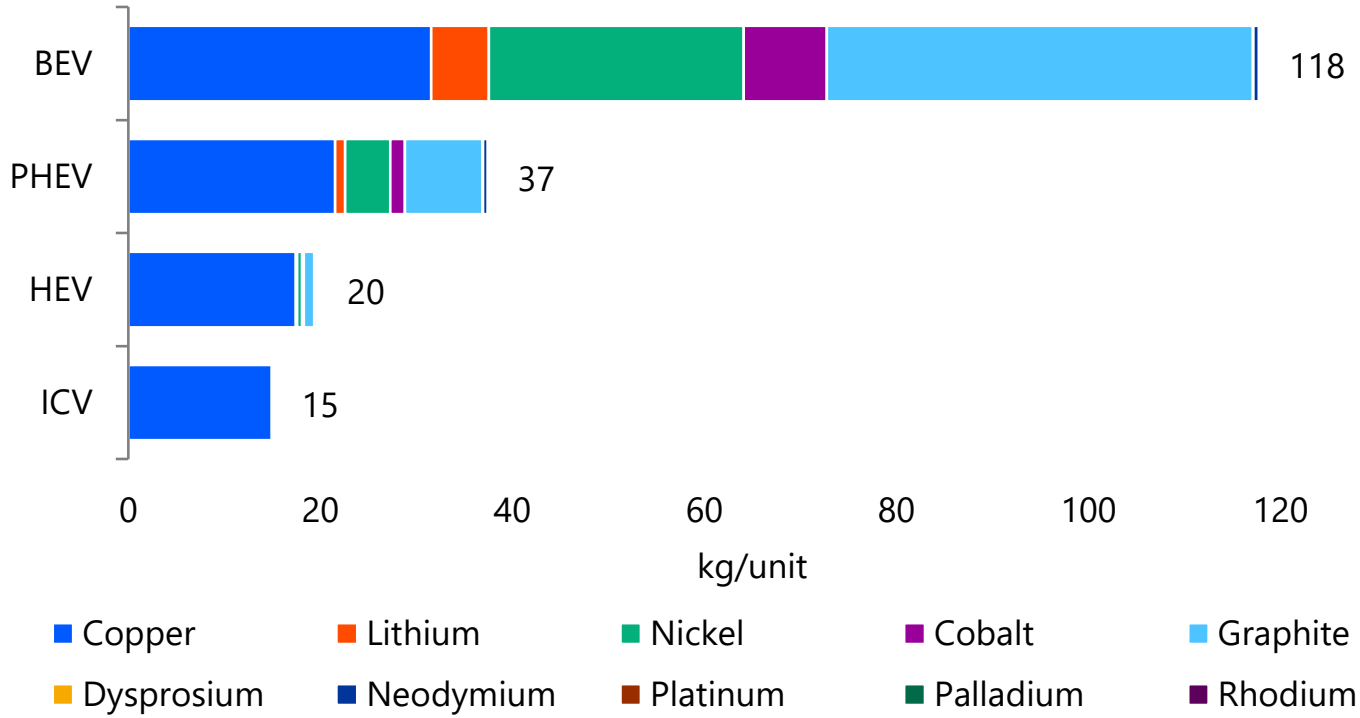
If Brazil imports batteries from China, battery-related emissions will increase by 1.4 times.



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

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)

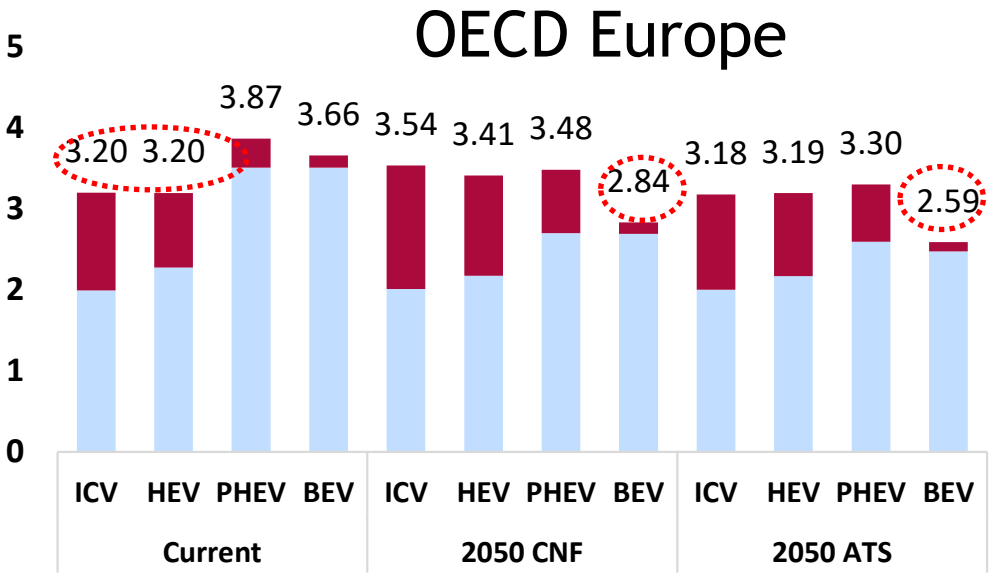


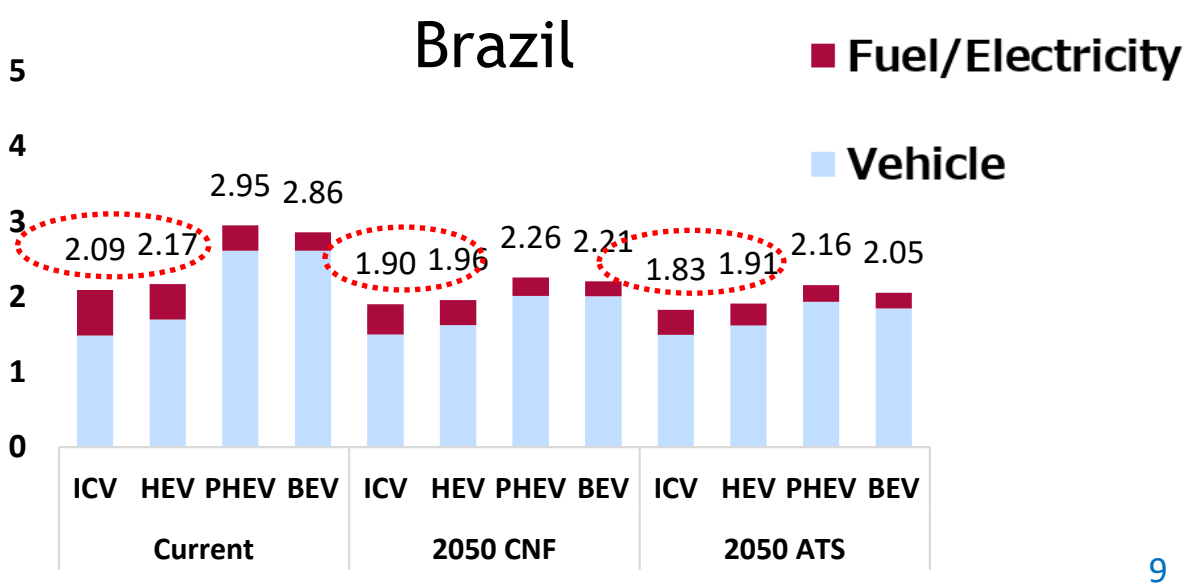
Source:Japan Organization for Metals and Energy Security (2022) "Critical minerals supply and demand toward achieving carbon neutral" (in Japanese)

Total Cost of Ownership also varies by country/region

- In OECD Europe, in 2050, Total Cost of Ownership (TCO) of BEVs become the lowest because oil prices become relatively higher than electricity prices in addition to expected decline of BEV prices.
- In Brazil, ICV and HEV's TCO is expected to continue to be lower than BEV until 2050.

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

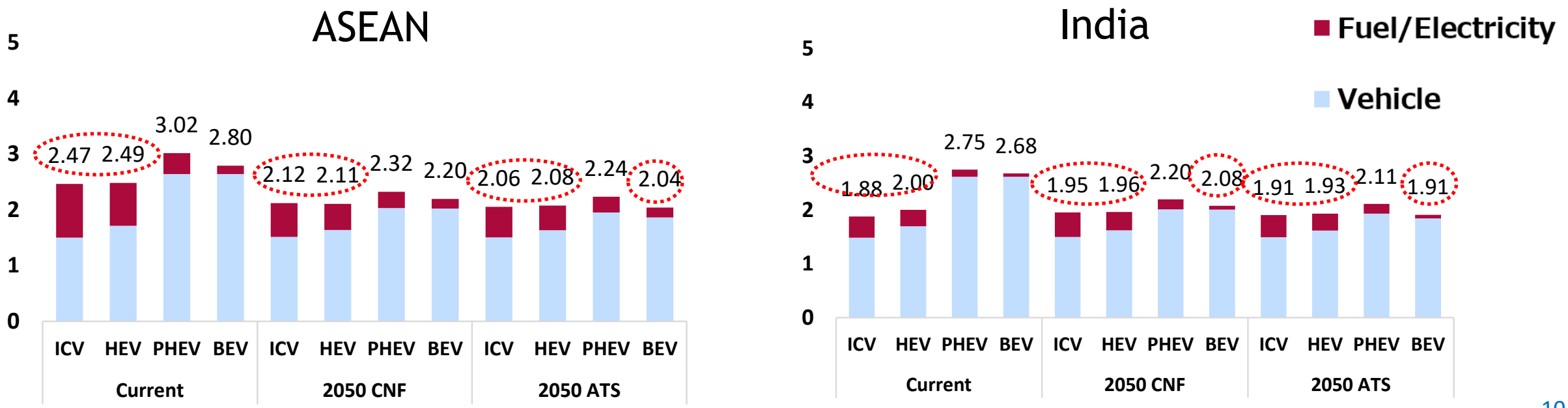




Total Cost of Ownership also varies by country/region

- In ASEAN and India, the TCO of ICVs and HEVs will be lower than that of BEVs in 2050 CNF and almost the same in 2050 ATS because oil prices are relatively lower than electricity price.

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



Implications

- In the pathways toward decarbonizing the road transport sector, **CN fuels** such as biofuels and e-fuels as one of the "**realistic solutions**“ as important as ZEVs such as BEV and higher fuel efficiency.

- The pathways for decarbonizing the road transport sector vary depending on national/regional circumstances, such as the **“Affordability” and “Availability” of powertrains, and CN fuels (such as biofuels).**

- It is worth noting that as the **battery production** is the **most energy 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.