IEEJ Outlook 2024

－How can various pathways toward energy transition be achieved?－

Yukari Niwa Yamashita
Managing Director
Institute of Energy Economics, Japan (IEEJ)

Contents

What is IEEJ Outlook 2024 ?

- Quantitative outlook of energy supply and demand in the world, toward 2050.

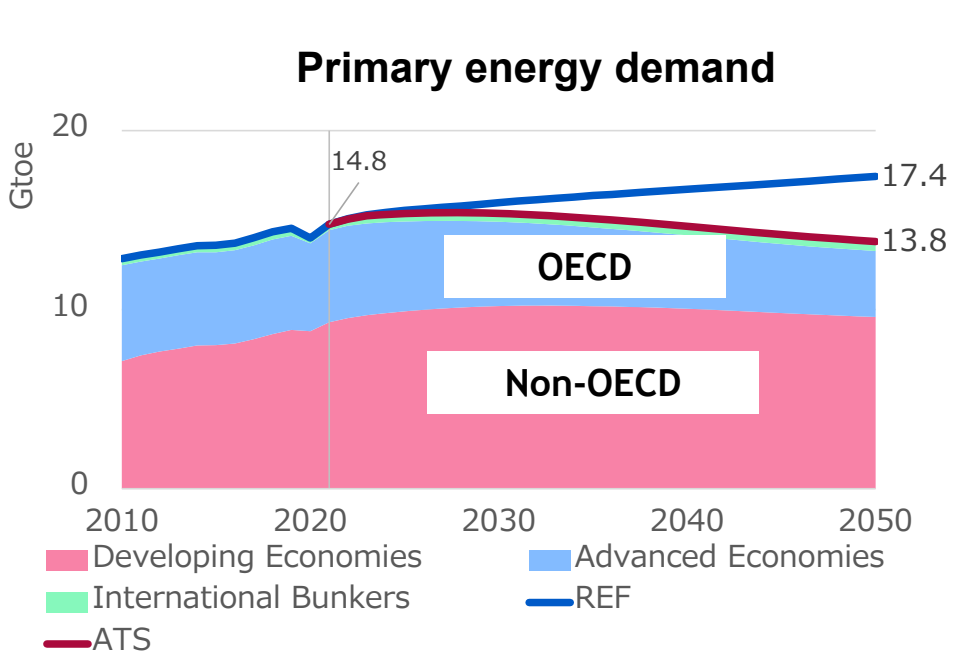
- Has two scenarios;

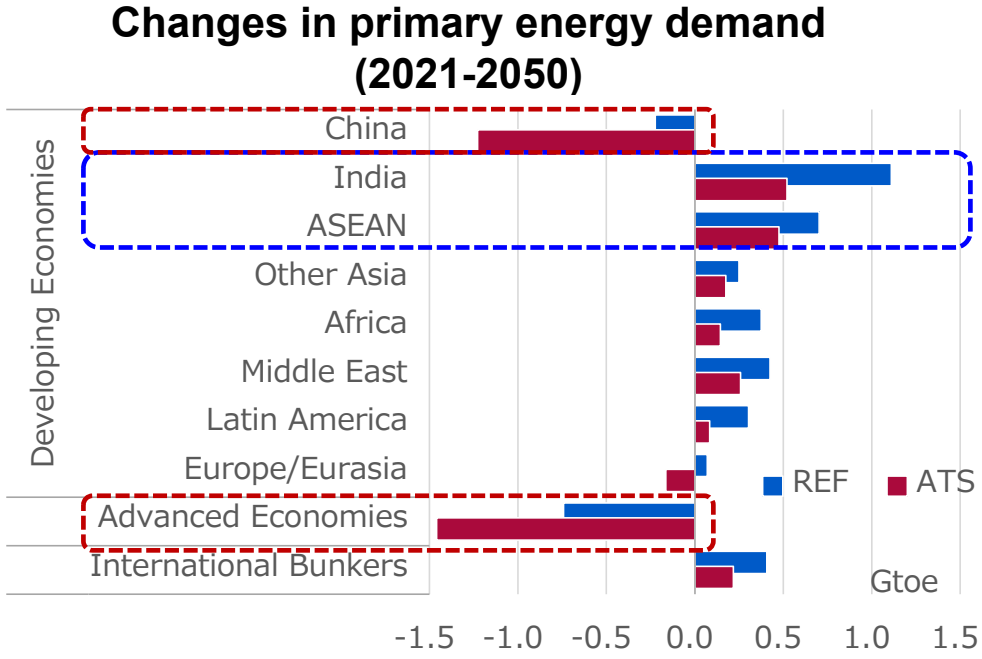
REF: (Reference Scenario)
the prevailing changes will continue against the backdrop of current energy and environmental policies

ATS: (Advanced Technologies Scenario)
Energy/environmental technologies are introduced to the maximum extent possible to ensure a stable supply of energy and strengthen measures against climate change

- **Forecast** analysis using econometric and other models.

Part 1: Global Outlook
Demand will grow significantly in Asia, Middle East, and Africa

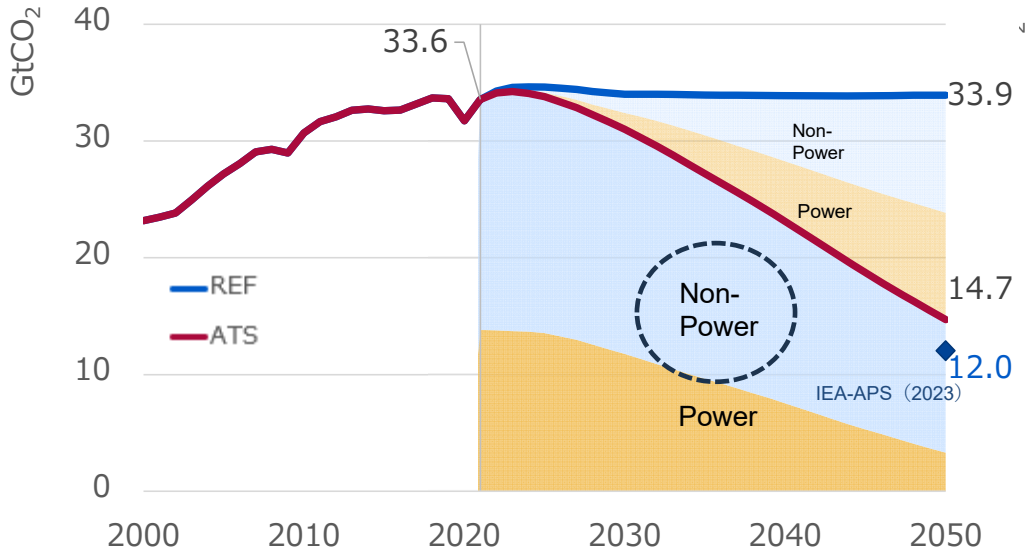




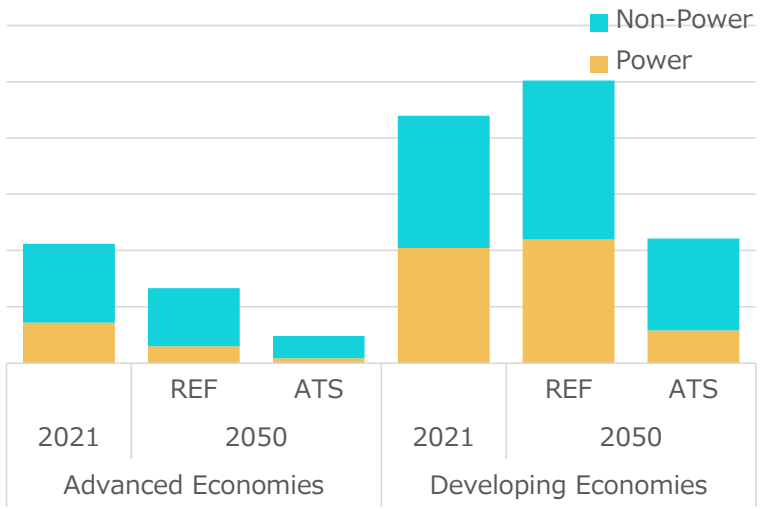
- (**REF**) Demand continues to increase with the current trend, reaching 1.2 times the current level by 2050.
- (**ATS**) Global demand peaks before 2030, however, India, ASEAN, the Middle East, and Africa will continue their demand growth.

Part1: Global Outlook　Power generation moves closer to CN. Decarbonization of non-power is a challenge.

Energy-related CO_2 emissions



CO_2 emissions by region

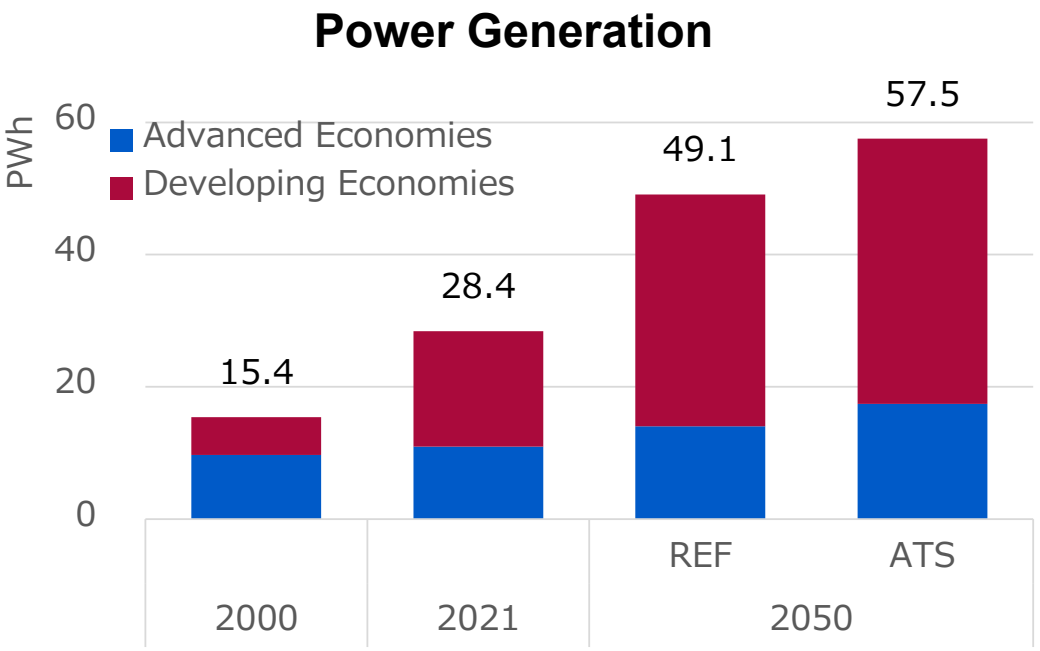


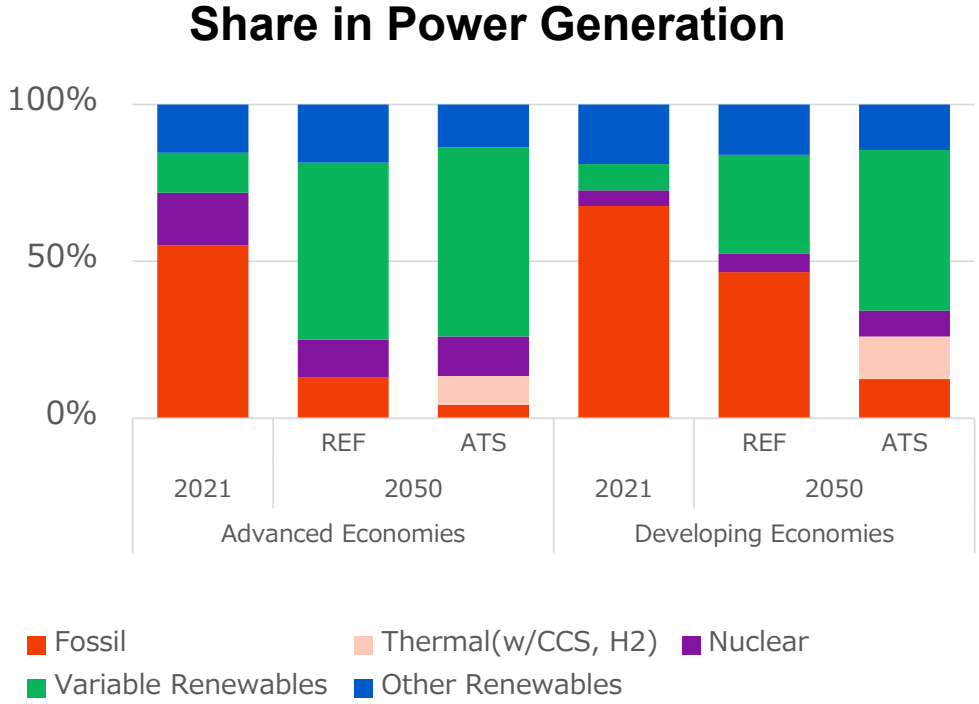
- （**REF**）CO2 emissions are nearly flat as increased demand is offset by lower CO_2 intensity.
- （**ATS**）The emission peaks out before 2030 and decline to 14.7 $GtCO_2$ in 2050 (56% below 2021).

It is still far from carbon neutrality, and decarbonization in the non-power sector and emerging and developing countries are significant challenges.

＊IEA-APS: Announced Pledges Scenario from IEA “World Energy Outlook 2023”

Part 1: Global Outlook　Power generation will be 1.7 to 2 times. Among them, renewable increase significantly.





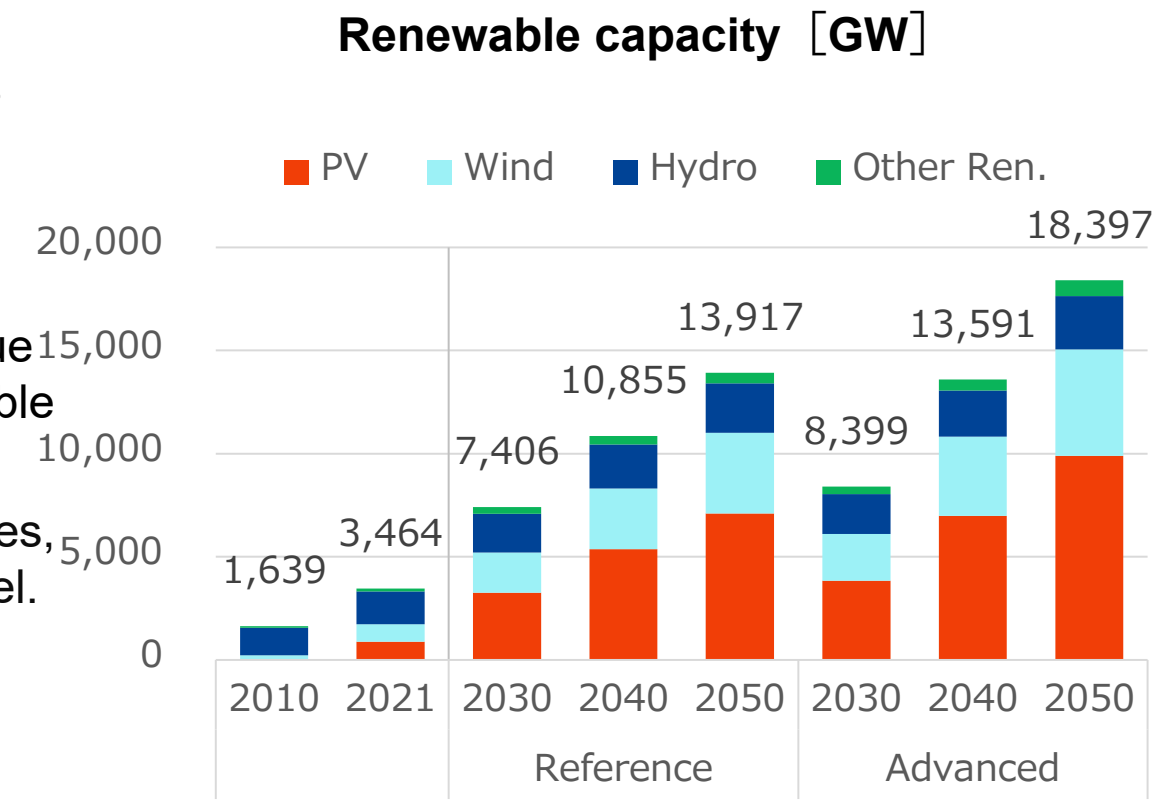
- (**REF**)　Power generation increases 1.7 times from current levels. Most of the increase is in developing countries, but also in developed countries as electrification progresses.
- (**ATS**)　Power generation doubles the current level. In addition to electrification progress, demand for green hydrogen is boosting demand. About 85% of power sources are decarbonized.

Part 1: Global Outlook　Renewable energy capacity will more than double by 2030 and continue the expansion.

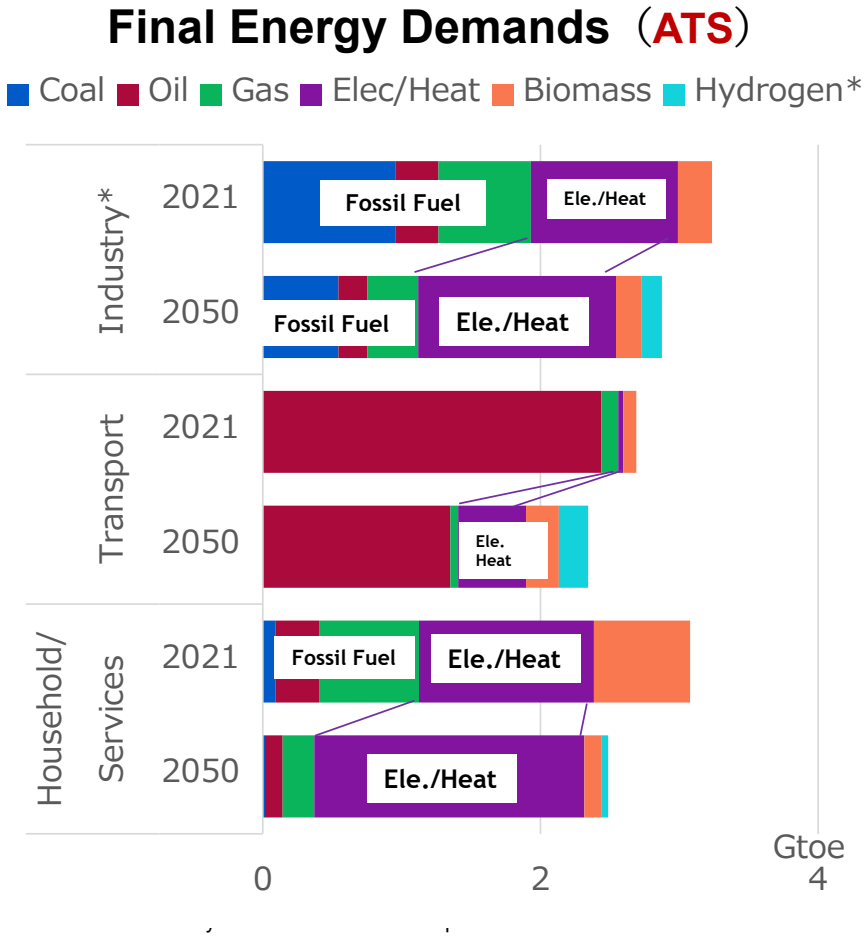
- Remarkable penetration of renewables continues. The installed capacity of renewable energy in 2030 is expected to be 2.0~2.4 times that of 2021.
- Increases will continue after 2030 under both scenarios;
- **(REF)** The expansion will slightly slow down due to higher system costs and a decrease in suitable locations.

  (ATS) Renewable energy installation accelerates, increasing capacity to 5.4 times the current level.

Particularly, solar PV and wind will be nearly 10 times the current capacity. Both daily and seasonal storage will be essential for a stable power supply.



Part 1: Global Outlook While electrification and hydrogenation proceed rapidly, the role of fossil fuels remains



**Hydrogen includes ammonia and synthetic fuel from H_2.

- Industry

Fossil fuels remain due to the difficulty of substitution in heat demand at higher temperatures. (especially for steel and cement).

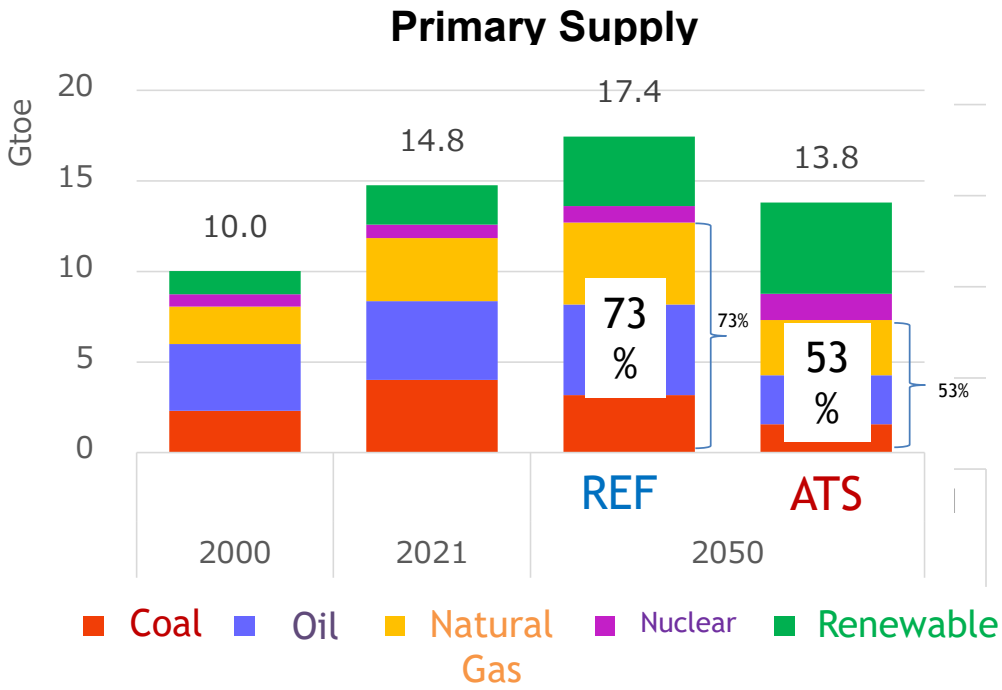
- Transport

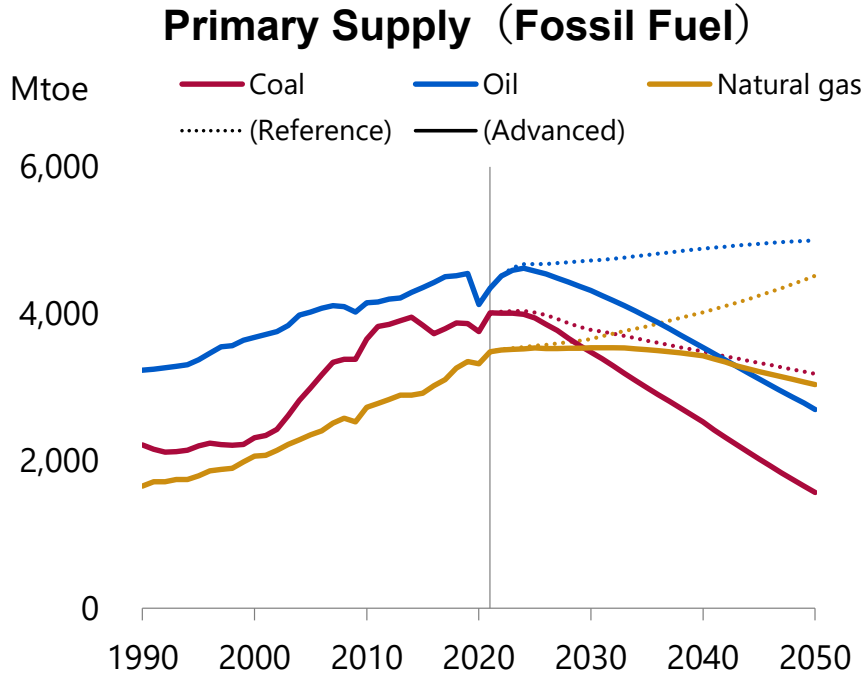
ZEVs (EVs + H_2 FCVs) are largely penetrating in the automobile subsector. They account for 60% of the passenger cars fleet and 47% of the trucks and buses.

- Others (Household and Services)

Significant electrification of both service subsectors and homes (often substituting from traditional biomass).

Primary oil and gas supply increases in Reference, and decreases in Advanced Tech..





- **(REF)** Primary supply in 2050 increases 1.2 times that of 2021, 73% of which will be fossil fuels. Oil demand increases 1.2 times and gas 1.3 times, while coal decreases 0.8 times.
- **(ATS)** Half of the primary supply is fossil fuels, and the other half is renewable and nuclear.

  Oil and coal supply peaks in the 2020s because of a decrease in transportation demand for oil and power generation demand for coal. Gas supplies remains flat until the 2030s and begin to decline before 2040.

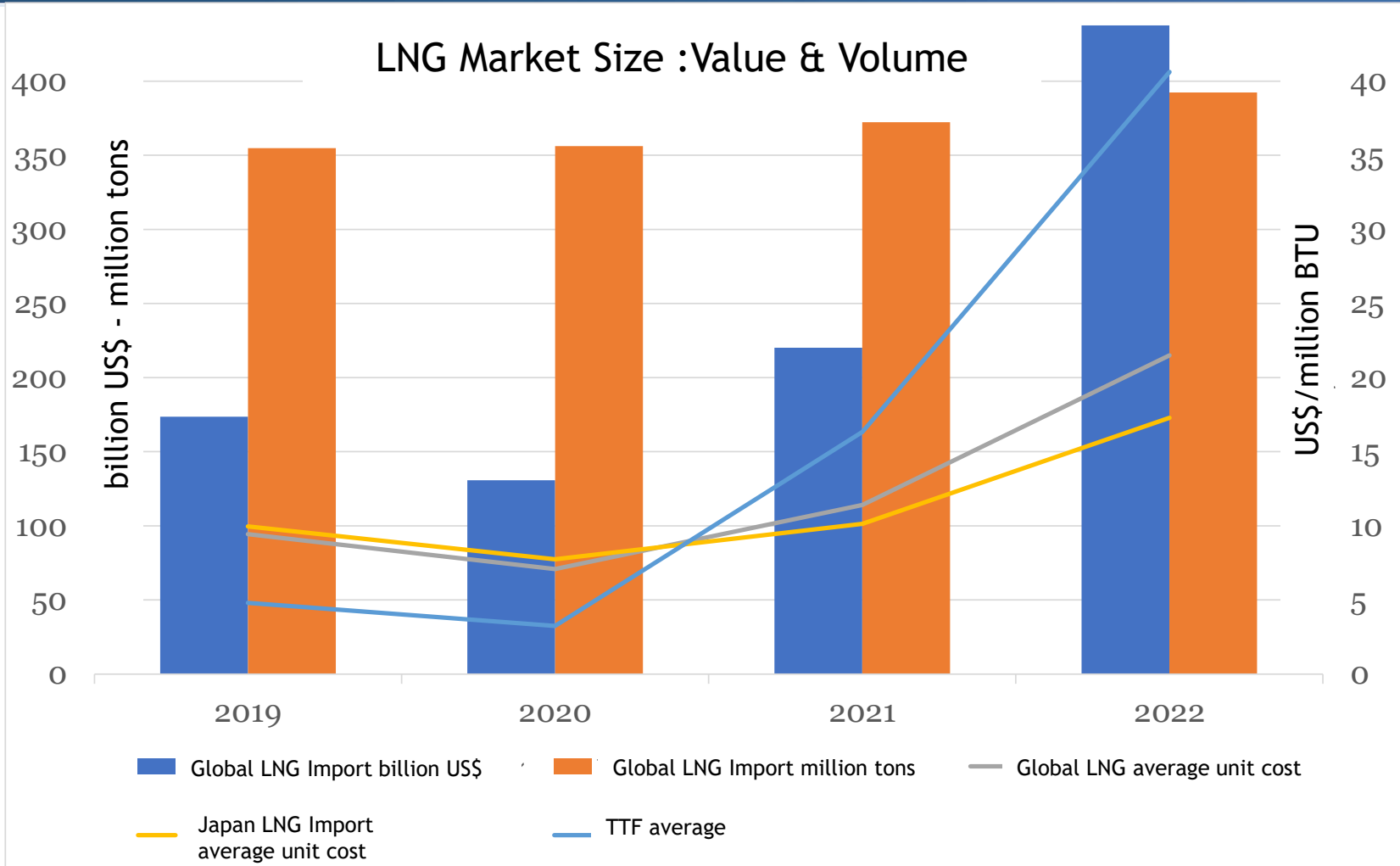
Part 1: Global Outlook
Conclusion

- India, ASEAN, Middle East, and Africa will be the center of demand growth in both scenarios.
- Emissions in the Reference scenario remains flat, and those from the Advanced Technologies scenario are halfway from reaching carbon neutrality. The remaining emissions are mainly from the non-power sector and the developing countries. To further cut emissions will remain a difficult challenge.
- Power generation doubles in the next three decades due to factors such as economic growth, electrification, and demand for green hydrogen. As variable renewable covers a large part of electricity, storage and dispatchable power are key to a stable electricity supply.
- In 2050, fossil fuels account for 73% of primary supply in Reference scenario and 53% in Advanced Technologies scenario. The effort for a stable supply of fossil fuels must be continued.

Topic: To Achieve the Important Role of LNG and Natural Gas

The rapid rise in prices resulted in a more significant expansion of the LNG market in terms of the total amount than the volume

- ✓ The LNG market experienced a steady growth in the volume wise in 2022
- ✓ The paid amount doubled in 2022, in a stark contrast against 2020 when the amount decreased significantly
- ✓ The economic value of the market is expected to shrink in 2023 due to lower LNG prices



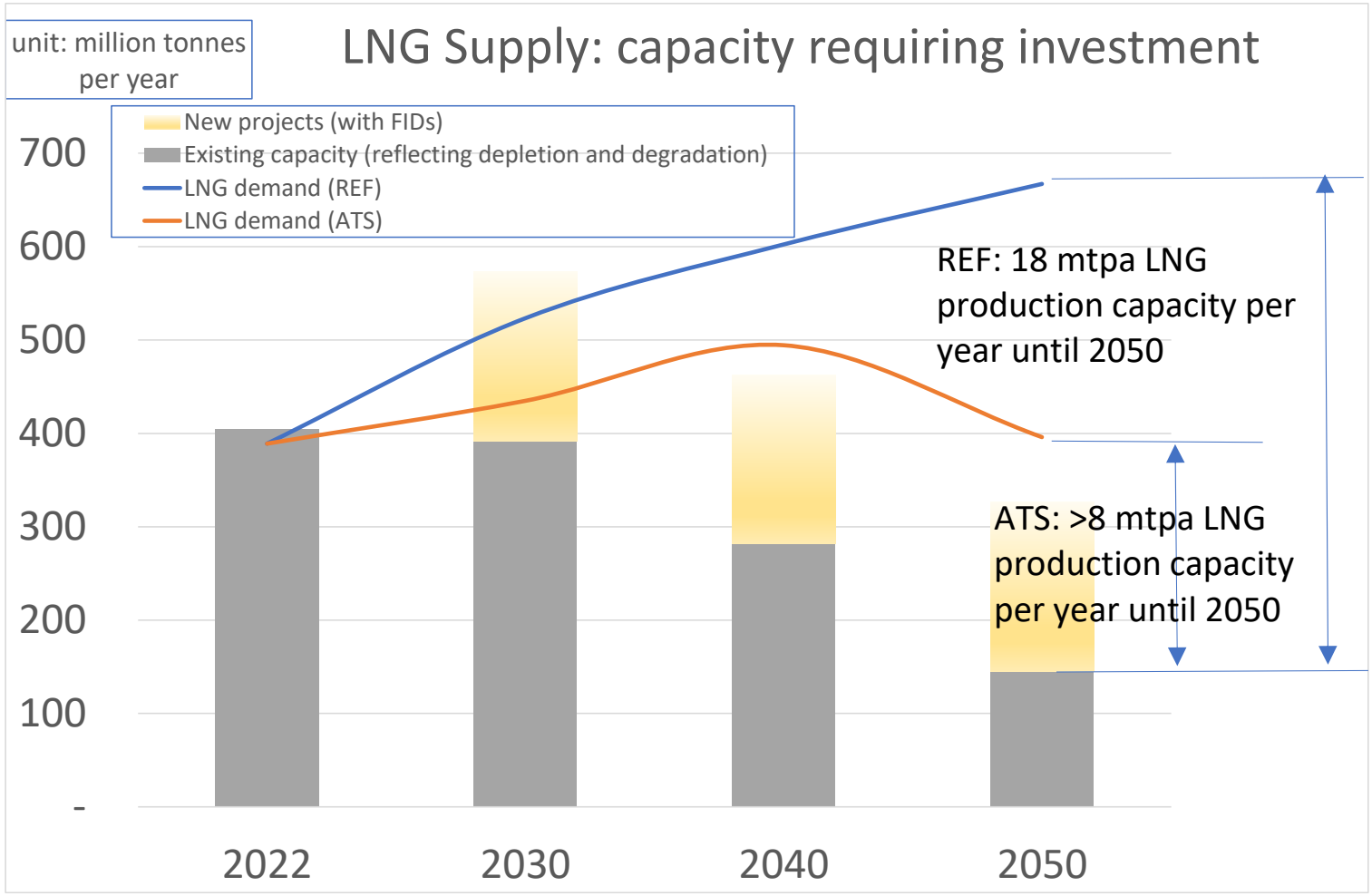
Source: Estimated using GIIGNL, Global Trade Atlas, Trade Statistics, and ICE data

Investment is needed to meet incremental LNG demand, as well as replace depleting existing LNG production capacity

- Investment is needed in 8 - 18 mtpa LNG production capacity per year until 2050
- Required additional capacity investment means the gap between projected LNG demand and decreasing existing production capacity, to be filled by the followings:

1. Greenfield project investment
2. Alternative new field development (backfill) investment
   (the yellow stack indicates already sanctioned projects)
3. Investment in existing fields to offset production decline
4. Rejuvenation of existing liquefaction facilities

✓ *Those projects already greenlighted (included in the yellow stacks) may entails uncertainty with possible delays and failures to materialise



Challenges to Long-Term Stabilization and Development of the LNG Market

	Points of focus and issues to be addressed from LNG-consuming countries
Supply side	Steady realization of the U.S. LNG project (will be the future source of supply). Expansion and maintenance of LNG projects from Australia, Canada, Mexico, etc. Realization of LNG projects in frontier regions of Africa Utilization of amortized LNG projects to contribute to market flexibility
Demand side	As the focus of demand growth shifts to developing countries, support from leading LNG consuming countries is important While the pursuit of flexibility in the LNG market is emphasized, it is necessary for the public and private sectors to formulate ways to secure stable demand and enable long-term commitments. Demand aggregation, portfolio player utilization, and joint procurement are required.
Pricing	The challenge is to find the right combination between crude oil linkage and the expanding gas hub price method linkage.
Environment	Clarification of LNG project standards that are compatible with the energy transition to decarbonization. Promotion of CC(U)S/Power Greening in LNG Liquefaction (LNG Greening)
Financial	Need a financing method to meet shorter contracts. As the market expands, it is important to support the creditworthiness of new buyers.

Electrification of automobiles and Synthetic Fuels (e-fuels)

***Note: The following abbreviations are used in this presentation:**

ICEV: Internal Combustion Engine Vehicles

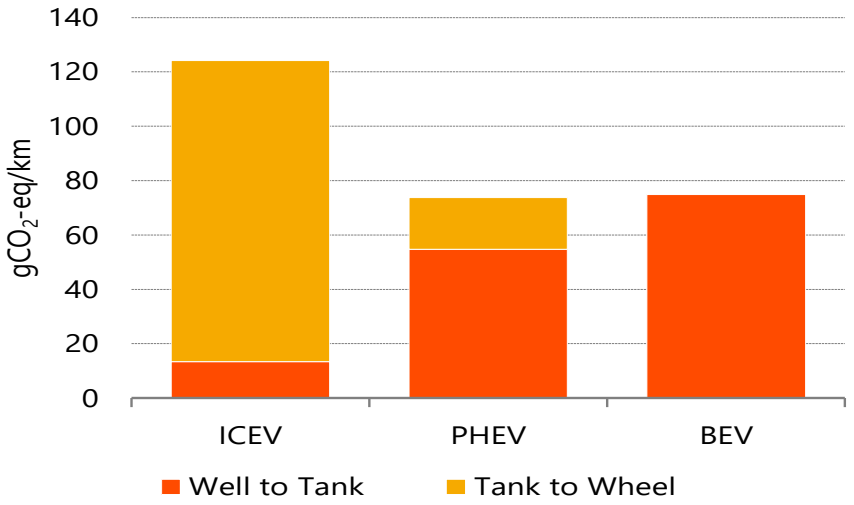
EV : Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs)

WtW: Well to Wheel (1) Well to Tank (2) Tank to Wheel

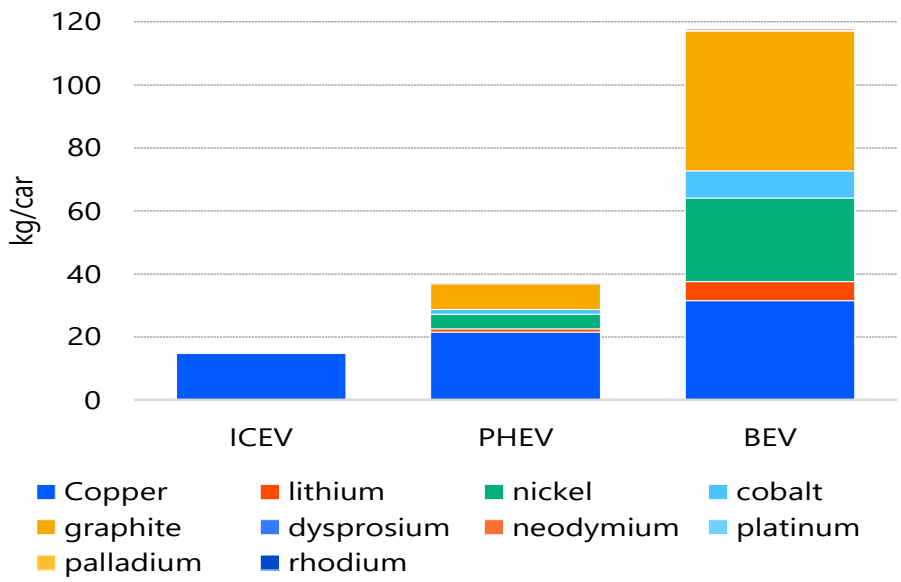
GHG emissions from EVs are lower than those of ICEVs, but bigger batteries require more critical minerals

- EVs accounted for 14% of global vehicle sales in 2022, up from 9% in 2021 and less than 5% in 2020
- Well-to-Wheel, GHG emissions are lower for EVs than for ICEVs. As the average power generation mix (coal is included) becomes more decarbonized, emissions from EVs become even smaller.
- However, EVs are equipped with a high-capacity batteries that require more critical minerals, such as nickel and graphite, as raw materials. BEVs require about three times more critical minerals than PHEVs.

GHG emissions per kilometer (WtW basis)

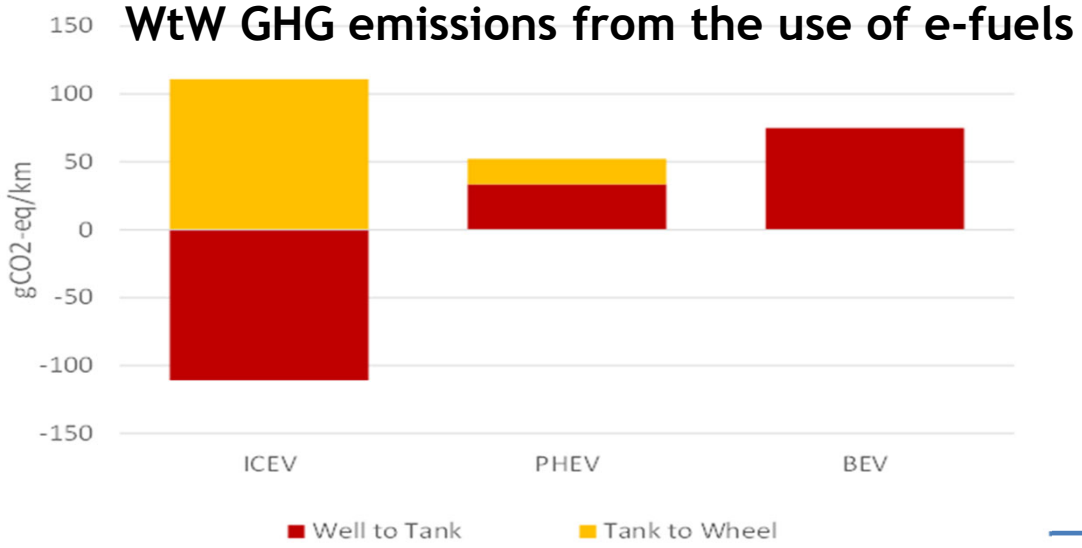


Critical minerals required



PHEVs not only require less critical minerals than BEVs, but can further reduce GHG emissions by using e-fuels

- Our analysis assumes that PHEVs run in EV mode until the battery becomes low, and then the engine (ICE) kicks in to drive the vehicle. Because there is an ICE, the batteries can be smaller than those in BEVs, therefore using about 2/3 less critical minerals as raw materials.
- If the components of e-fuels are CO2 directly captured from the atmosphere (DACs) and H2 produced from renewable electricity, the net emissions during e-fuel production (well to tank) will be negative. Those negative emissions will be offset during combustion (tank to wheel). PHEVs (and ICEVs) may have a relative advantage to BEVs in terms of environmental characteristics.

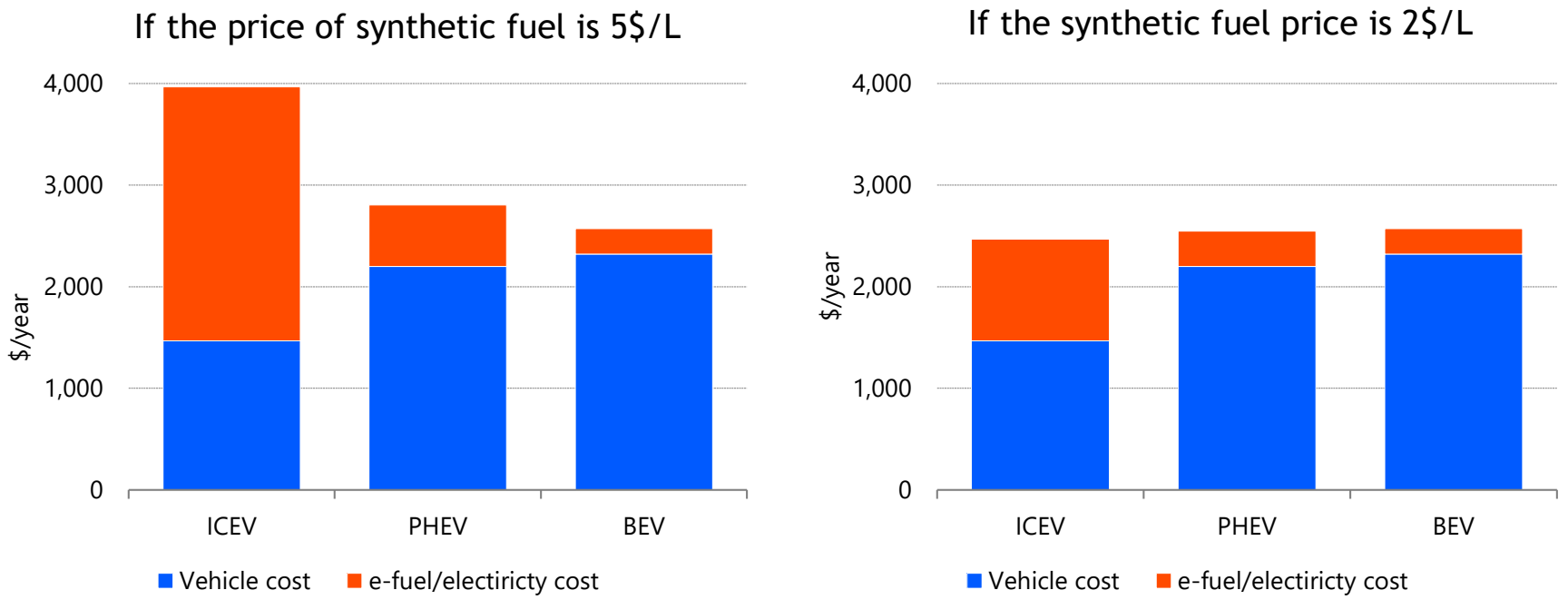


N.B.:Renewable electiricity is used for e-fuels while global average electricity is used for EV batteroes.

The high cost of e-fuels is an issue. If prices fall, owning ICEVs may become similar in price and less emitting than BEVs.

- The cost of e-fuels is still very high being still at the development stage. The current price is estimated at $5/L, assuming the current costs for green hydrogen, DACs and production costs. At $5/L, the total annual cost of BEVs (ownership and fuel/electricity) is lower.
- If the price of e-fuels was to fall to about $2/L, due to mass production and other factors, the cost of conventional vehicles (ICEVs) would be comparable to EVs

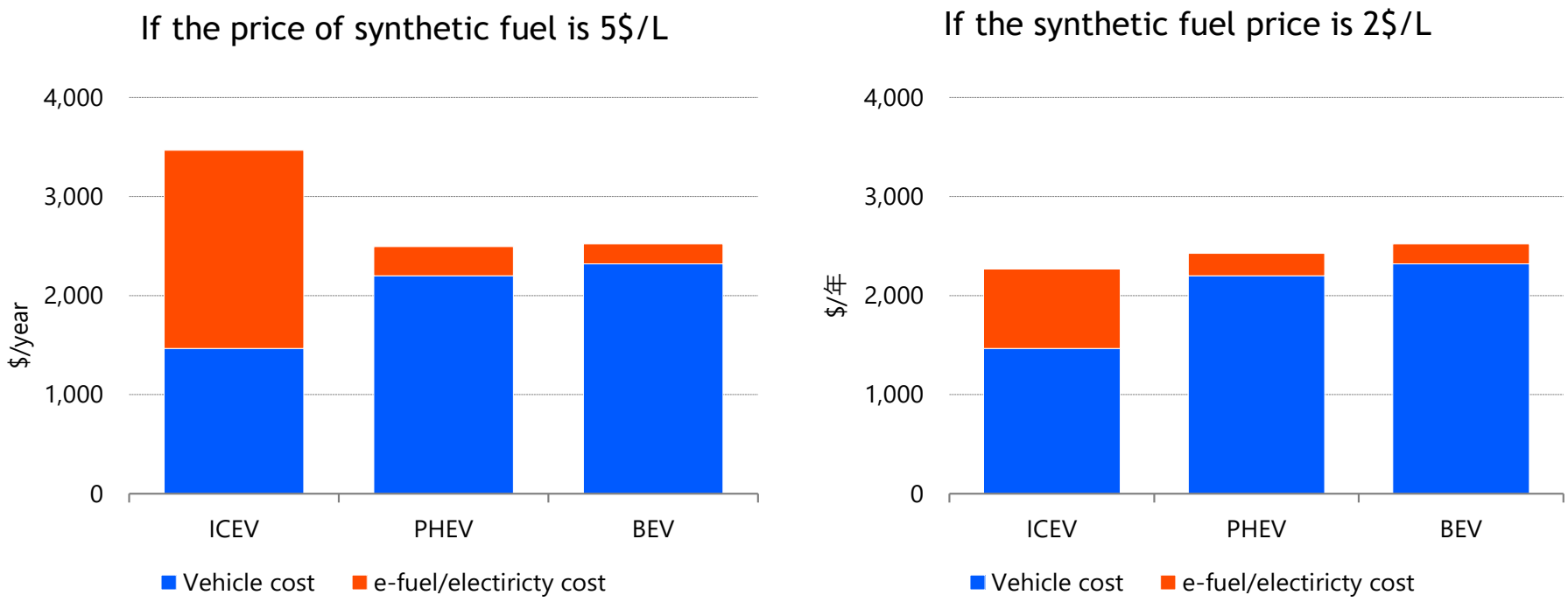
Estimation of annual costs for the use of passenger cars



BTW: PHEV users with short driving range, even the current price of $5/L can compete with BEVs

- The PHEVs that are in the EV mode 90% of the time, there is no need for large batteries. Even with the current $5/L, the total cost would be about the same as that of a BEV.

Estimated annual cost of using a passenger car (assuming low driving range)



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