IEEJ Outlook 2025

- How to Address the Uncertainties Surrounding the Energy Transition -

Global Energy Supply and Demand Outlook to 2050

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Key Points

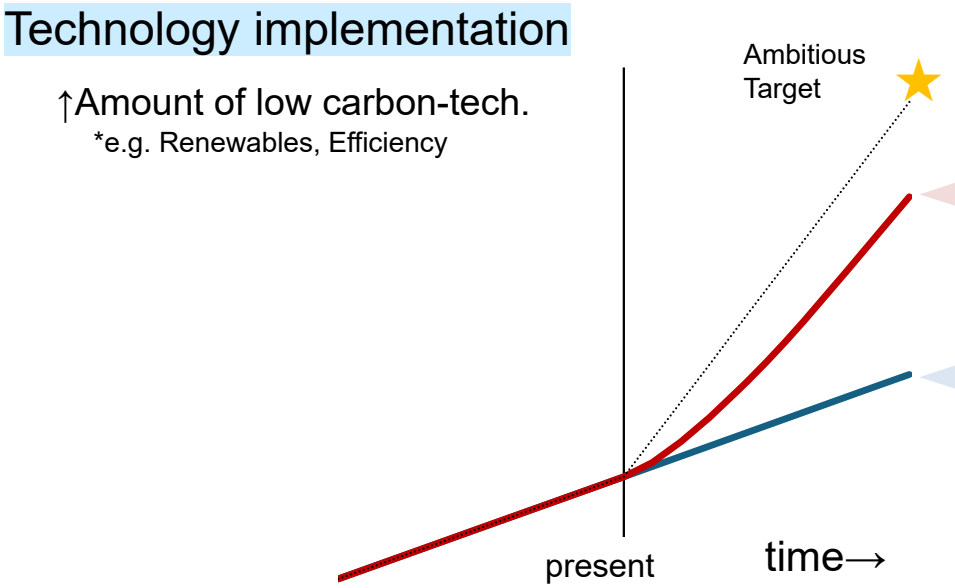
- ✓ Quantitative assessment of global energy supply and demand outlook through 2050, using two scenarios:
  (**Reference**: Current Trends & **AdvancedTechnologies**: Max.Climate Actions)

- ✓ CO2 reduction requires deployment of all available technologies .
  Short term **(1) energy efficiency**, **(2) renewables** (especially solar and wind)
- ✓ Longer term **(3) CCUS** (significant contributions).
  - ✓ The outlook and implementation challenges for each are analyzed.

- ✓ Demand for fossil fuel faces significant uncertainty.
  - ✓ Securing stable supply remains essential over the coming decades.

Scenario Framework

- Global energy supply and demand outlook through 2050.
  - Model analysis incorporating the latest energy and socioeconomic data. Estimated energy demand by type and CO_2 emissions for 44 global regions plus international bunkers.
- Two scenarios with assumptions on different levels of technology and policy progression.
  - Both are forecast-type scenarios examining "what if" scenarios (target achievement is not incorporated).
  - They are not back-cast-type scenarios (which work backward from targets to determine "what should be done").

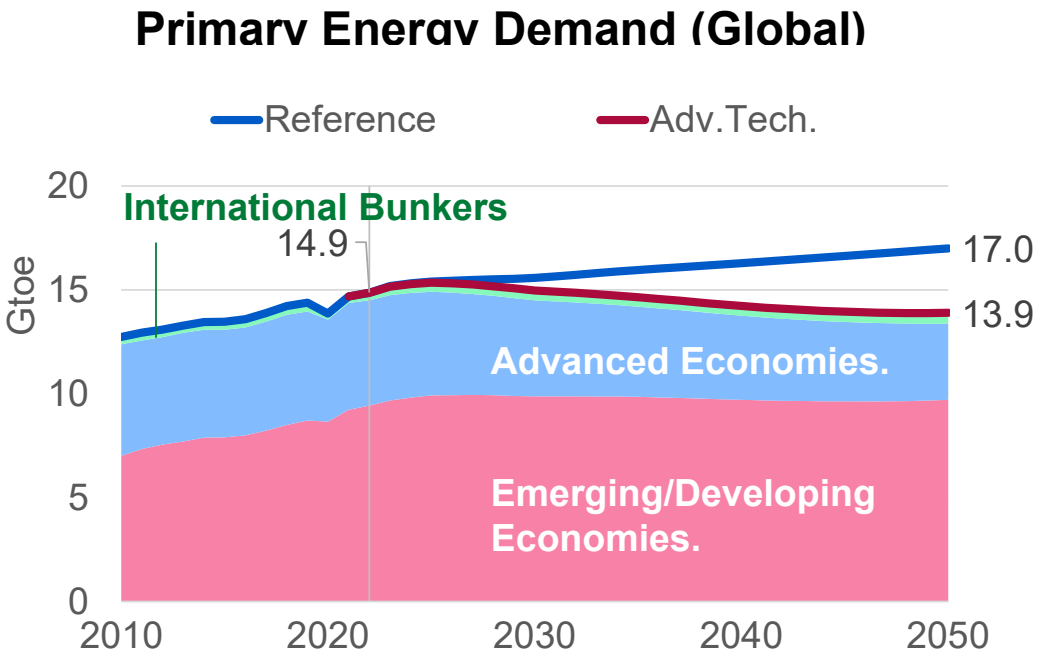


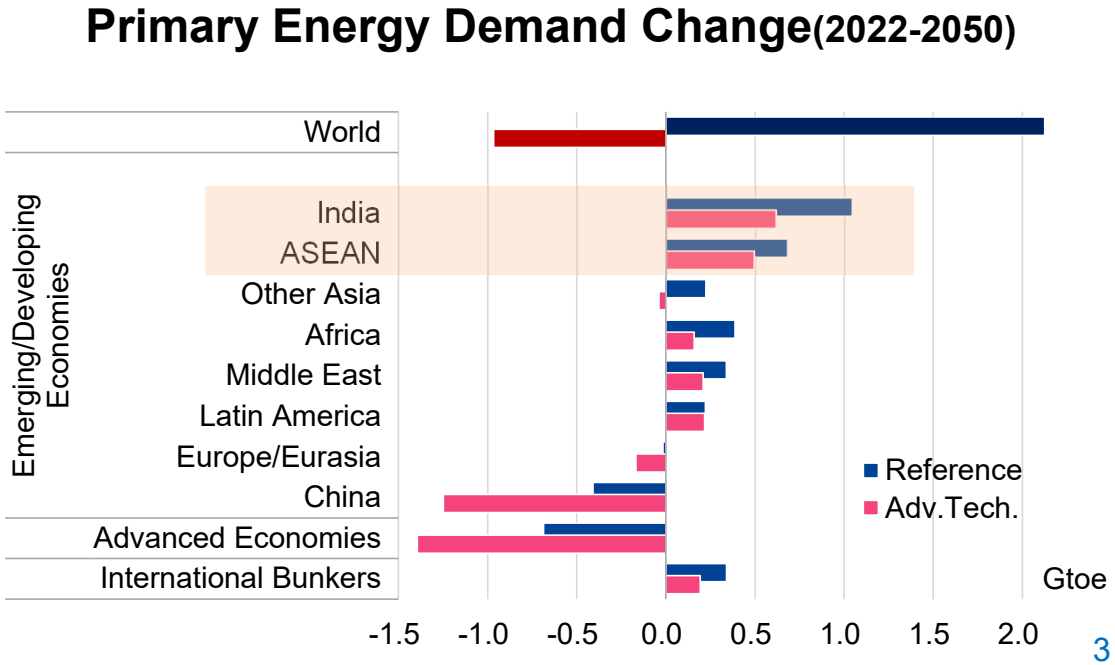
[Advanced Technologies] (Adv.Tech.)
Maximum implementation of policies for energy security and climate actions, with technologies & policies deployed to maximum extent (considering feasibility and acceptance)

[Reference]
Continuation of current **trends** in energy and environmental policies.
*Does not imply fixed current policies/technologies

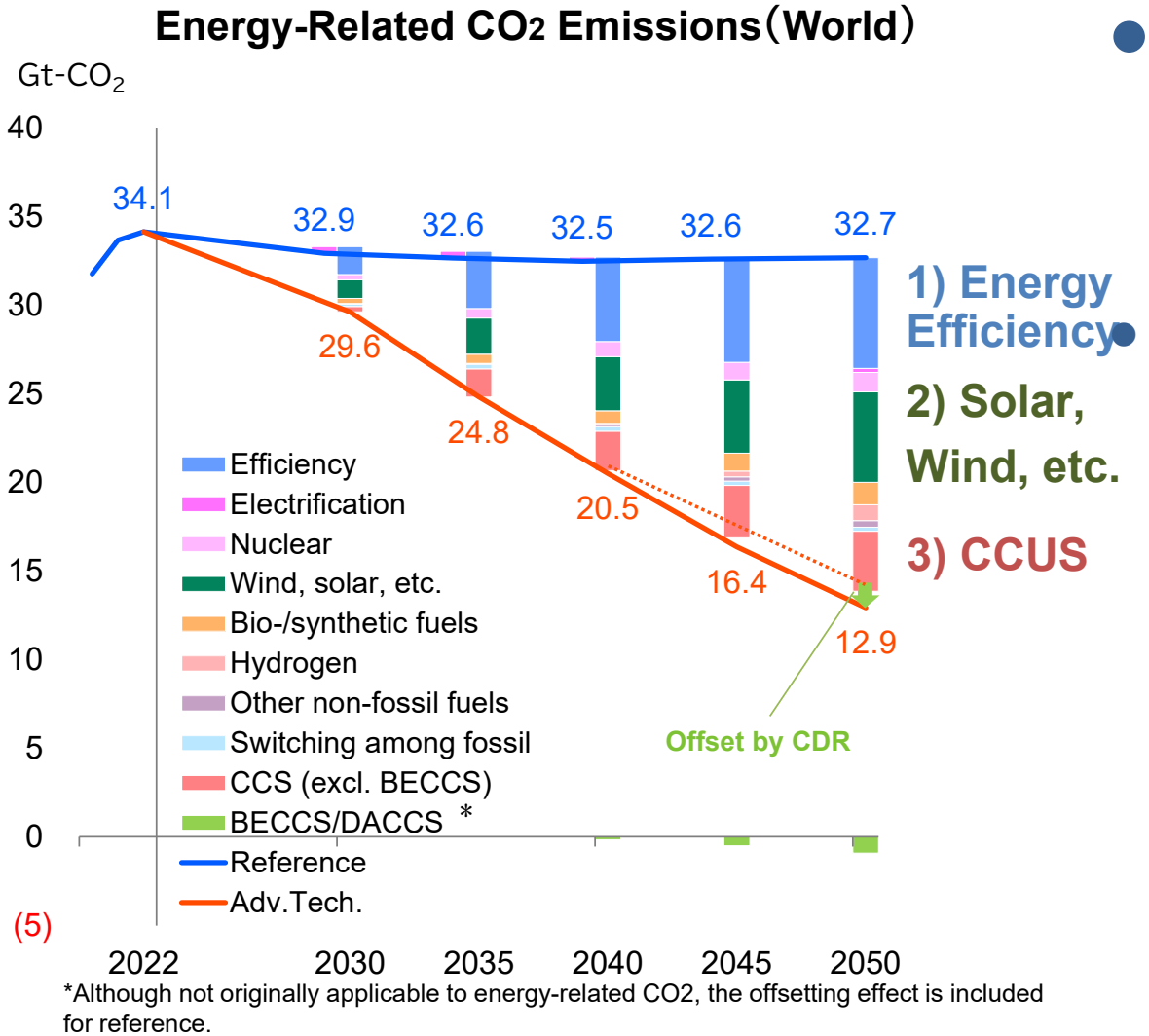
Primary Energy Demand:
India and ASEAN at Center of Demand Growth

- **Reference:** Primary energy demand increases by14% from 2022 to 2050.
  - Real GDP doubles during this period. Efficiency improvements and industrial structure transformation suppress demand.
- **Adv.Tech:** Energy efficiency improvements accelerate, primary demand peaks before 2030.
- India and ASEAN drive demand growth in both scenarios, pushing up global demand.
  - Global emissions reduction requires engagement of these two regions plus other emerging/developing economies.





CO2 Reduction: Energy Efficiency, Renewables and CCUS



*Although not originally applicable to energy-related CO2, the offsetting effect is included for reference.

Reference

- Despite growth in energy demand, expansion of renewables, electrification and natural gas switching suppress emissions.

Adv.Tech

- Major contributors to CO2 reduction are (1) energy efficiency, (2) renewables (solar/wind), and (3) CCUS.
- (1) and (2) contribute significantly from 2030, CCUS expands after 2040
  - Carbon removal (BECCS, DACCS) cancels a part of remaining emissions.
- The remaining gap between the 2 scenarios and the "2050 Net Zero" target, is particularly challenging for emerging/developing economies and non-power sectors.

1) Energy Efficiency: Different Priority Areas by Regional/Economic Level

Sectors with particularly effective efficiency improvements vary by region.

- **Advanced economies show improvement in efficiency across sectors.**

  Transportation shows particularly large reductions due to next-generation vehicles (EVs, hybrids) with better efficiency.

- **Emerging economies (especially China, India, ASEAN) focus on industry.**

  Major industrial production in China and expected growth in India/ASEAN make industrial efficiency improvements effective.

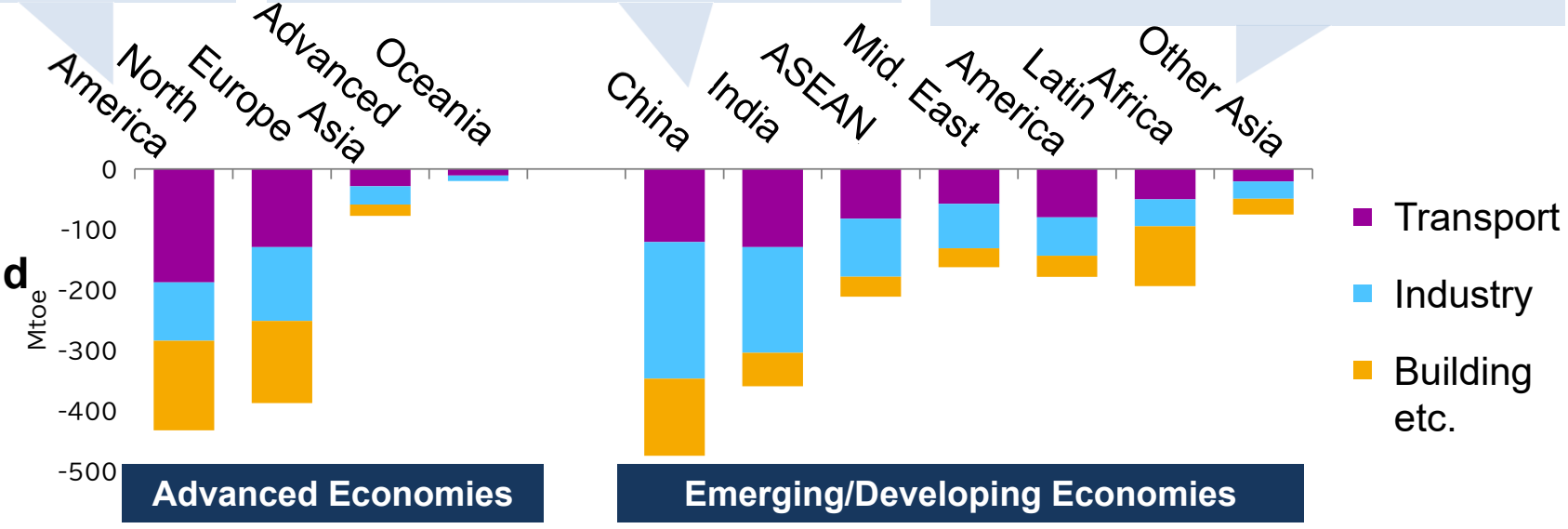
- **Developing economies (Africa, Other Asia) show major reductions in residential.**

  Household transition from traditional biomass (wood) to LPG, city gas, and eventually electricity.

  Challenges: Funding for equipment adoption and affordable modern energy supply

Difference in Final Energy Demand
[Adv.Tech.-Reference]

(2050)



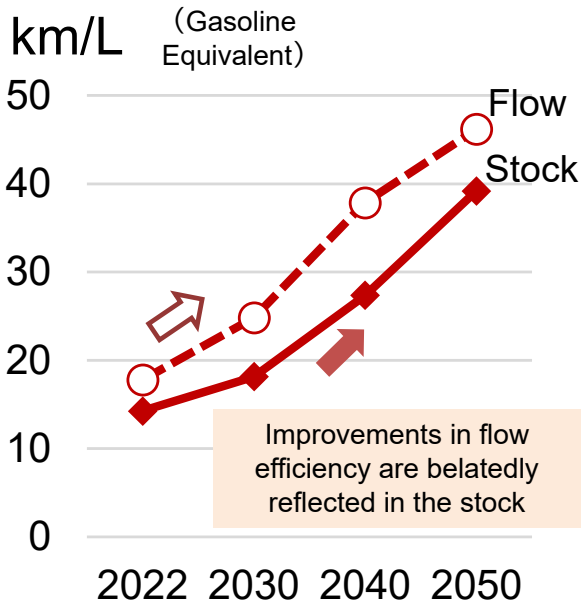
1) Energy Efficiency: Delayed Effect of Improvements

- Energy Efficiency: Delayed Effect of Improvements.
  - Intensity improvements in **Adv.Tech** become particularly evident after 2030.
- Flow efficiency (new equipment) reflects in stock efficiency (existing equipment) with delay.
  - Particularly pronounced in industrial sector with long equipment lifespans
  - Early action necessary for significant energy savings by 2050.

Average annual improvement of primary energy demand intensity (World)

		2010-2022	2022-2030	2030-2040	2040-2050
TPES/GDP	Reference	-1.4% (history)	-2.0%	-2.2%	-2.0%
	Advanced		-2.5%	-3.1%	-2.7%

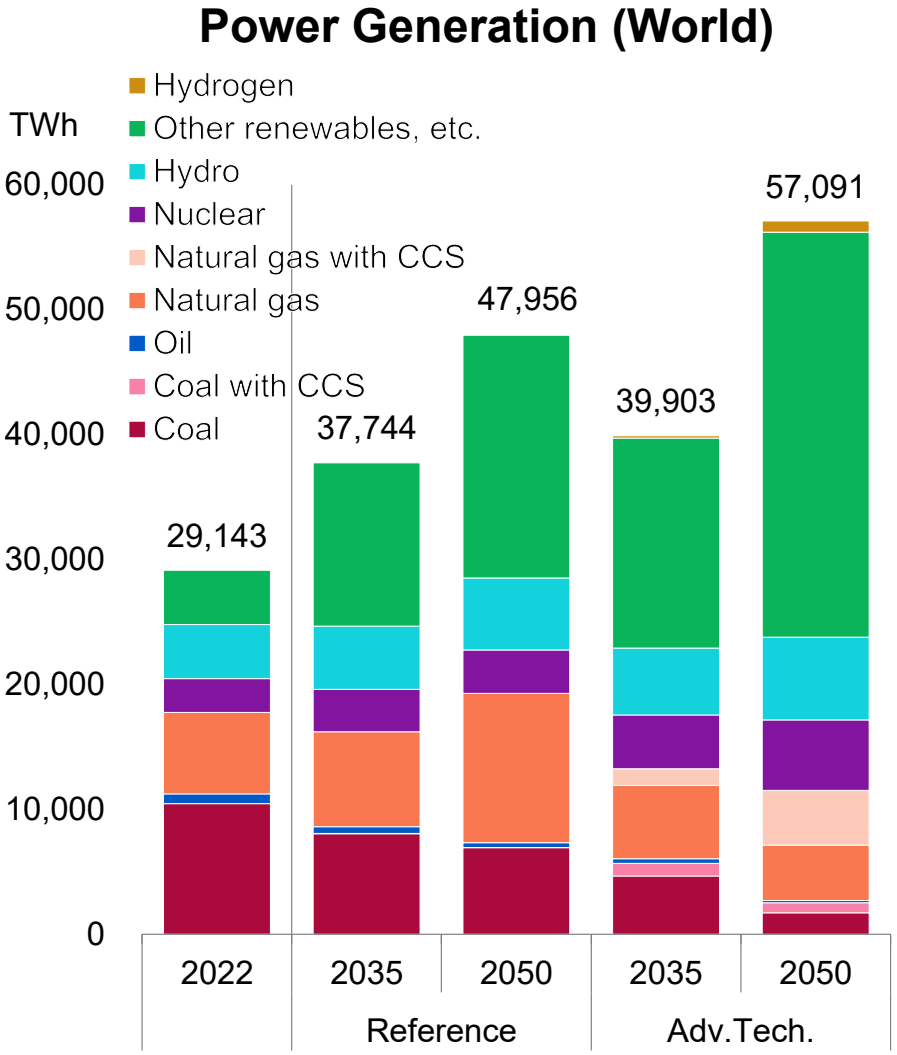
Average fuel economy of passenger vehicles (Adv.Tech, World)



Average years of equipment use (example)

Sector	Facilities	Lifetime (year)
Industry	Blast Furnace	10～25
	Boiler	20～40
Building	Air Conditioner	10～20
	House	30～
Transport	Passenger Vehicles	10～15
	Airplanes	20～30
Power	Thermal	25～40
	Solar PV	15～30

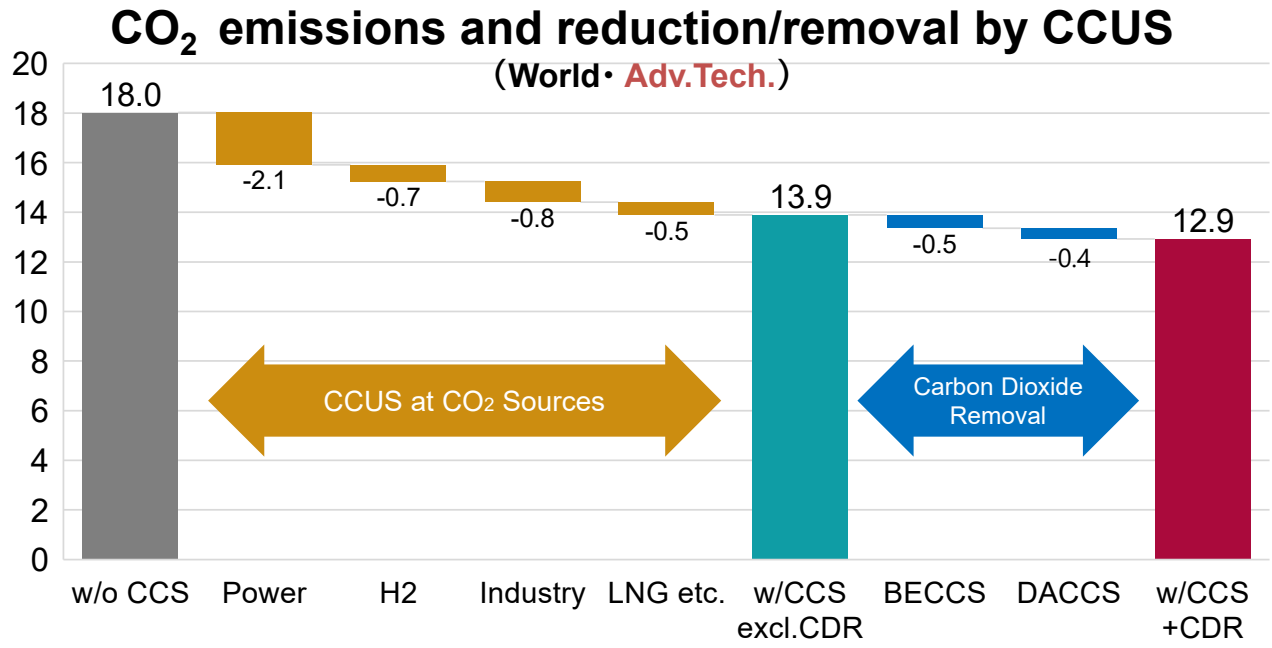
2) Renewables: Share reaches 60% in Adv. Tech.



- **Power generation in 2050 requires 1.6x (Reference) and 2.0x (Adv.Tech.) vs 2022 levels.**
  - Substantial power demand increase is unavoidable in both scenarios.
  - Particularly in emerging/developing economies; urgent need for generation and transmission expansion.
- **Adv.Tech: "Renewables (excl. hydro)" increase dramatically to 60% of power.**
  - Mostly solar and wind; implementation at this scale requires fundamental intermittency countermeasures.
- **Nuclear expands particularly in emerging/developing economies.**

3）CCUS:
Major Deployment Potential in Industry and Power Generation

- **Adv.Tech.** projects total CCUS deployment of 5.1 Gt-CO2 by 2050.
  - Shows the largest reduction potential for point-source in Power sector.
  - Becomes a key decarbonization method for industry sectors with limited electrification potential, like steel and cement.
  - Carbon removal (BECCS, DACCS* in this outlook) expected to be higher cost but valuable for offsetting residual emissions from sectors where capturing is difficult (Building/ Transport).

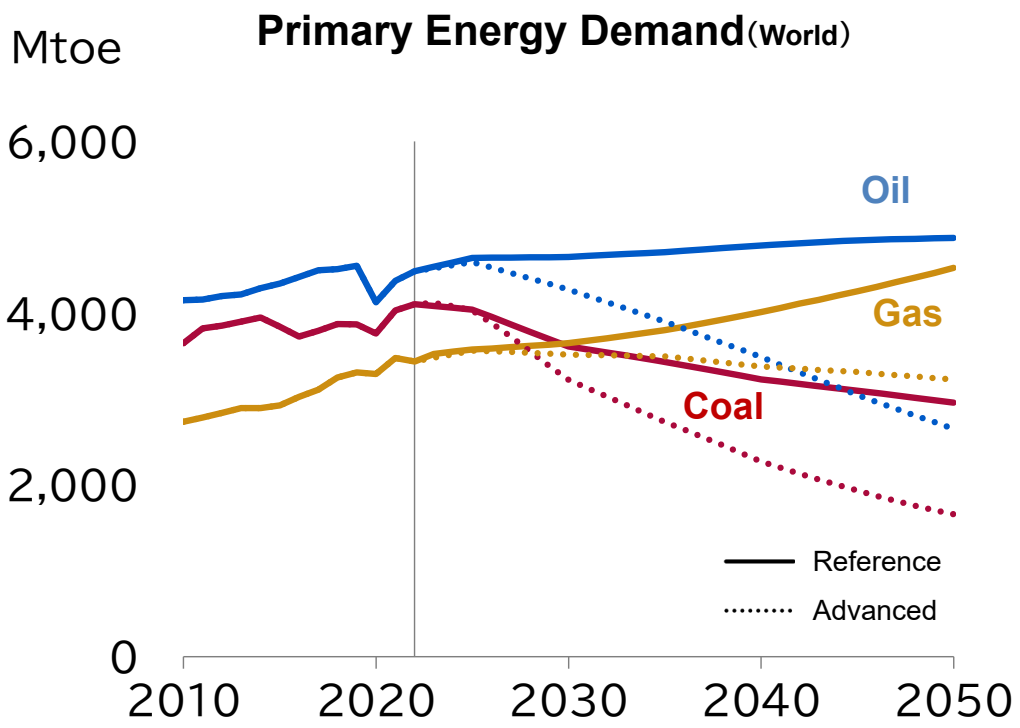


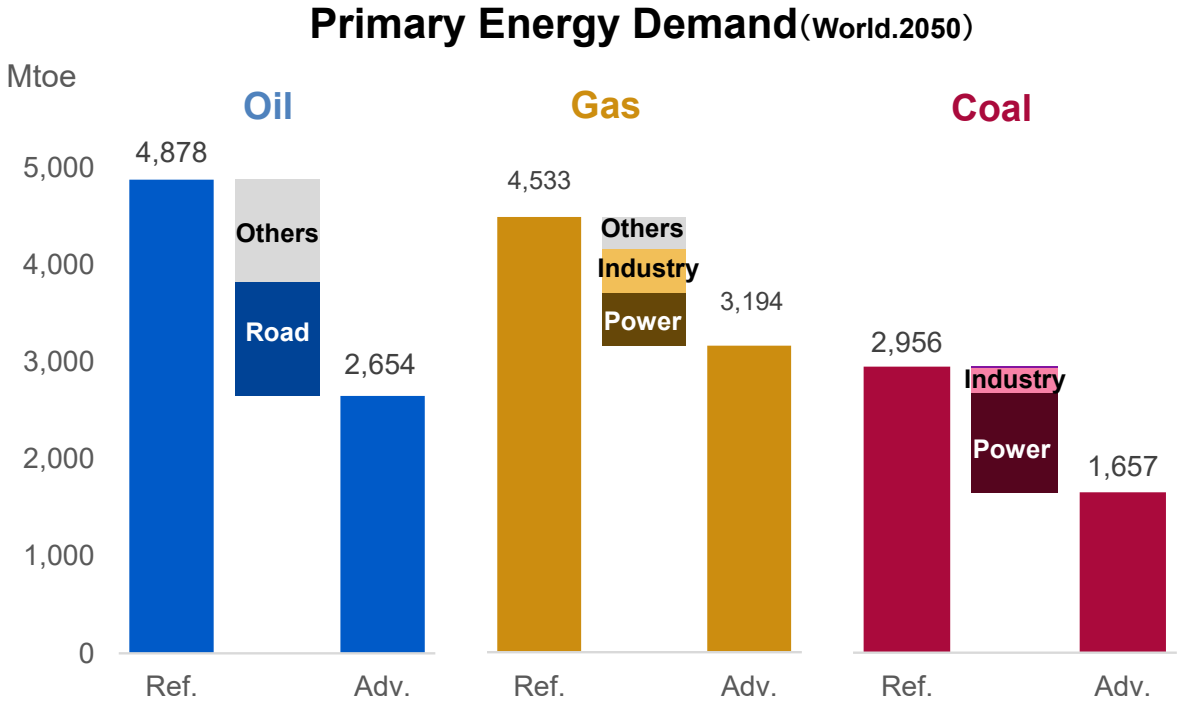
For Additional reduction…
- Addition of various CCUS/
- Nature-based Carbon Removal
(e.g.) Forests, Agricultural lands, and other land uses, Blue carbon, etc.

*BECCS: Bioenergy with CCS, DACCS: Direct Air Carbon Capture and Storage
Both qualify as negative emission technologies directly reducing atmospheric CO2

Fossil Fuel Demand Uncertainty: Wide Gap Between Scenarios

- Large divergence in fossil fuel demand between **Reference** and **Adv.Tech.** scenarios. While pursuing energy transition, a stable fossil fuel supply remains necessary.
  - Oil shows the largest demand difference, with road transport accounting for over half. Uncertainty in EV/HEV adoption, and ICE efficiency improvements.
  - Natural gas and coal demand differences are primarily driven by power generation and industry.

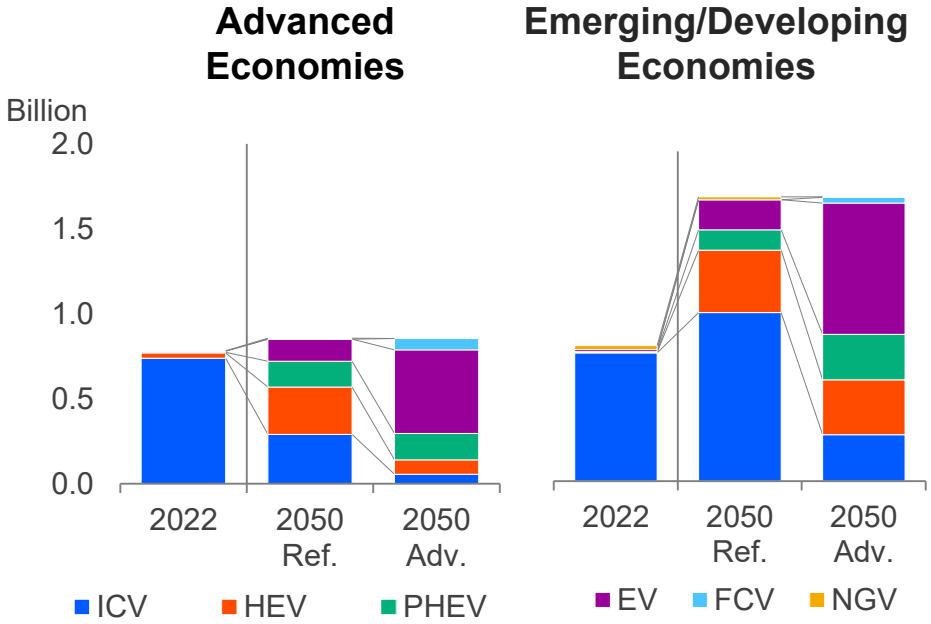




Final Energy Demand: Transport (Especially Road) Shows Major Divergence

- [**Reference**]Transport sector demand grows significantly in emerging economies.
  - Vehicle ownership in emerging/developing economies more than double by 2050 from 2022. Oil demand varies greatly depending on fuel efficiency improvements and powertrain choices.
- [**Adv.Tech.**]Efficiency improves particularly in road transport.
  - While EVs see mass adoption, ICEs and hybrids maintain presence, especially in emerging/developing economies. Vehicle choice is important based on power mix, range requirements, and usage frequency.

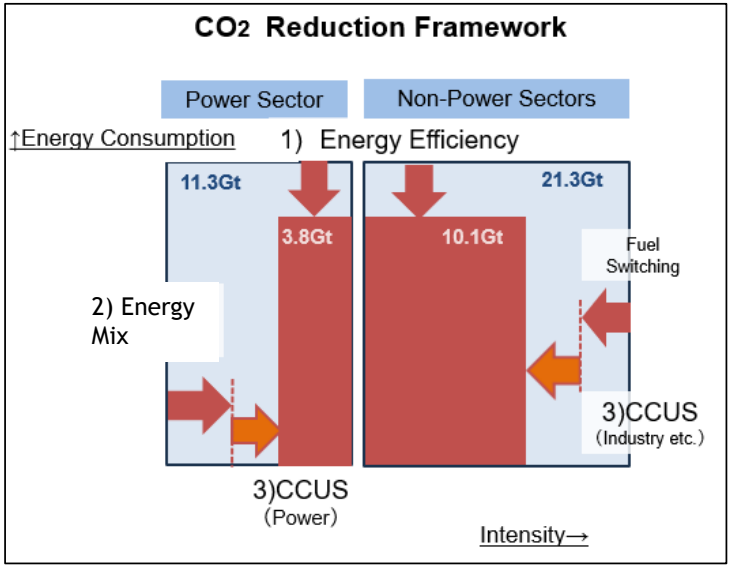
Vehicle Ownership（By Powertrain）



Summary

✓ **CO2 reduction relies primarily on (1) energy efficiency, (2) renewables, and long-term (3) CCUS. [Adv.Tech.]**

- Energy efficiency enhancement provides 6.2 Gt-CO2 reduction; early action is essential due to implementation lag.
- Renewables (excl. hydro) reach ~60% of total generation; variable renewable capacity exceeds twice the average load.
- CCUS promising for large emission sources in power and industry; 5.1 Gt-CO2/year capture (including CDR).



✓ **Primary Demand and Power Generation Trends**

- India, ASEAN show dramatic primary energy demand increase. International climate actions must cover these regions.
- Global power generation increase by 2050 from 2022: 1.6x (**Reference**), 2.0x (**Adv. Tech.**).

✓ **Significant Fossil Fuel Demand Uncertainty.**

- Under current trends, gas and oil demand will continue growing through 2050.
- Drivers of uncertainty : road transport for oil; industry and power generation for gas/coal.
- Stable fossil fuel supply remains critical through 2050. Sustained adequate investment essential.