International Energy Outlook 2023

with projections to 2050

U.S. Energy Information Administration

#IEO2023

October 11, 2023
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What does EIA do?

The U.S. Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy.

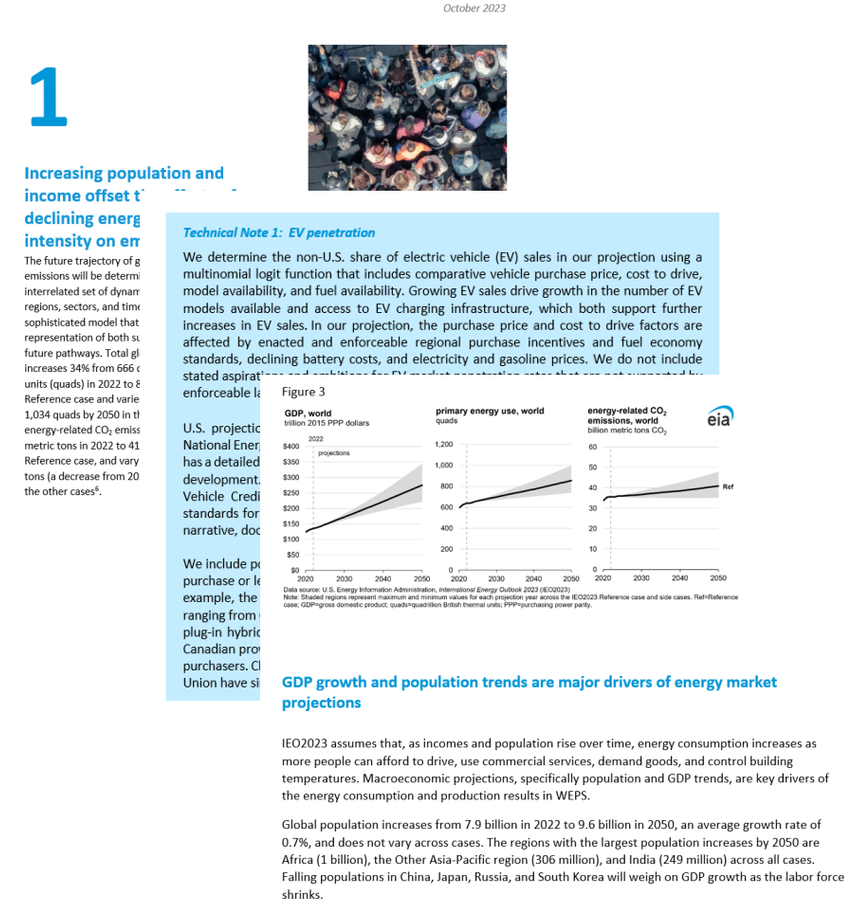
EIA is the nation's premier source of energy information.

By law, our data, analyses, forecasts, and projections are independent of approval by any other officer or employee of the U.S. government.

Our *International Energy Outlook 2023* (IEO2023) explores long-term energy trends across the globe.

What's new in the *International Energy Outlook 2023*?

- Narrative improvements carried from the *Annual Energy Outlook 2023* (AEO2023), including technical notes and an emphasis on the range of results
- New cases examining capital costs of zero-carbon technologies
- Modeling improvements:
  - New analysis regions
  - New oil and natural gas model
  - Higher temporal resolution in the electricity model
  - Assumptions about the impacts of Russia's full-scale invasion of Ukraine



October 2023

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Increasing population and income offset t… declining energ… intensity on em…

The future trajectory of g… emissions will be determi… interrelated set of dynam… regions, sectors, and time… sophisticated model that… representation of both su… future pathways. Total gl… increases 34% from 666 q… units (quads) in 2022 to 8… Reference case and varie… 1,034 quads by 2050 in th… energy-related CO_2 emiss… metric tons in 2022 to 41… Reference case, and vary… tons (a decrease from 20… the other cases[6].

Technical Note 1: EV penetration

We determine the non-U.S. share of electric vehicle (EV) sales in our projection using a multinomial logit function that includes comparative vehicle purchase price, cost to drive, model availability, and fuel availability. Growing EV sales drive growth in the number of EV models available and access to EV charging infrastructure, which both support further increases in EV sales. In our projection, the purchase price and cost to drive factors are affected by enacted and enforceable regional purchase incentives and fuel economy standards, declining battery costs, and electricity and gasoline prices. We do not include stated aspirat… and ambitions for EV market penetration rates that are not supported by enforceable la…

U.S. projectio… National Ener… has a detailed… development. Vehicle Credi… standards for… narrative, doc…

We include p… purchase or le… example, the… ranging from… plug-in hybri… Canadian pro… purchasers. Cl… Union have si…

Figure 3

Data source: U.S. Energy Information Administration, *International Energy Outlook 2023* (IEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the IEO2023 Reference case and side cases. Ref=Reference case; GDP=gross domestic product; quads=quadrillion British thermal units; PPP=purchasing power parity.

GDP growth and population trends are major drivers of energy market projections

IEO2023 assumes that, as incomes and population rise over time, energy consumption increases as more people can afford to drive, use commercial services, demand goods, and control building temperatures. Macroeconomic projections, specifically population and GDP trends, are key drivers of the energy consumption and production results in WEPS.

Global population increases from 7.9 billion in 2022 to 9.6 billion in 2050, an average growth rate of 0.7%, and does not vary across cases. The regions with the largest population increases by 2050 are Africa (1 billion), the Other Asia-Pacific region (306 million), and India (249 million) across all cases. Falling populations in China, Japan, Russia, and South Korea will weigh on GDP growth as the labor force shrinks.

The IEO2023 includes cases that vary technical and economic assumptions

- All cases reflect current laws and regulations as of March 2023, and the U.S. results come directly from the AEO2023, which assumes U.S. laws and regulations as of November 2022 remain unchanged.

Case	Assumptions
Reference	Global average annual GDP (purchasing power parity) percentage change (2022–2050): 2.6% Brent: $102 per barrel (2022$) in 2050 Zero-carbon technologies' 2022–2050 cost reductions: up to 20%
Economic Growth	Low: 1.8% average annual GDP percentage change (2022–2050) High: 3.4% average annual GDP percentage change (2022–2050)
Oil Price	Low: $48 per barrel (2022$) in 2050 High: $187 per barrel (2022$) in 2050
Zero-Carbon Technology Cost (electric power sector)	Low: 40% reduction in capital costs below Reference case by 2050 High: No reduction in costs

Note: Zero-carbon technologies include solar, wind, battery storage, and nuclear.

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Things to keep in mind

- Although we model a number of cases, we do not comprehensively address all issues that could drive significant change, like in a forecast.

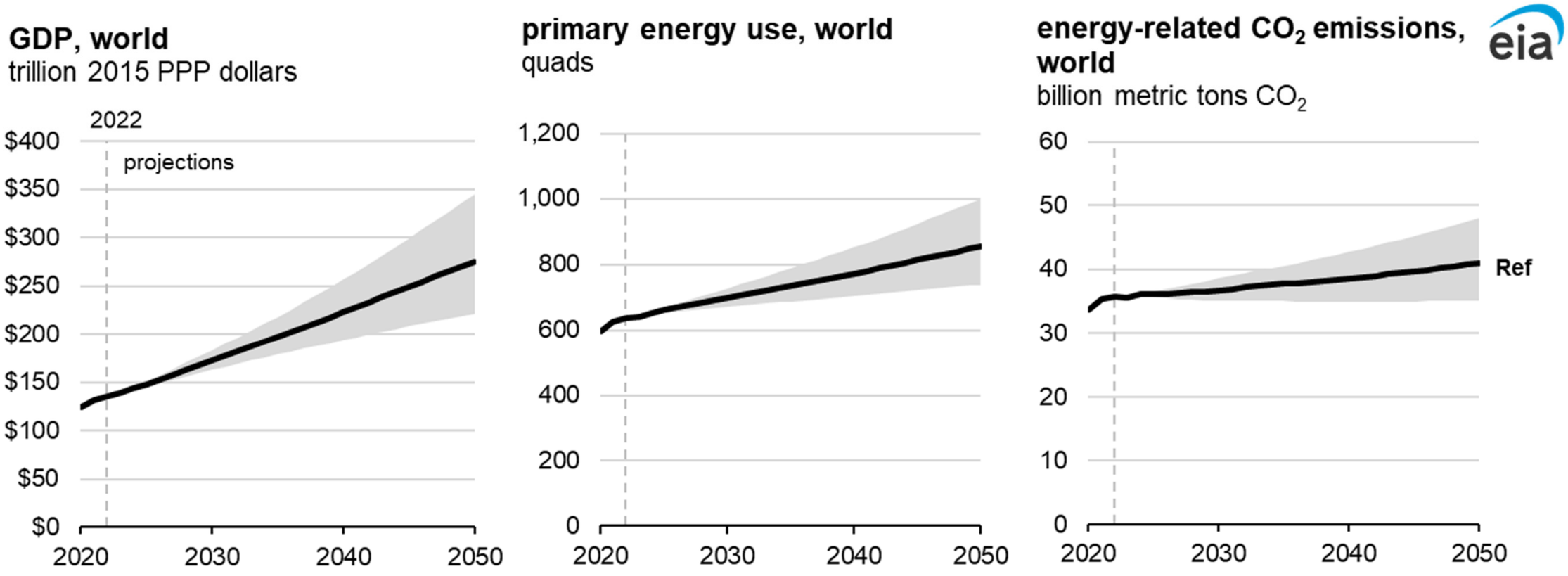
- New policies, geopolitical events, and technology breakthroughs will happen that shift the trajectory of the global energy system.

Therefore:

- IEO2023 is **not** a forecast.

- IEO2023 represents a set of policy-neutral baselines that focus on the current trajectory of the global energy system.

Across most cases, energy-related CO_2 emissions continue to rise through 2050 under current laws



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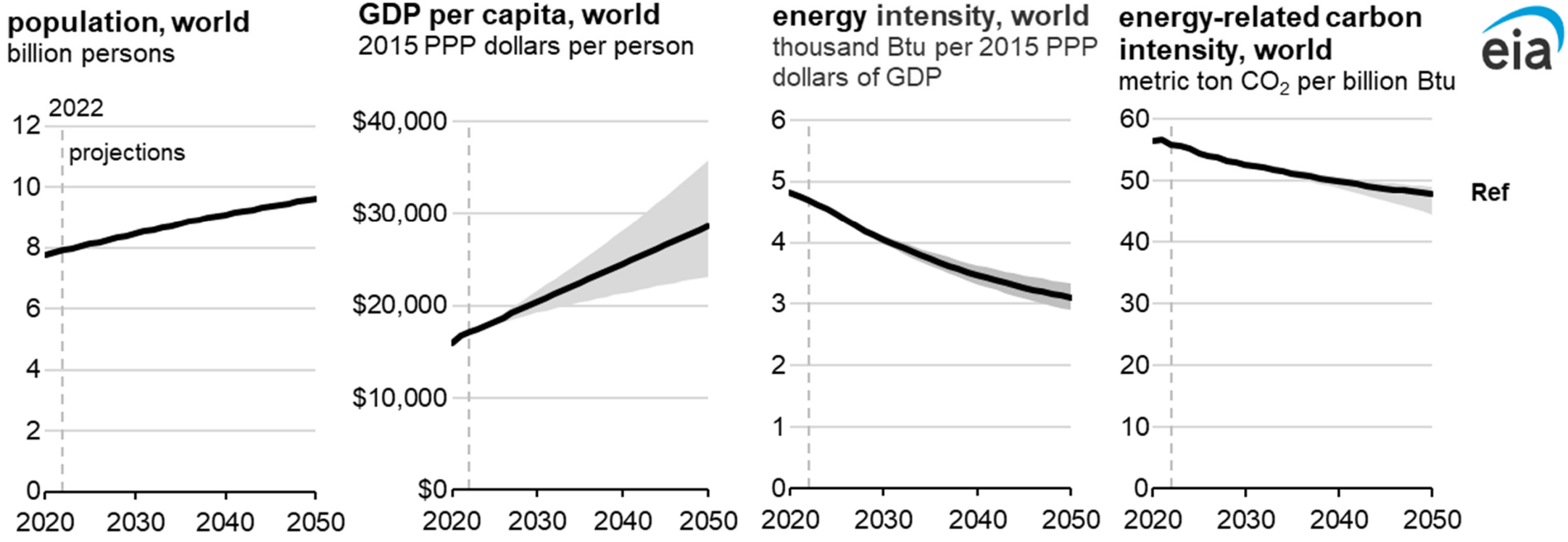
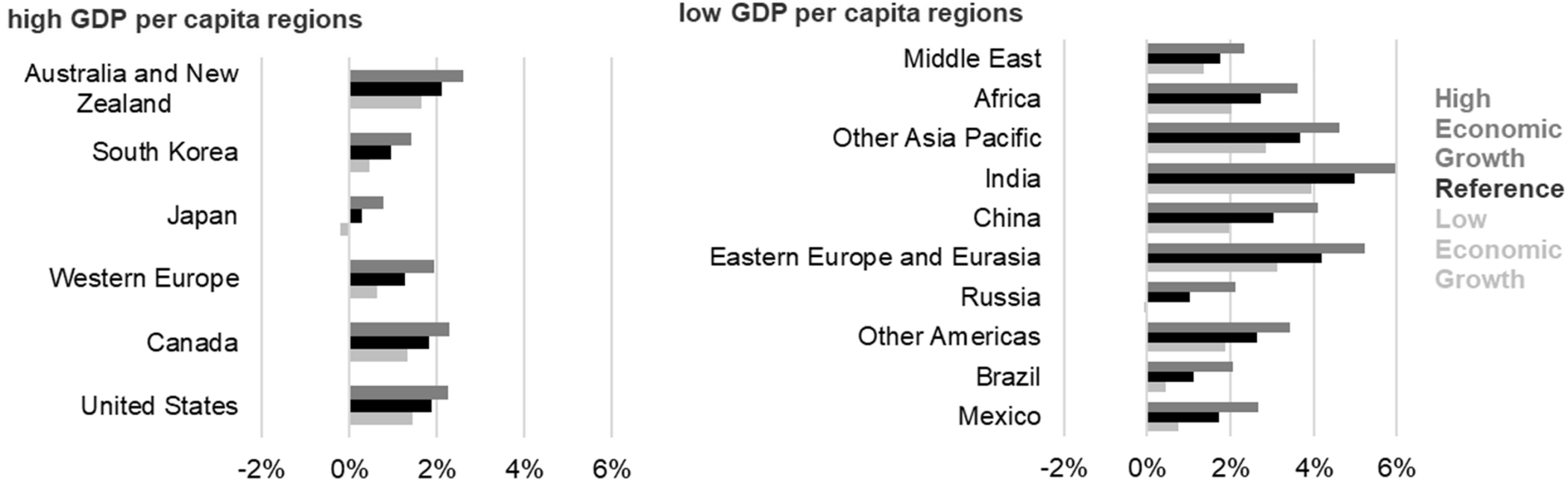
The upward pressures of population and GDP growth outweigh the downward pressures of energy and carbon intensity on emissions



Data source: U.S. Energy Information Administration, *International Energy Outlook 2023* (IEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the IEO2023 Reference case and side cases. Our global population assumptions do not vary across side cases. GDP=gross domestic product; PPP=purchasing power parity; Btu=British thermal units; Ref=Reference case.

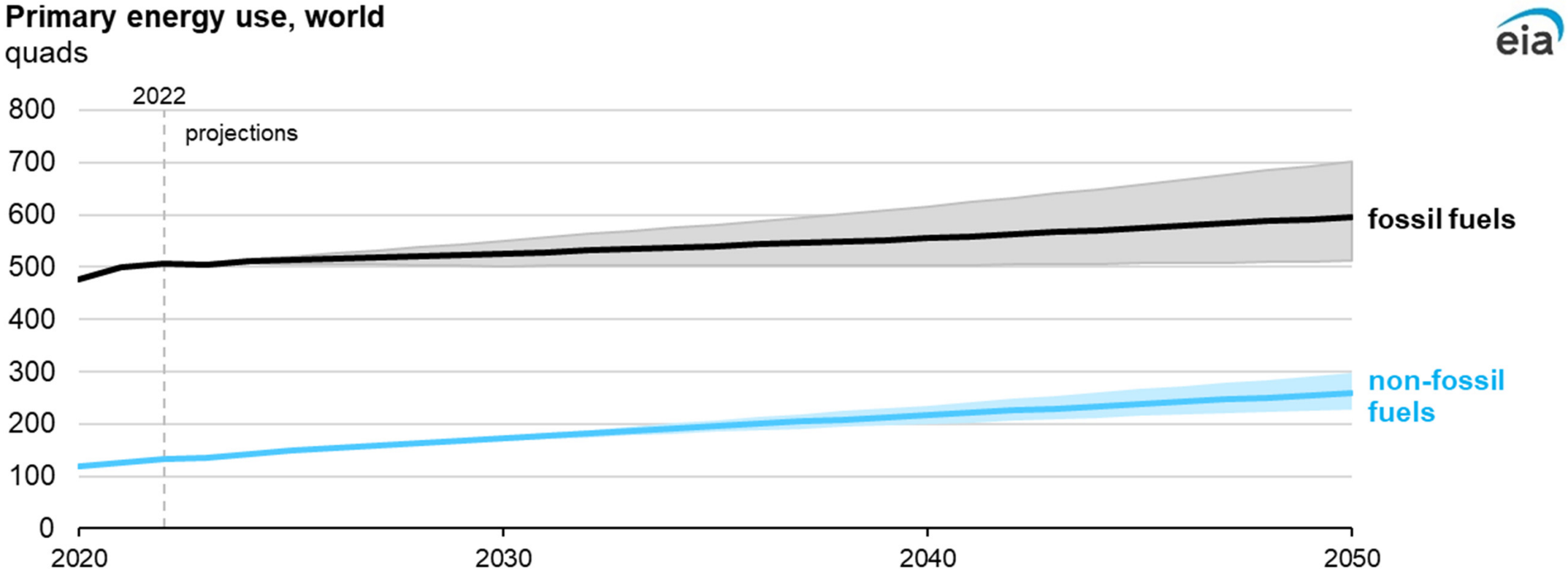
India leads the world in economic growth, and growth rates vary for other regions

GDP average annual growth rate by region
average annual percentage change, 2022–2050



Data source: U.S. Energy Information Administration, *International Energy Outlook 2023* (IEO2023)
Note: Because GDP growth rates define the Economic Growth cases, this figure displays case inputs. More information is available in Appendix A.

Increasing demand and current policies drive steady growth in fossil fuel energy—and faster growth in non-fossil fuel sources



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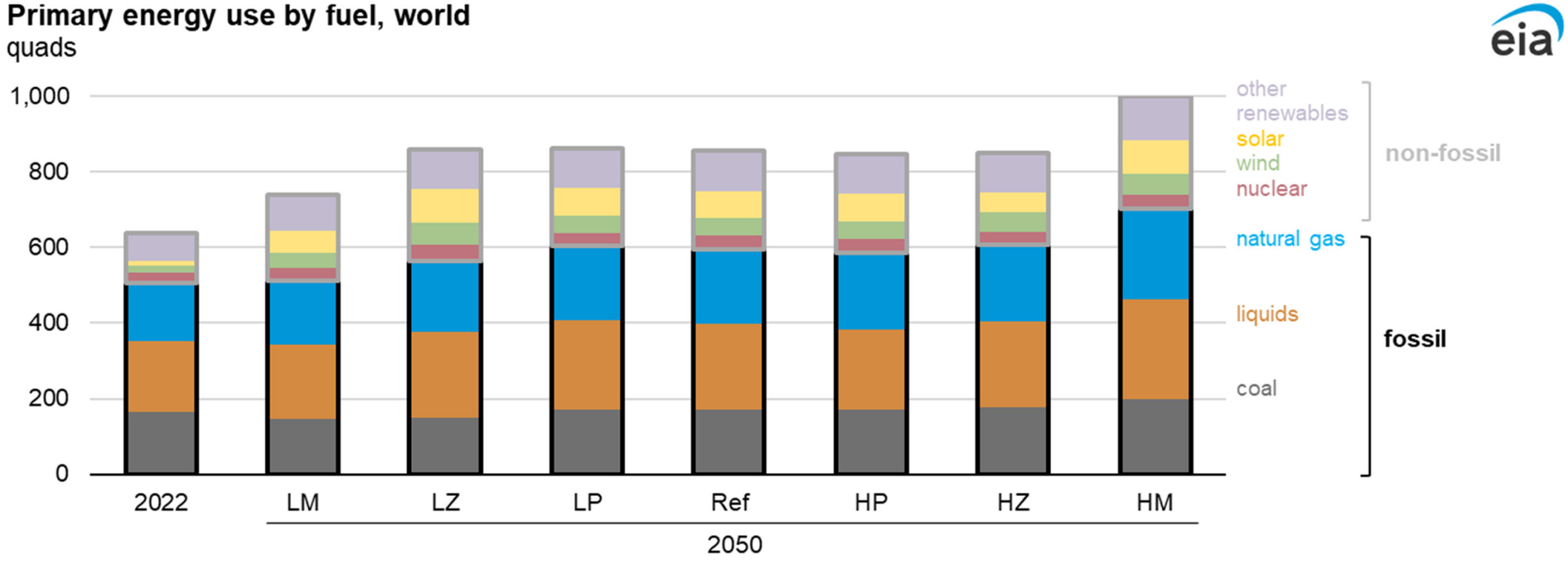
Renewable energy grows the fastest as a share of primary energy consumption across all cases due to current policy and cost drivers



Data source: U.S. Energy Information Administration, *International Energy Outlook 2023* (IEO2023)
Note: Biofuels are included in the "other renewables" category. Quads=quadrillion British thermal units; HZ=High Zero-Carbon Technology Cost case; LZ=Low Zero-Carbon Technology Cost case; HM=High Economic Growth case; LM=Low Economic Growth case; HP=High Oil Price case; LP=Low Oil Price case; Ref=Reference case.

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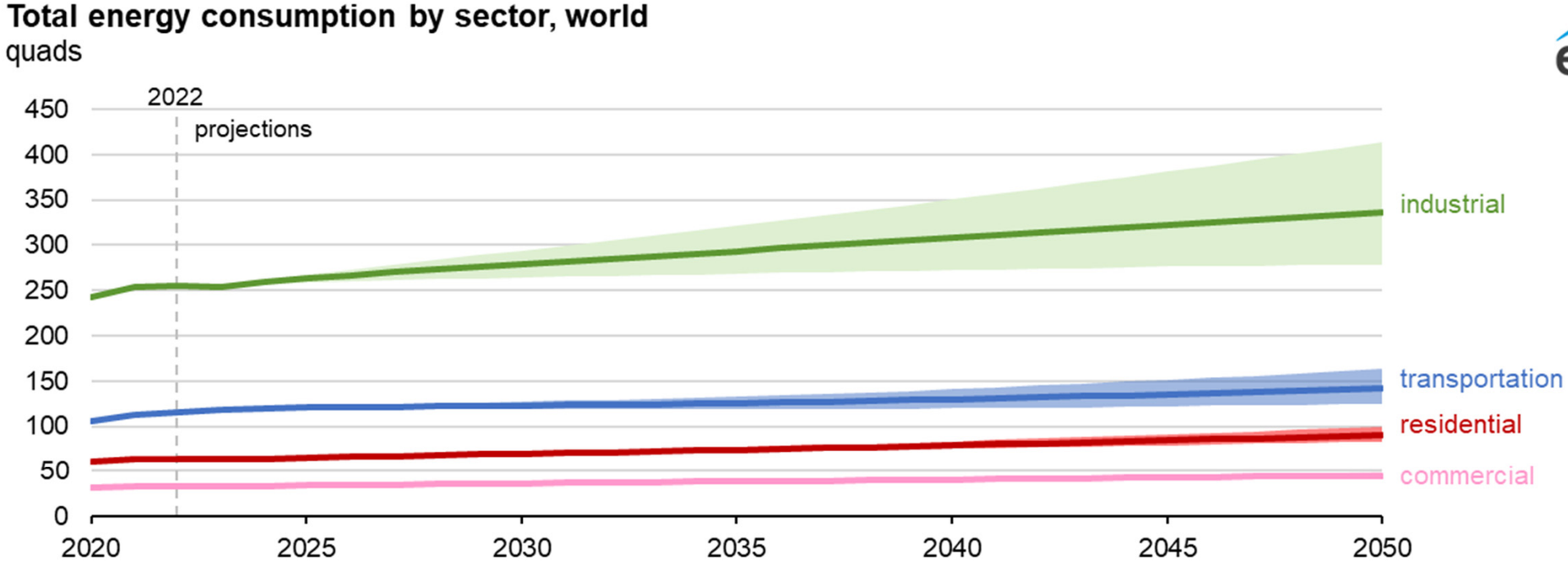
Across all IEO2023 cases, energy consumption increases, and global demand grows fastest in the industrial and residential sectors



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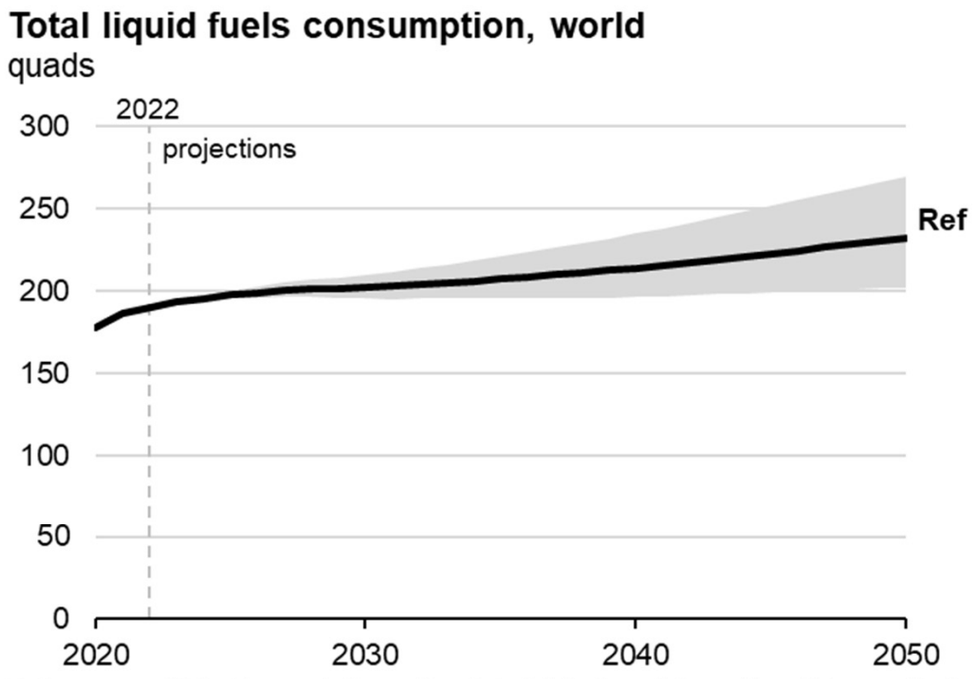
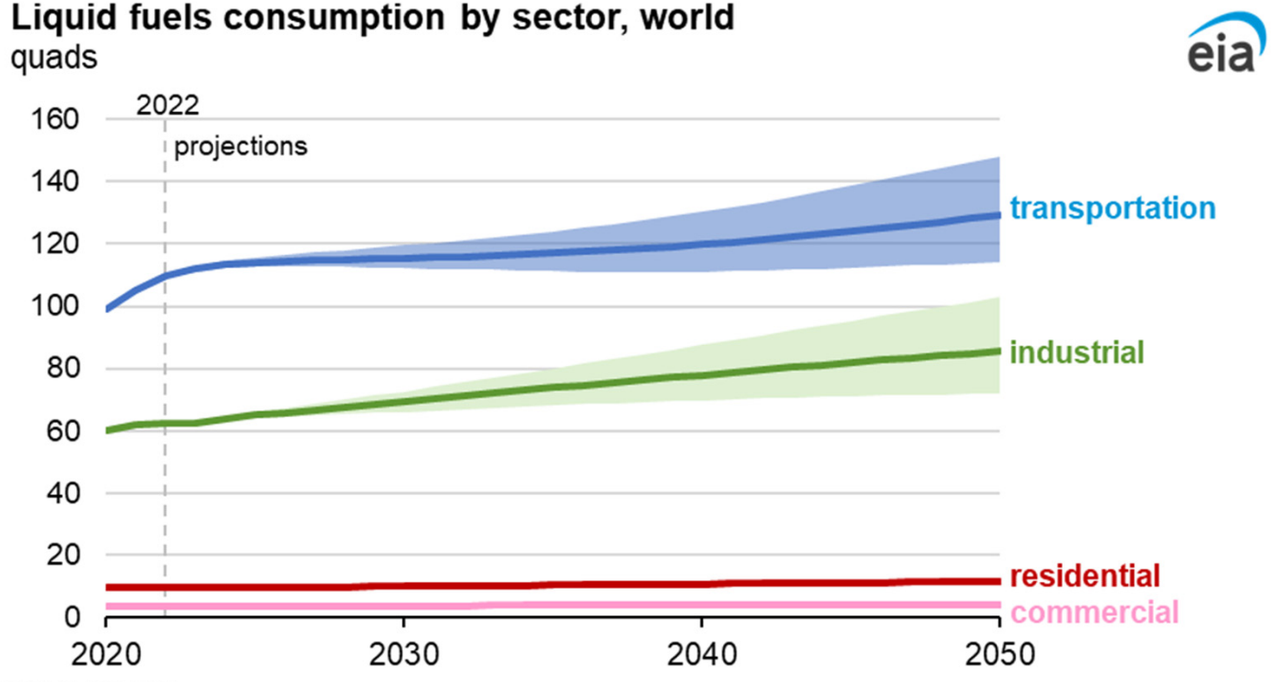
Under current laws, liquid fuels consumption increases through 2050 across all cases, driven by growth in the industrial sector





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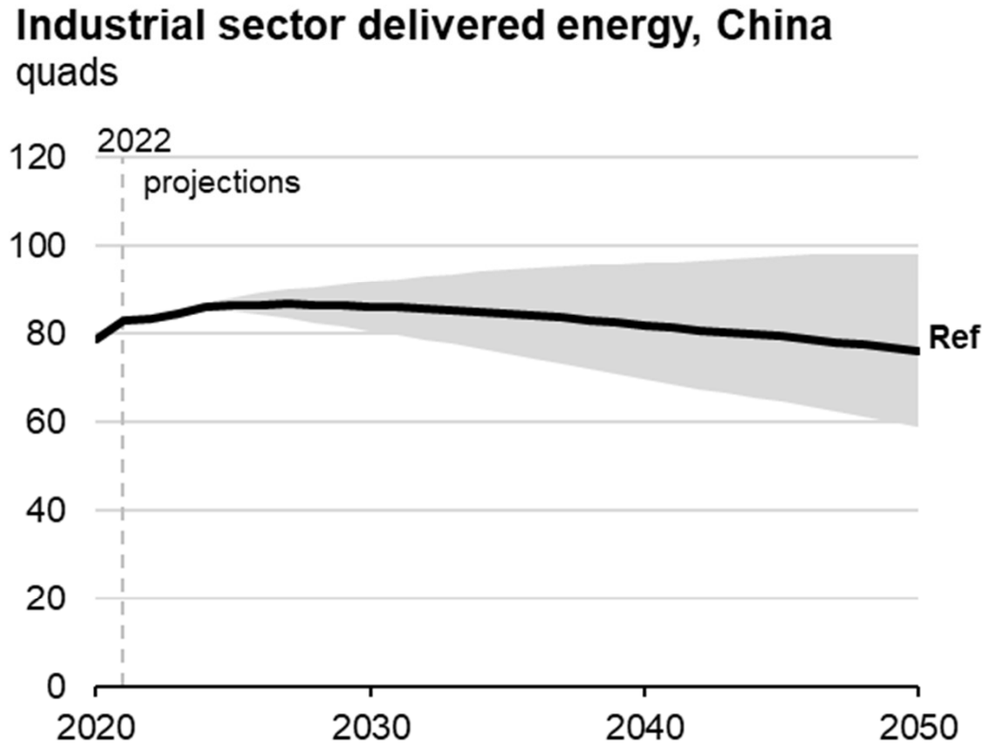
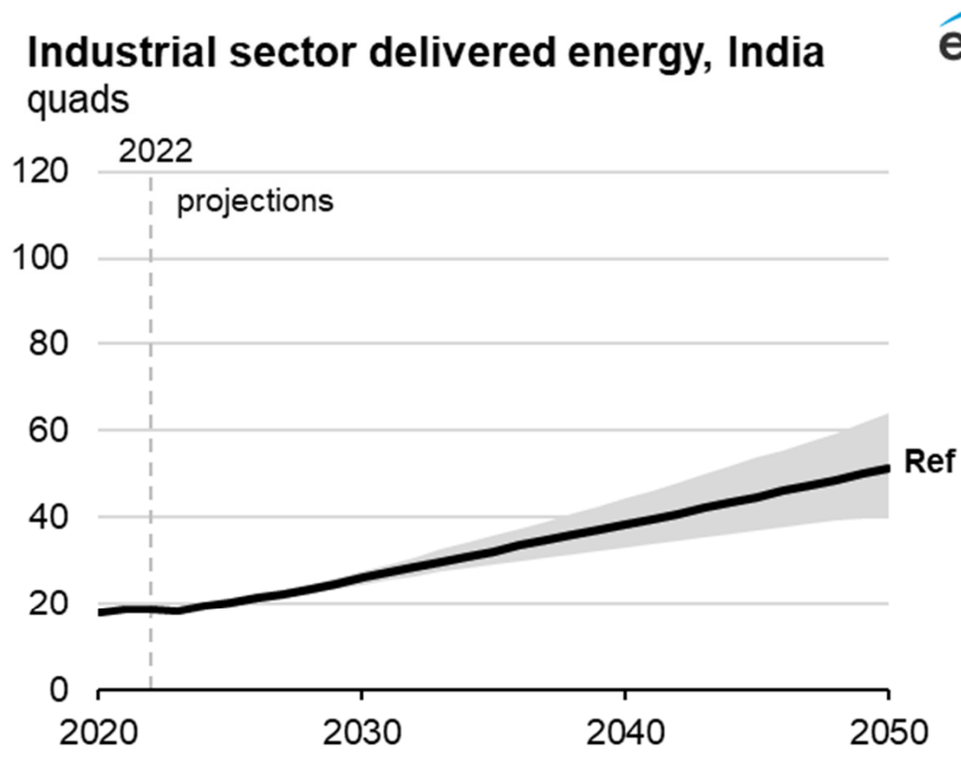
Industrial energy use varies across regions and is primarily determined by industrial gross output and energy efficiency; India's industrial sector has the steepest growth





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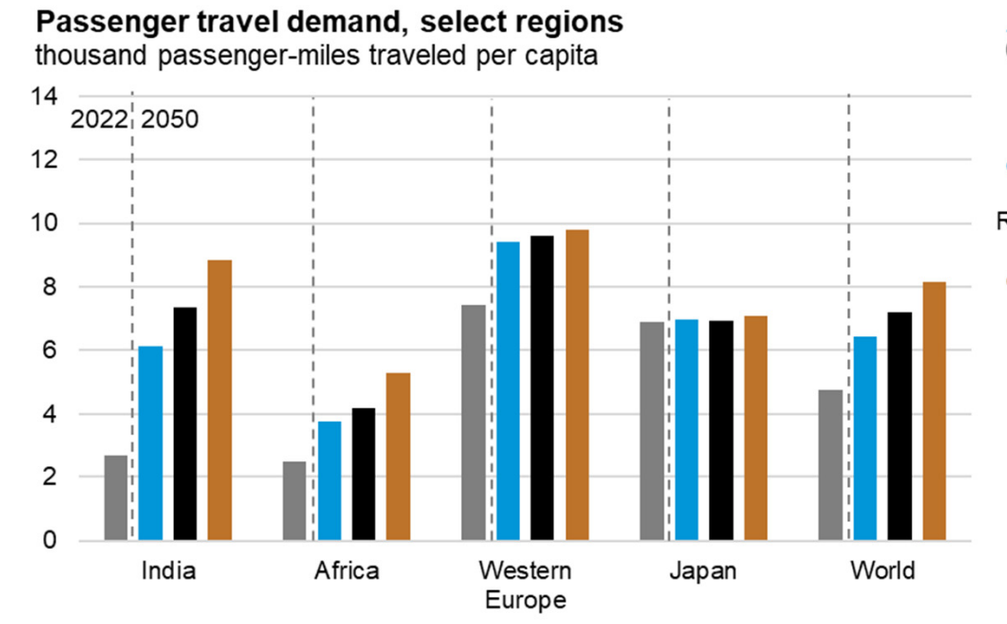
Increasing passenger demand drives global transportation consumption; Rising income enables travelers to shift from inexpensive, more efficient modes to more convenient, less efficient modes



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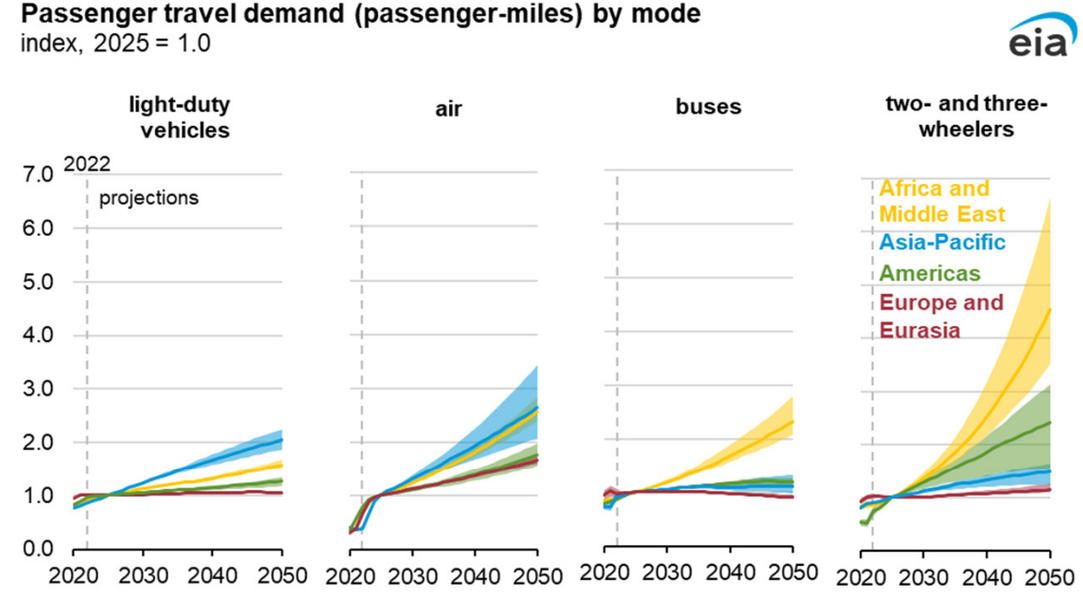

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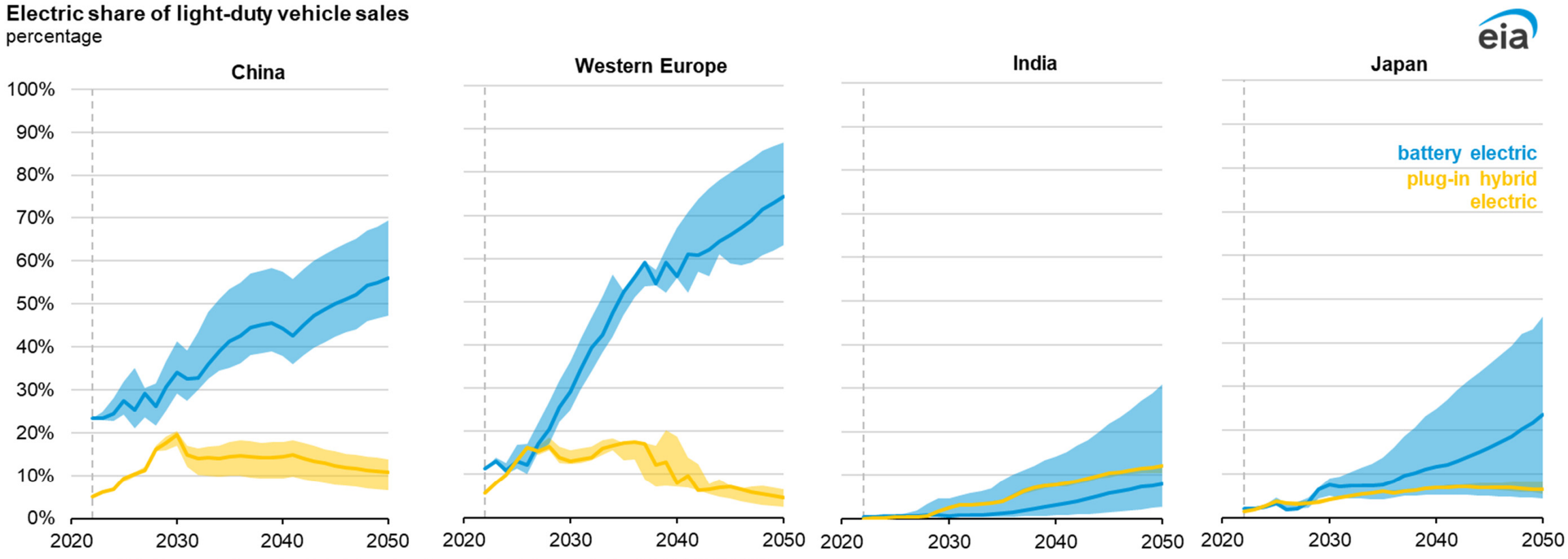
Electric vehicle sales grow due to policy incentives, battery costs, efficiency standards, and electricity prices



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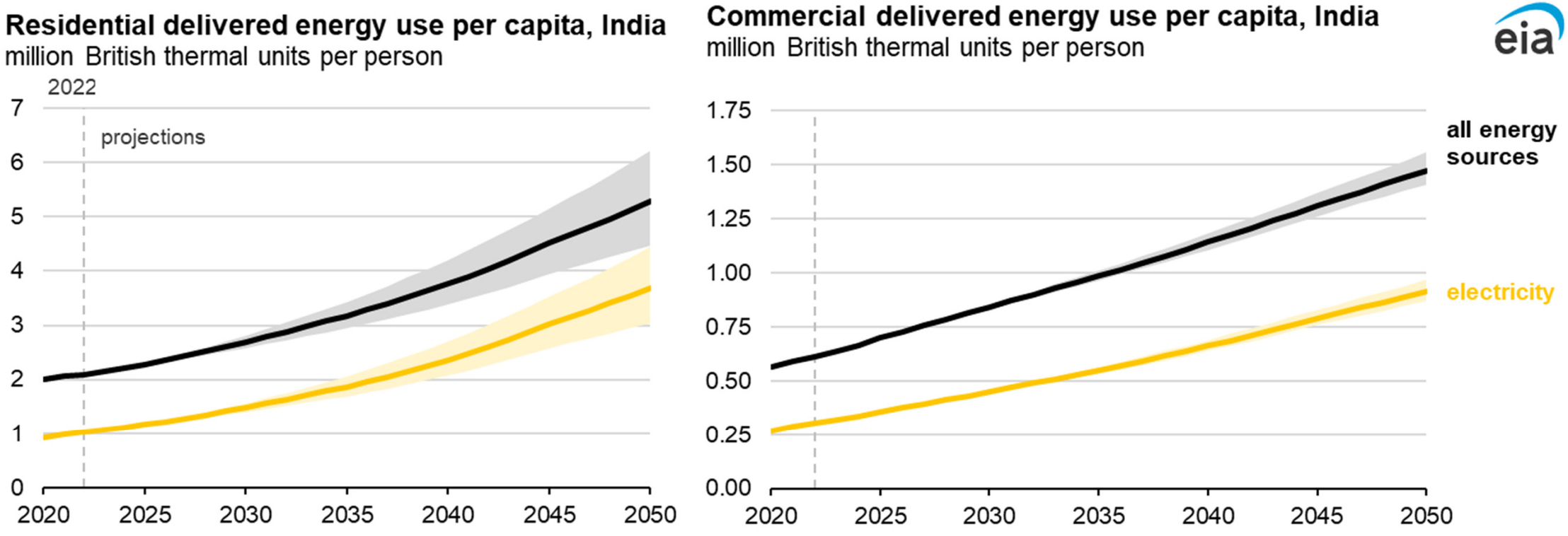
As India's economy expands, building electrification supports a rapidly expanding service sector and electricity use almost triples in homes



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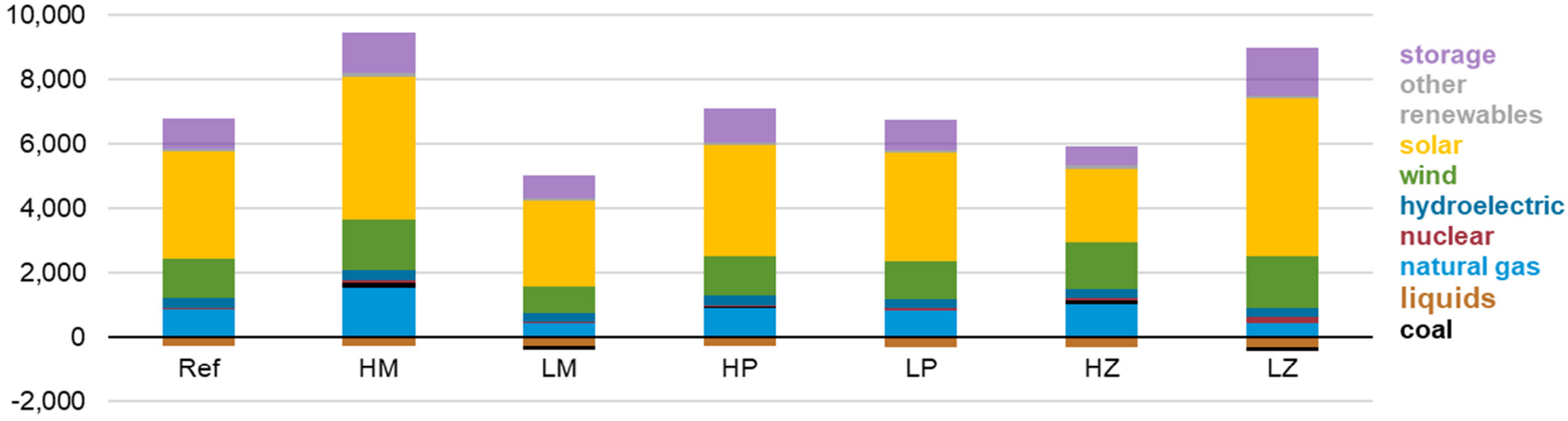
By 2050, global coal-fired and liquid fuel-fired electricity generating capacity decrease in most modeled cases

Change in total installed electricity generating capacity from 2022 to 2050, world
gigawatts



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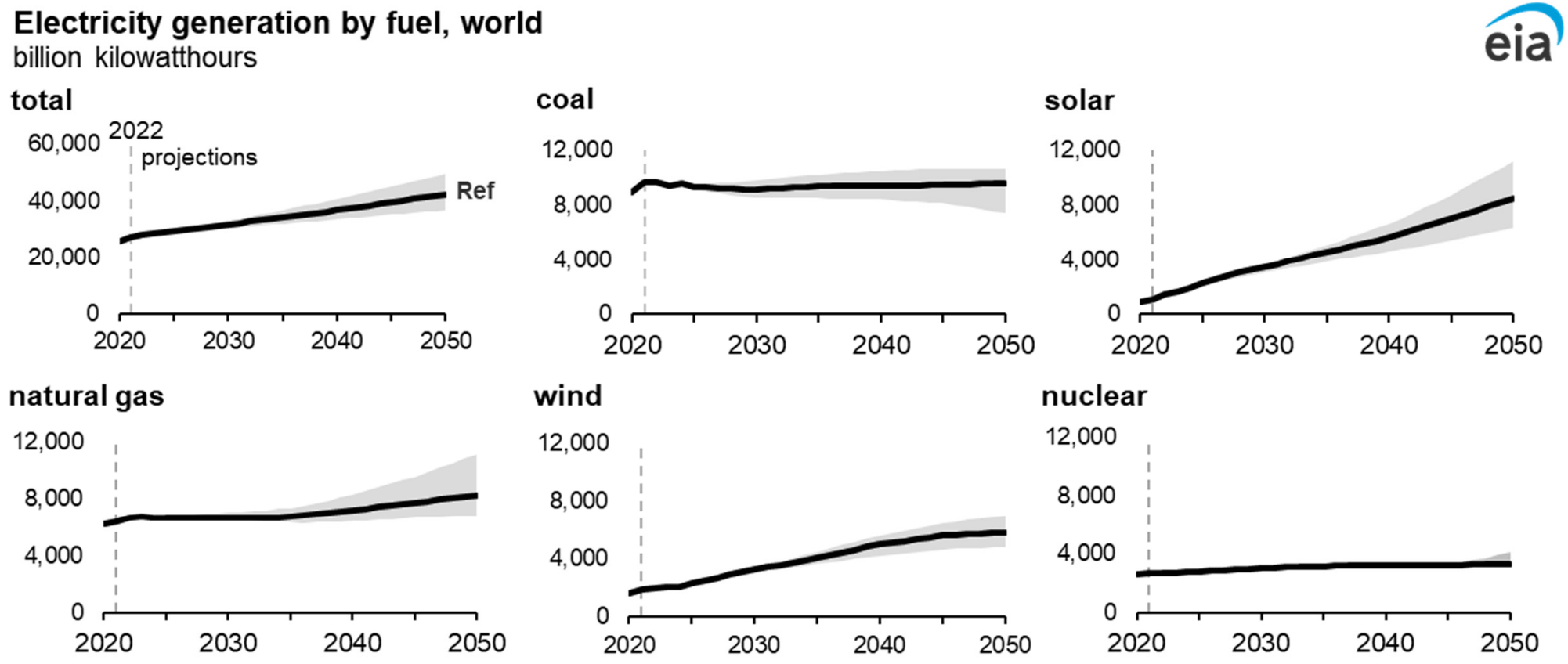
Total electricity generation worldwide increases 30% to 76% relative to 2022 across cases, and renewables and nuclear supply 54% to 67% of the total demand across cases in 2050



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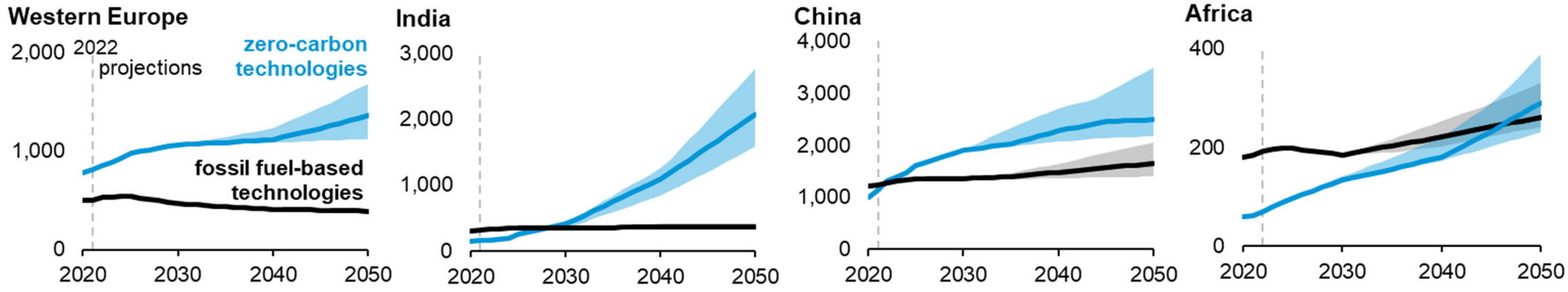
Energy security considerations that favor locally available resources contribute to zero-carbon technology growth, which varies by region

Electricity-generating capacity, zero-carbon and fossil fuel-based technologies, select regions
gigawatts



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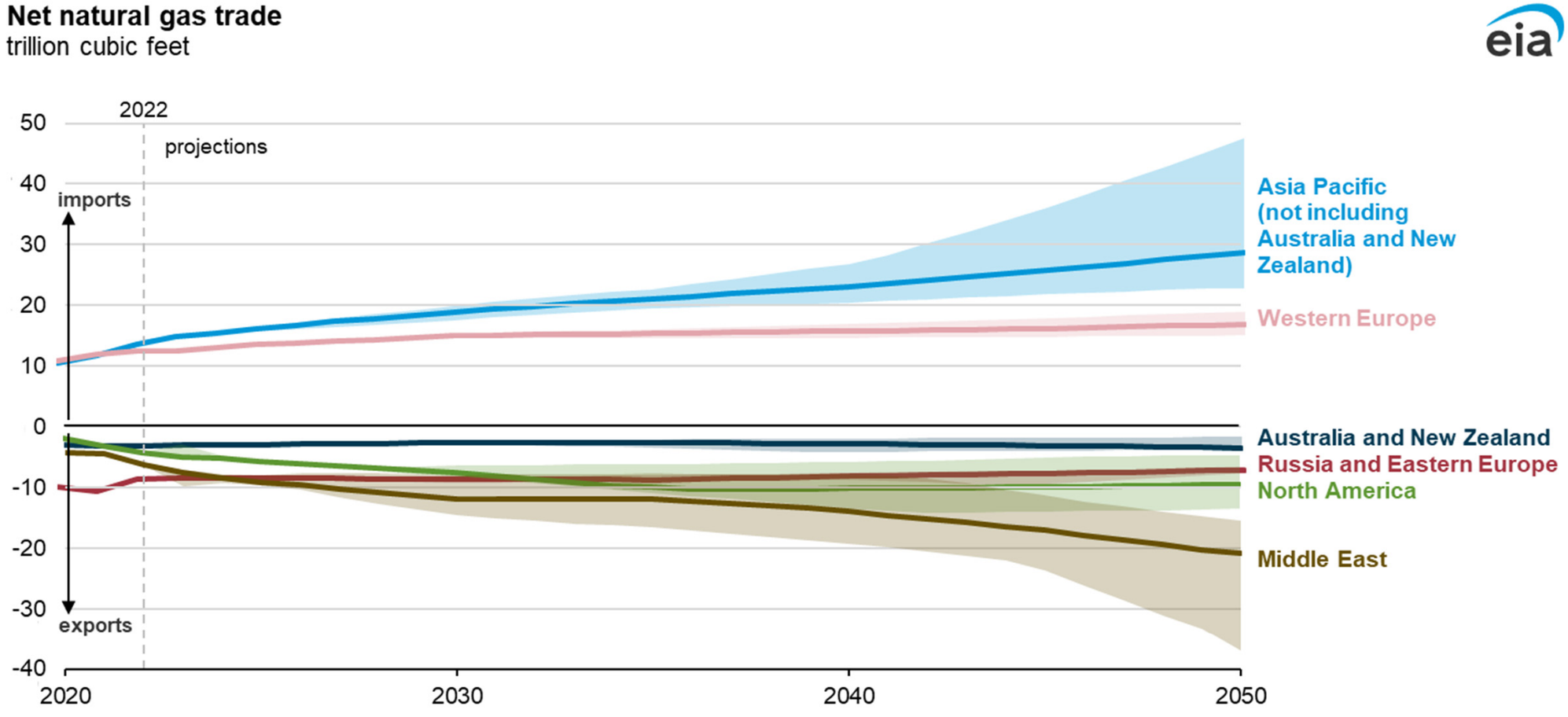
Asia and Europe import more natural gas to meet growing demand, mostly supplied by growing production from the Middle East



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