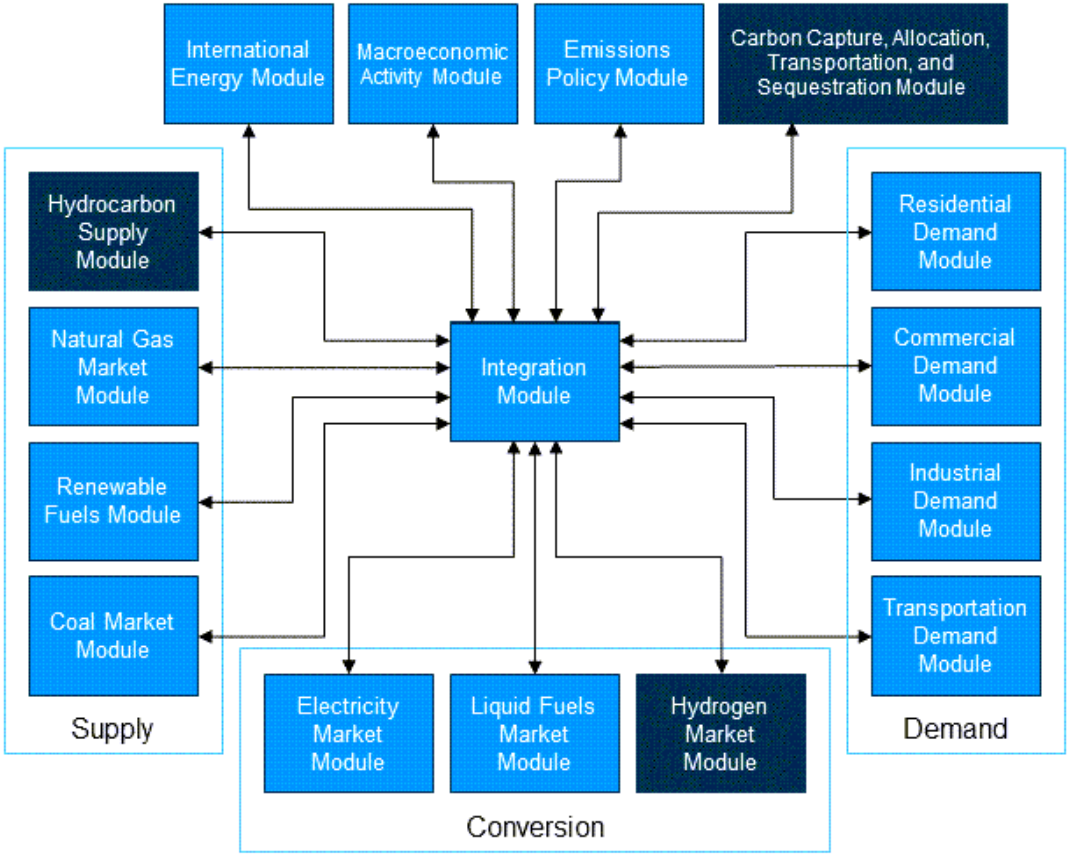
Annual Energy Outlook 2025 Working Group

Preliminary results for oil, natural gas, liquid fuels, and hydrogen

Internal and external stakeholders
Petroleum & Natural Gas Modeling Team
November 4, 2024 | Virtual

For AEO2025, EIA will introduce three new modules into NEMS, expanding our ability to project future energy markets.

- ***Hydrocarbon Supply Module***: upstream oil and natural gas production
- ***Hydrogen Market Module***: H_2 markets and infrastructure
- ***Carbon Capture, Allocation, Transportation, and Sequestration Module***: CO_2 markets and infrastructure



Working group presentation for discussion purposes.
Do not quote or cite because results are subject to change.

Hydrocarbon Supply Module

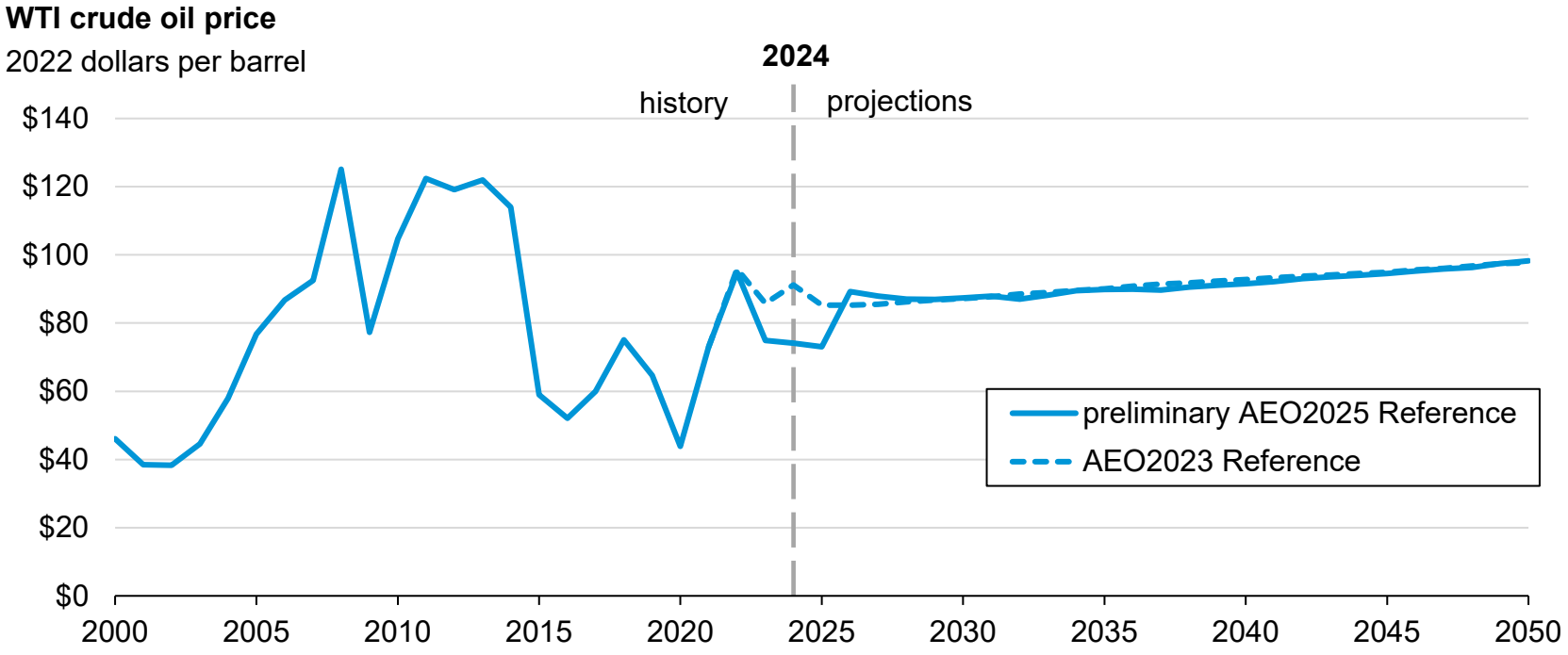
New Hydrocarbon Supply Module (HSM) enhancements

- New module introduced 7/11/24 replaces legacy Oil & Gas Supply Module
- Assumptions and enhancements described in presentation* and memo**

Enhancements	Preliminary impact on results
Less aggressive drilling assumptions	Lower hydrocarbon production in later years
Split decline curves for co-produced commodities	Higher natural gas relative to crude
Geology-specific cost equations	Lower hydrocarbon production
Added methane venting/flaring costs	Slight decline in hydrocarbon production
Dynamic CO_2 capture from natural gas processing	n/a
Simplified enhanced oil recovery representation	Slight decline in crude oil production
Federal/non-federal land representation	Decline due to revised royalty rates

Notes: * https://www.eia.gov/outlooks/aeo/workinggroup/hydrocarbon/pdf/Introduction_to_Hydrocarbon_Supply_Module.pdf
** https://www.eia.gov/aeo/workinggroup/hydrocarbon/pdf/AEO2025_HSMWorkingGroup_Memo.pdf

West Texas Intermediate (WTI) crude oil prices are similar to last AEO



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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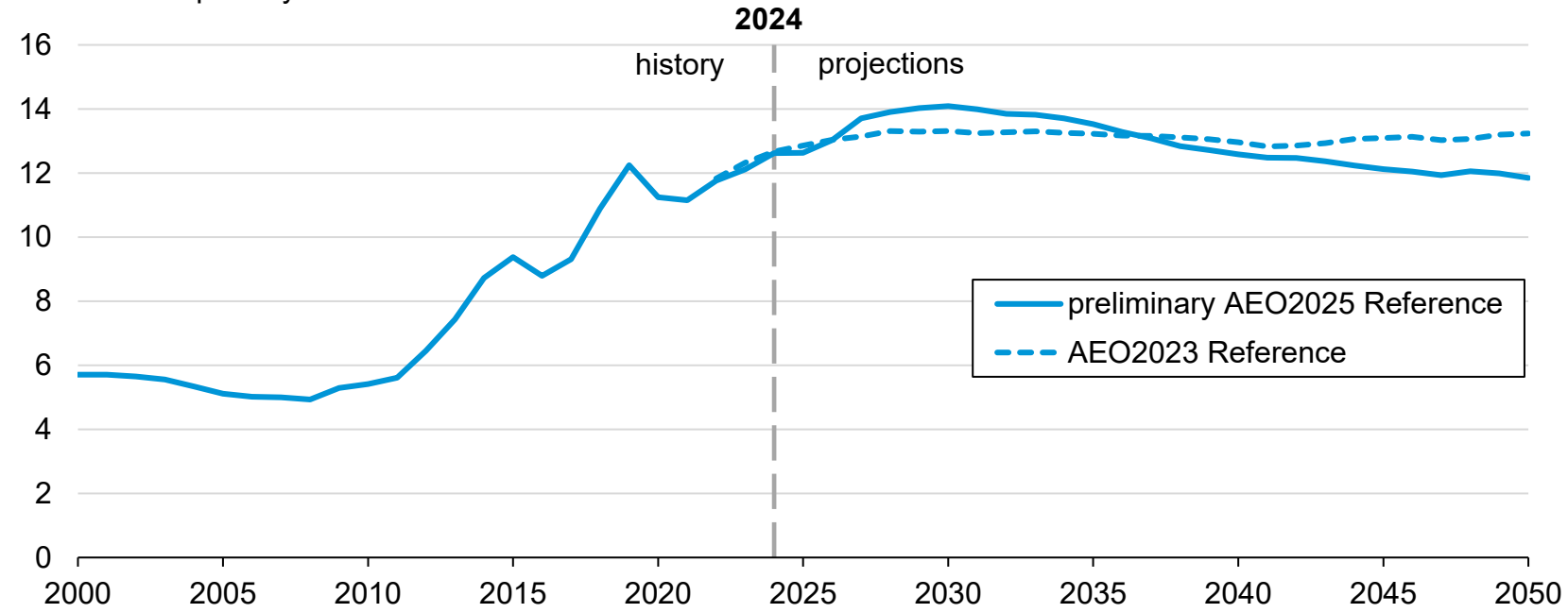
U.S. crude oil production increases through 2030, then declines gradually back to 2023 levels by end of projection period

U.S. crude oil production

million barrels per day



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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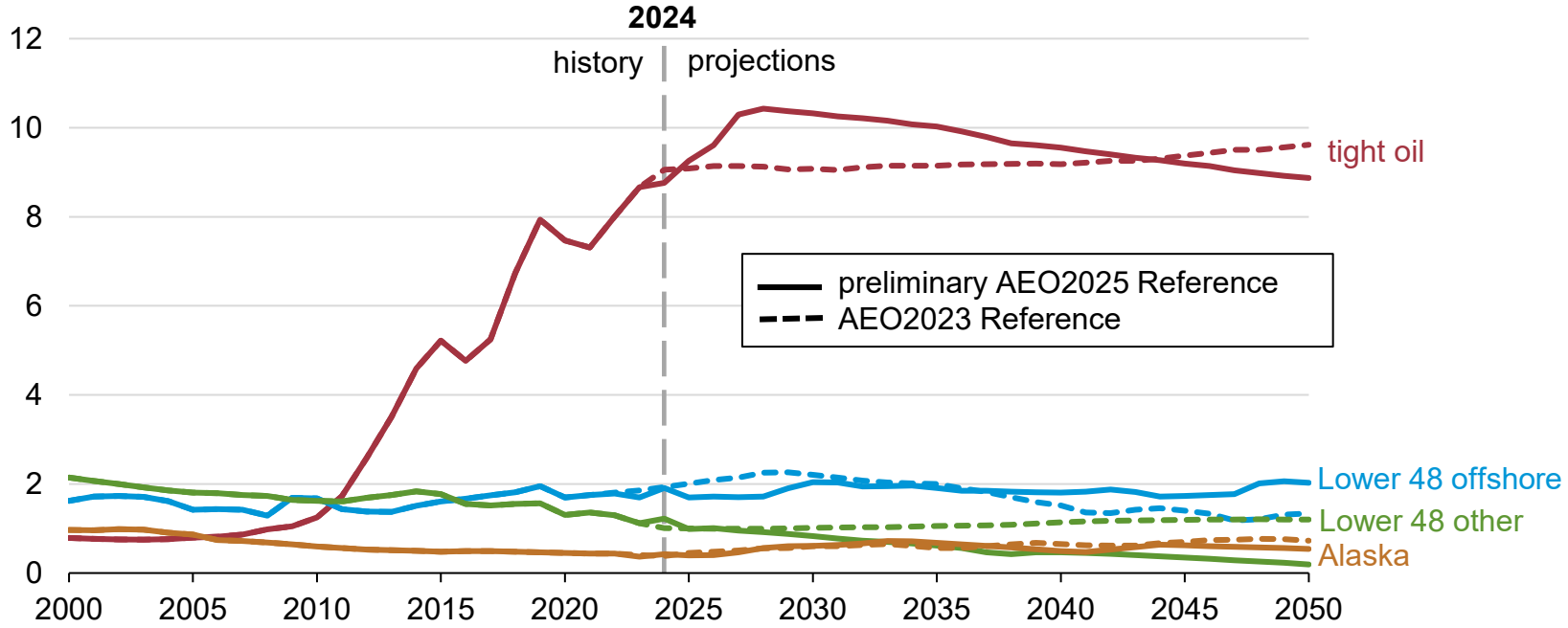
Tight oil leads growth in U.S. crude oil production in AEO2025

U.S. crude oil production by type

million barrels per day



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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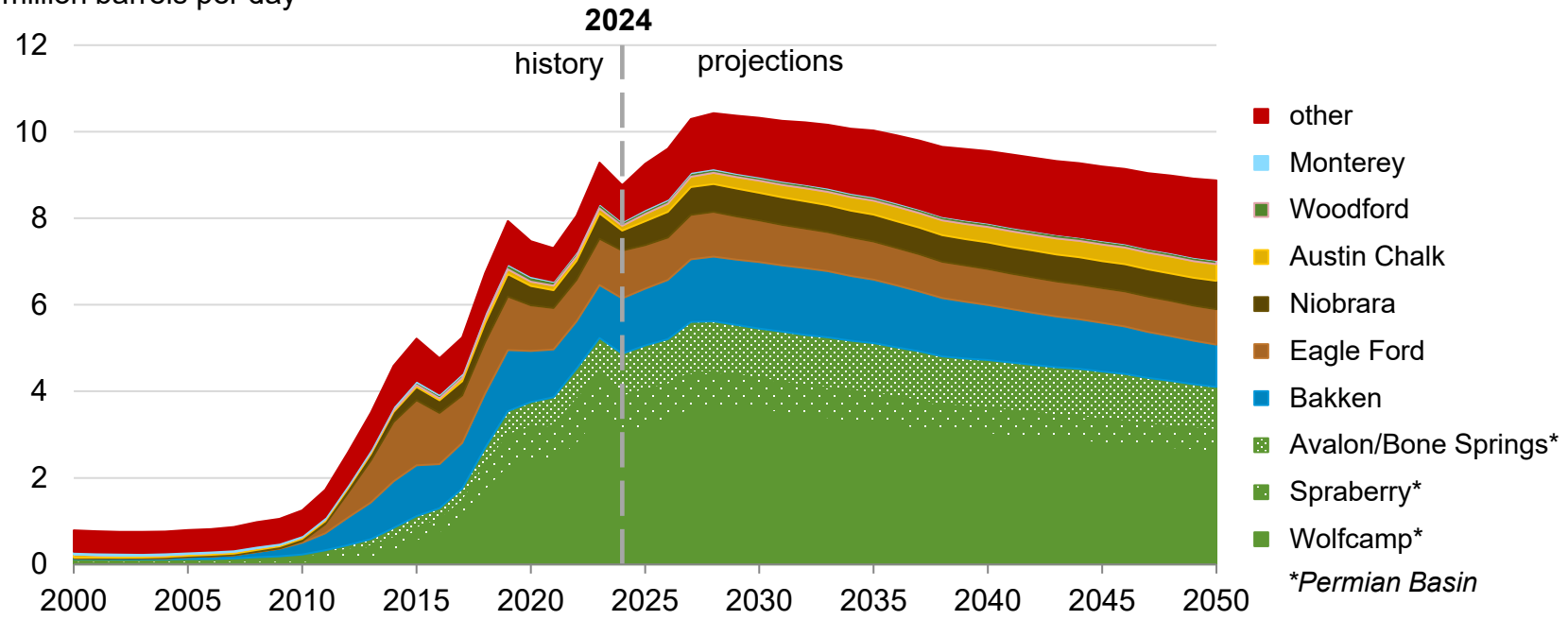
Permian plays lead production throughout the projection period

Crude oil production by selected tight oil plays

million barrels per day



Data source: Preliminary AEO2025 runs, dated October 11, 2024

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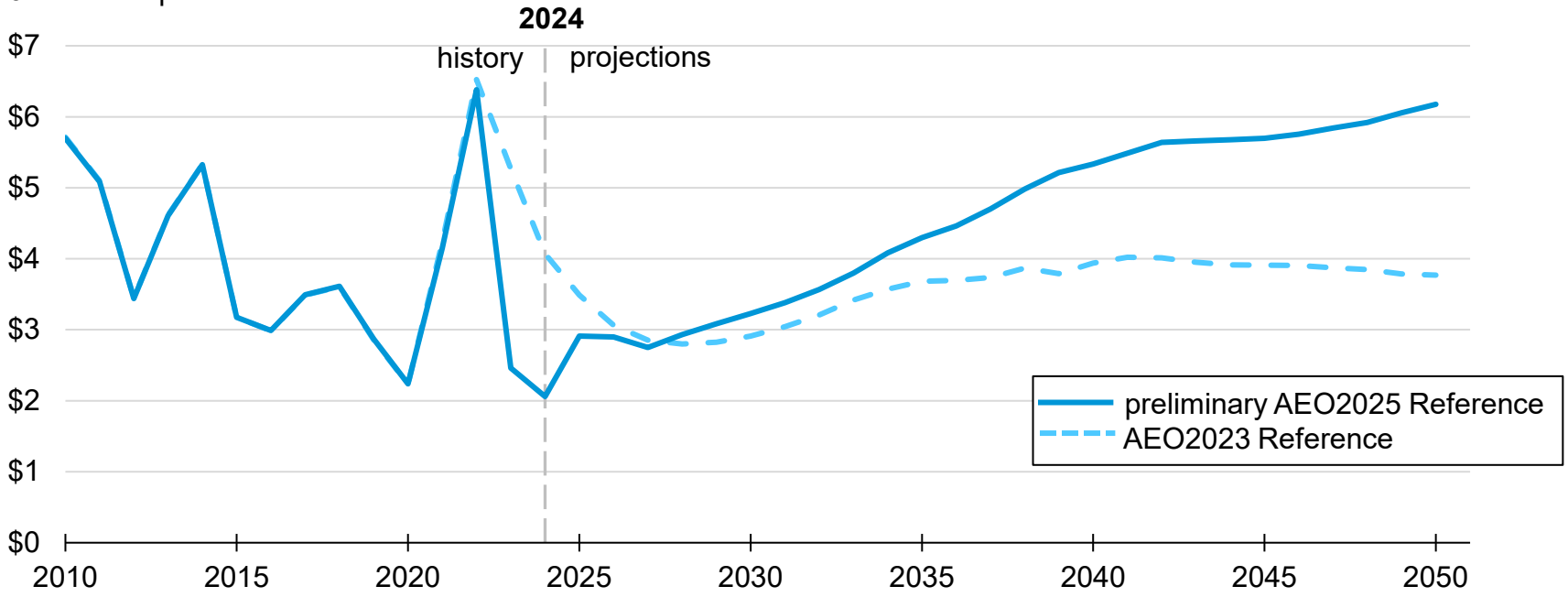
U.S. Henry Hub natural gas spot price increases steadily as highly economic resources deplete and production moves to less economical formations

Henry Hub natural gas spot price in the Reference case

2022 dollars per million British thermal units



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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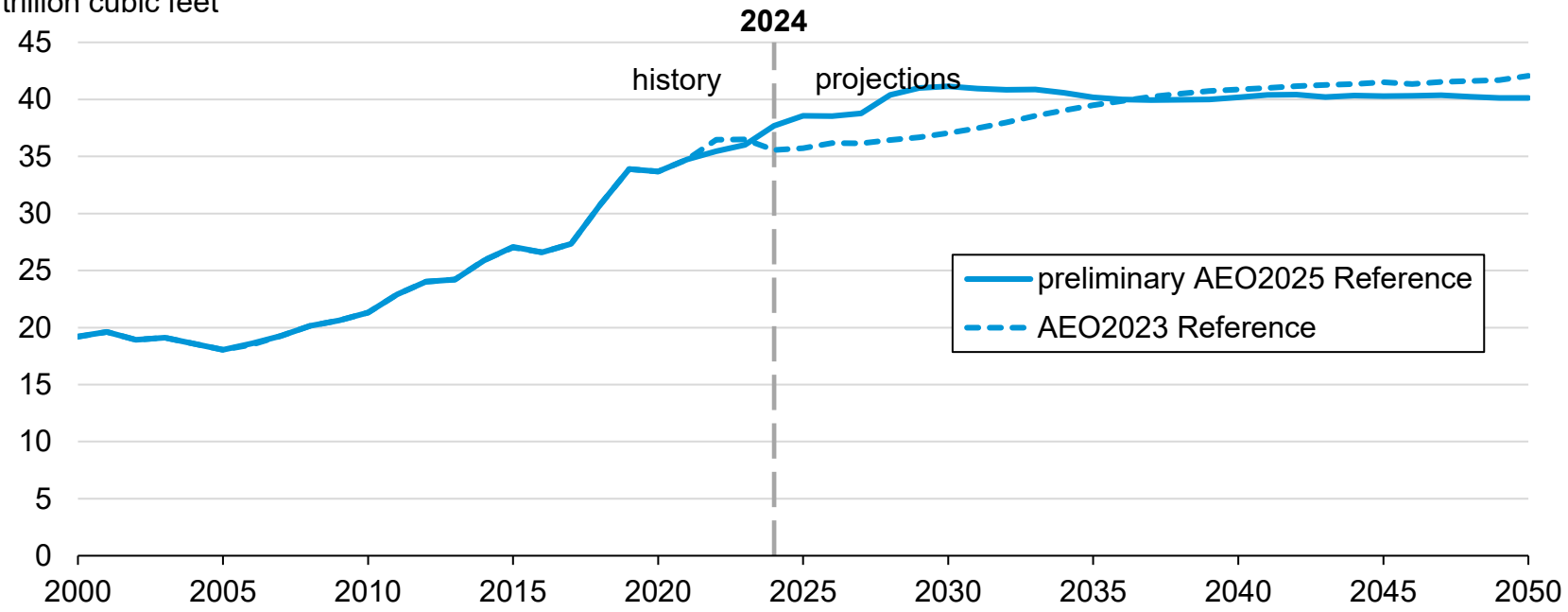
U.S. dry natural gas production increases through 2030 before leveling off

U.S. dry natural gas production

trillion cubic feet



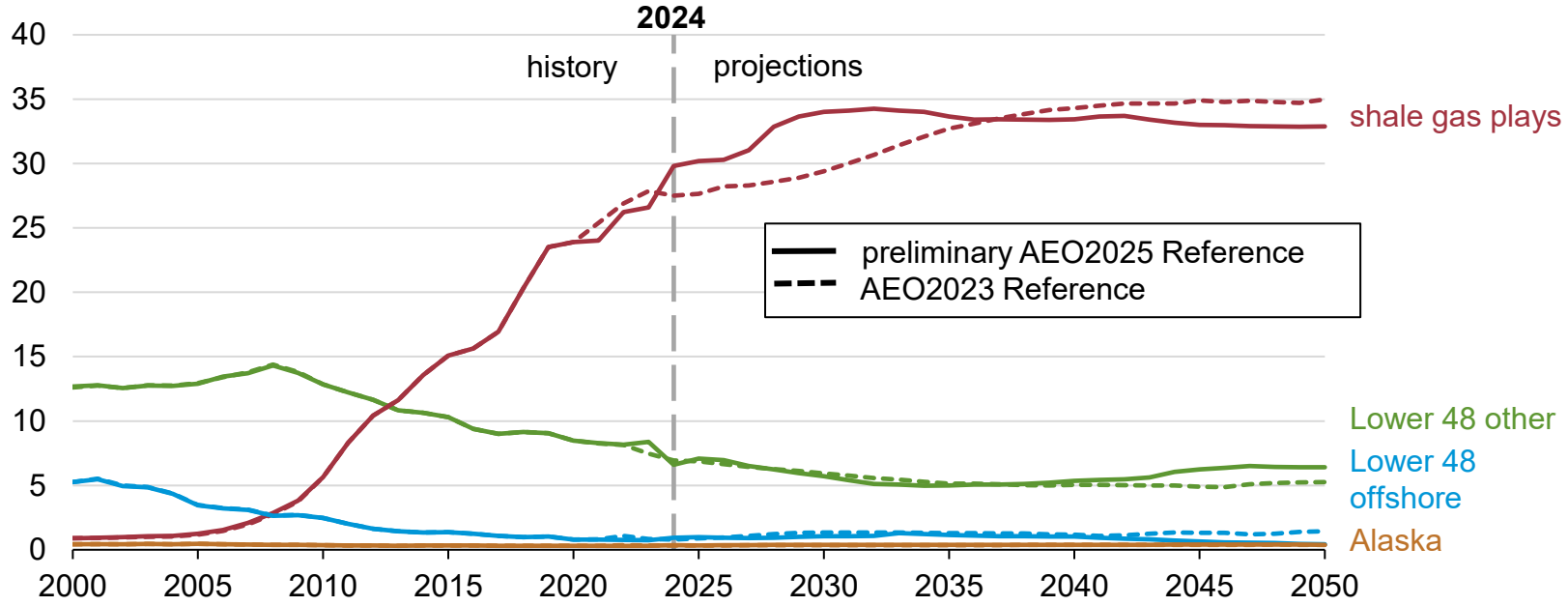
Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Note: 1 trillion cubic feet = 2.74 billion cubic feet per day

Shale gas leads growth in U.S. dry natural gas production in AEO2025

U.S. dry natural gas production by type

trillion cubic feet

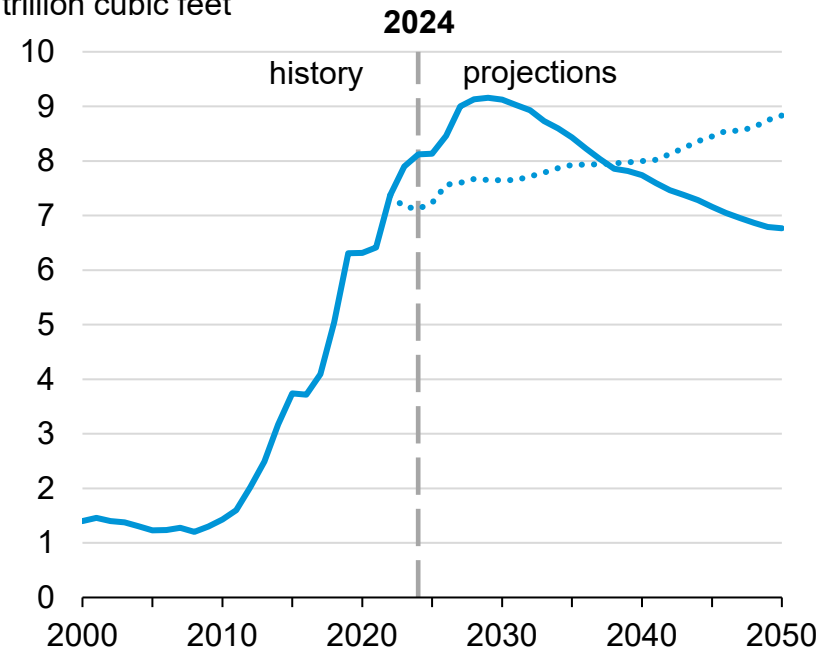


Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

U.S. dry natural gas production from oil formations trends with crude oil production

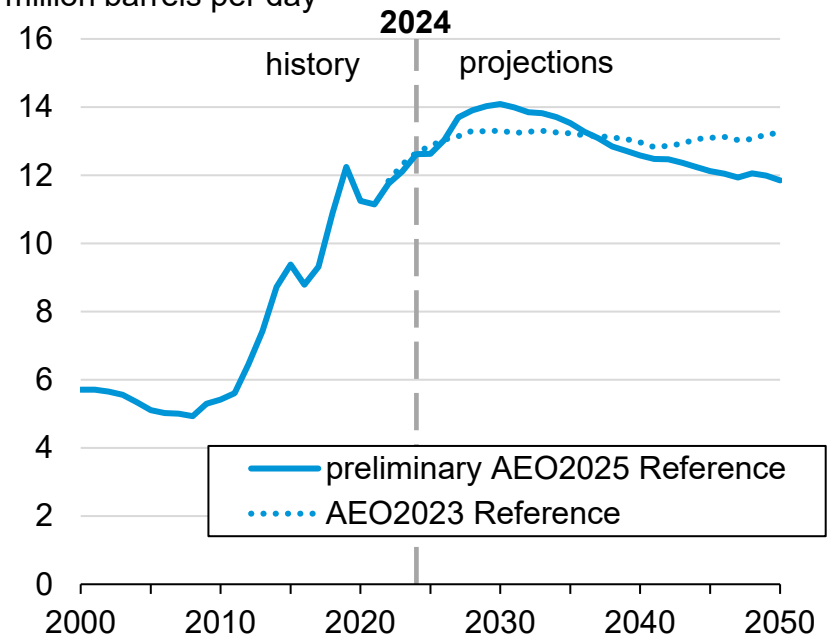
U.S. dry natural gas production from oil formations

trillion cubic feet



U.S. crude oil production

million barrels per day



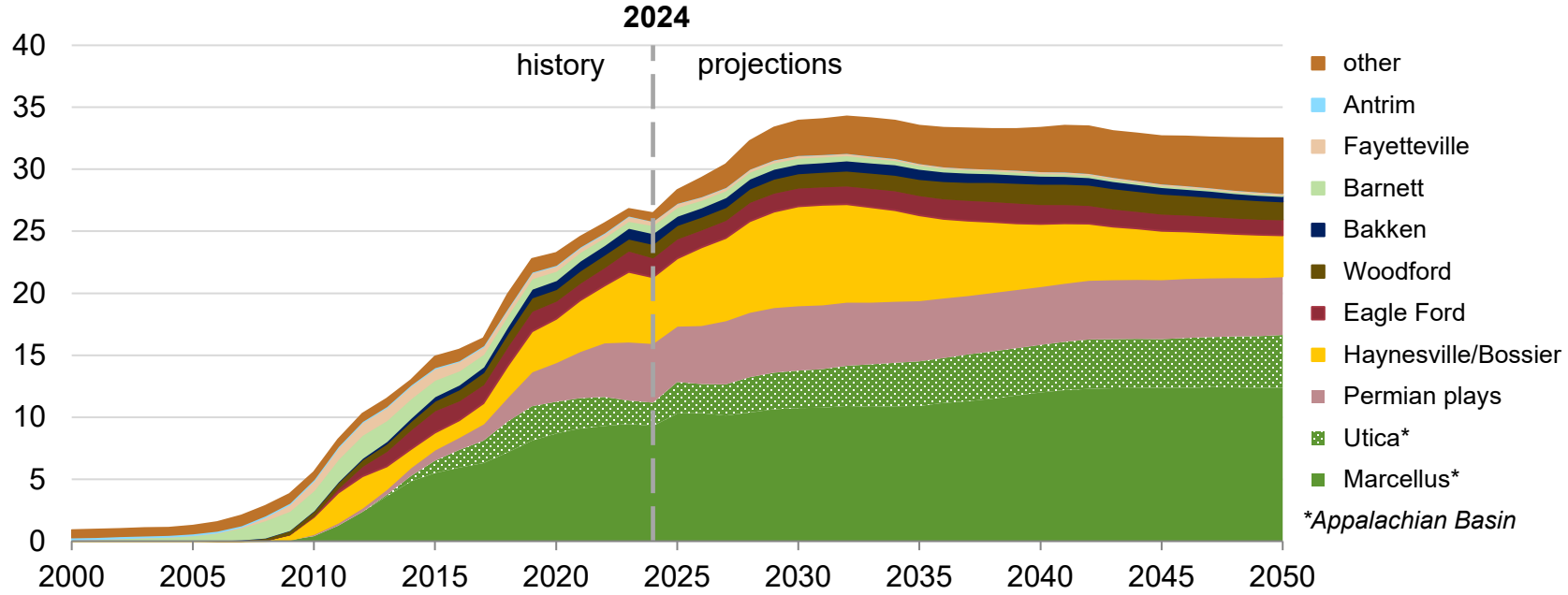
Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Note: 1 Tcf = 2.74 Bcf/d

Appalachian Basin leads shale gas production in AEO2025, with significant production volumes from the Southeast directed to LNG

Dry natural gas production by selected shale play

trillion cubic feet



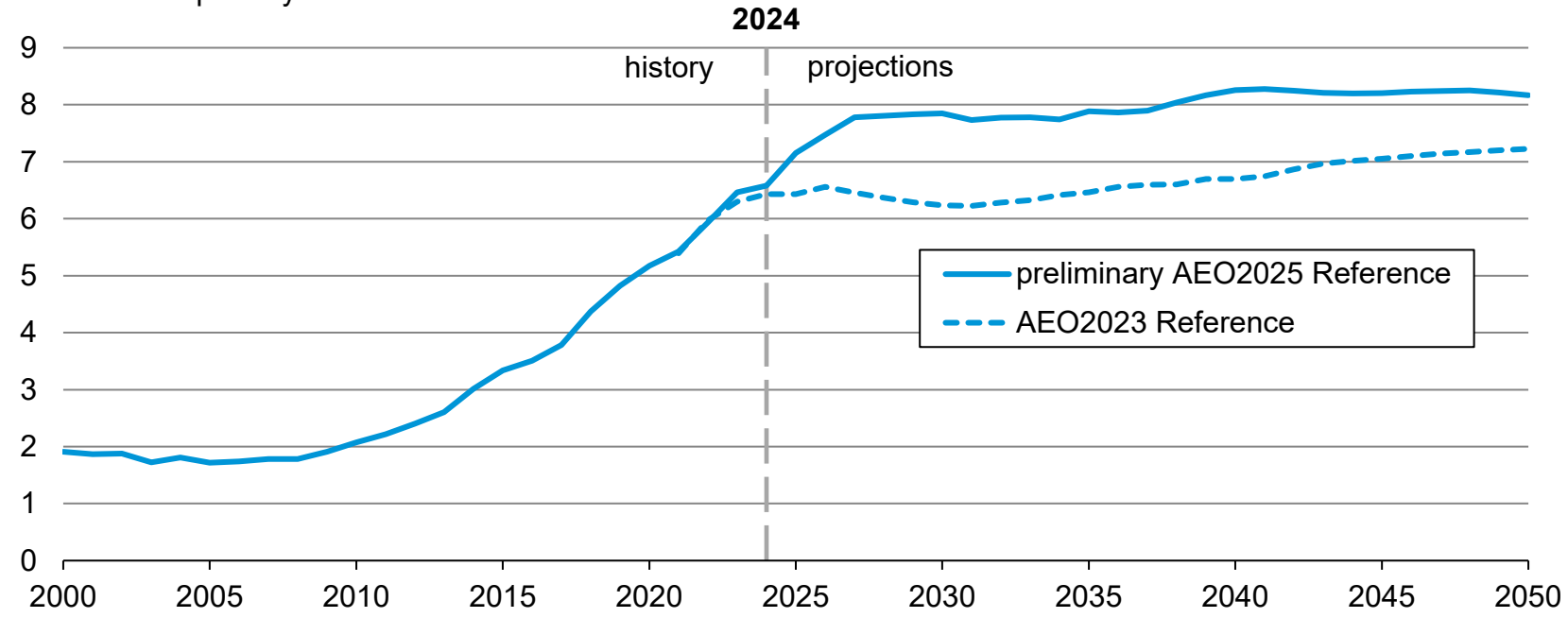
Data source: Preliminary AEO2025 runs, dated October 11, 2024

Note: *Other* includes natural gas production in tight oil plays.

Increased natural gas production in Appalachia, which has a high liquids-to-gas ratio, leads to higher natural gas plant liquids production through mid-term

U.S. natural gas plant liquids production

million barrels per day



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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Natural Gas Markets

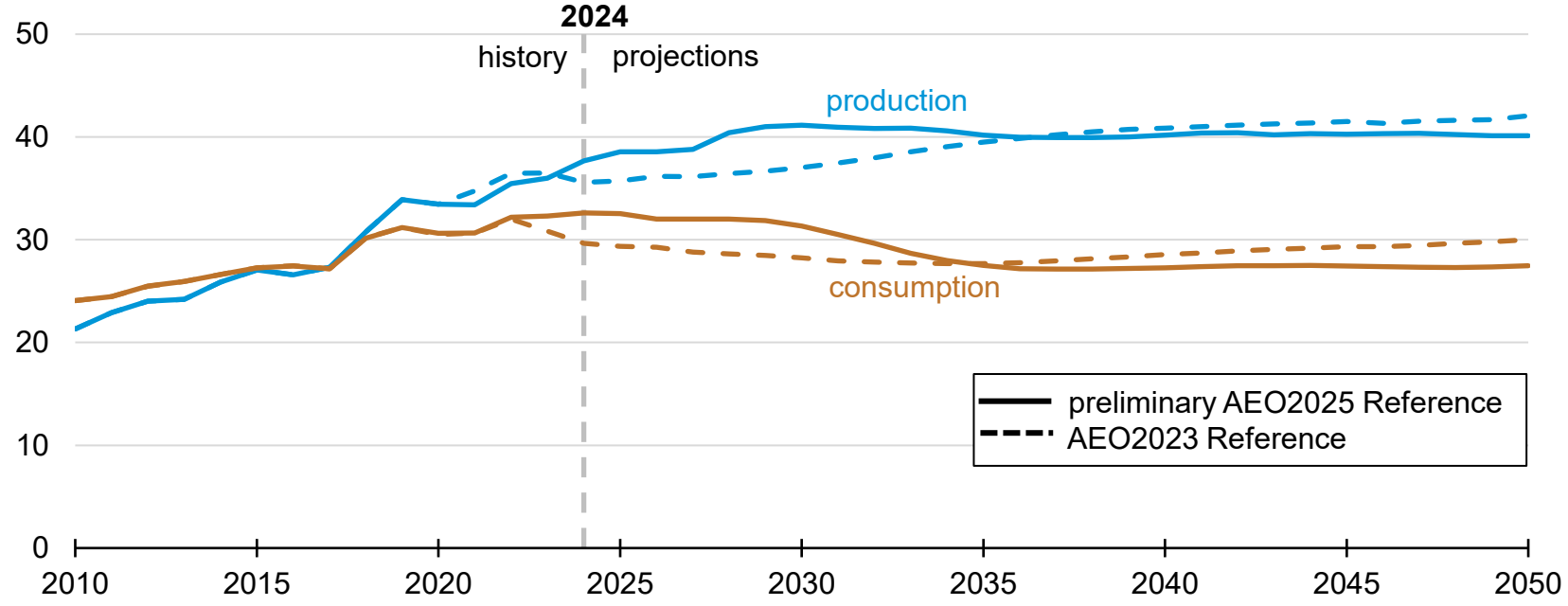
Natural Gas Market Module data updates and changes for AEO2025

- *Natural Gas Annual* released September 2024 (2023 annual data)
- *Natural Gas Monthly* through April 2024 (complete 2023 history)
- Historical data for Mexico and Canada through 2023
- Pipeline capacity and pipeline projects tracked by EIA
- Updates to natural gas spot price data
- These changes between AEO2023 and preliminary AEO2025 projections are driven by external changes in assumptions:
  - World oil price assumptions
  - *Short-Term Energy Outlook* forecast
  - Impacts from the Inflation Reduction Act in the upstream and electric power sectors

Overall domestic consumption of natural gas declines in AEO2025, while natural gas production grows slightly to accommodate rise in LNG exports

U.S. dry natural gas production and consumption in the Reference case

trillion cubic feet



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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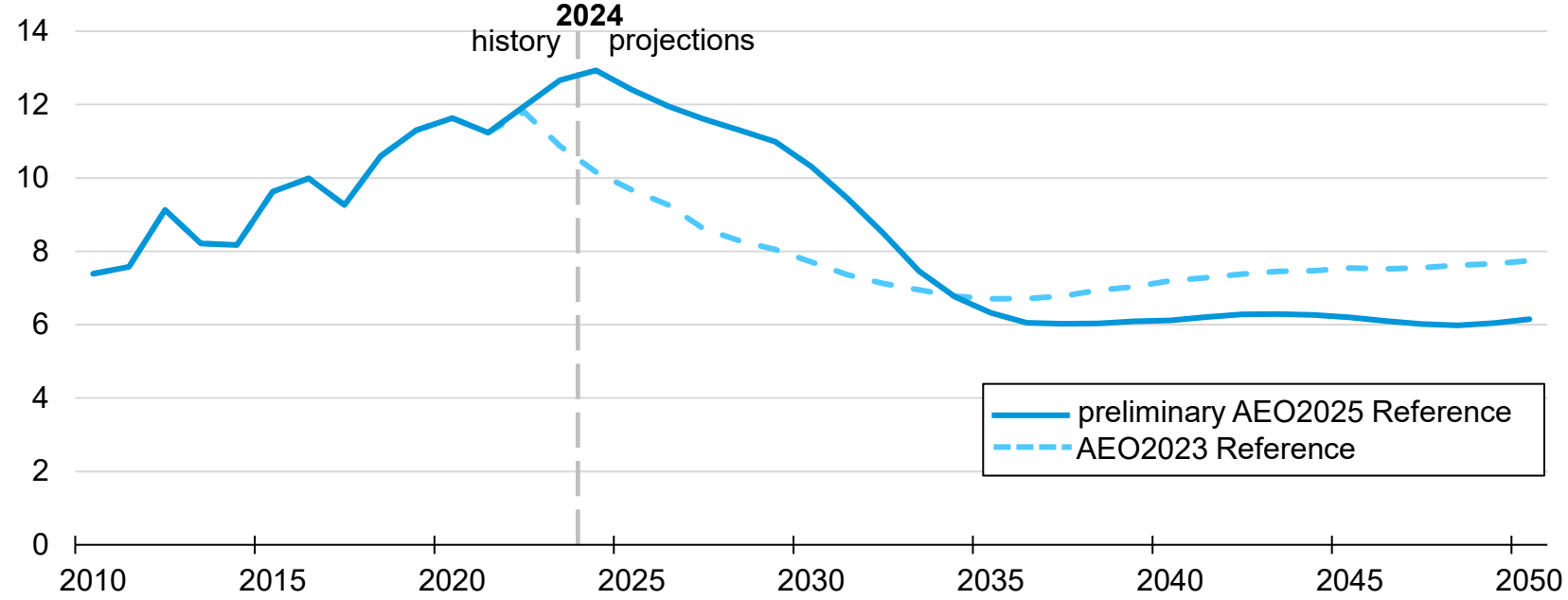
Natural gas consumption in the electric power sector declines in AEO2025 due to effects from the Inflation Reduction Act and higher natural gas prices

U.S. natural gas consumption in the electric power sector

trillion cubic feet



Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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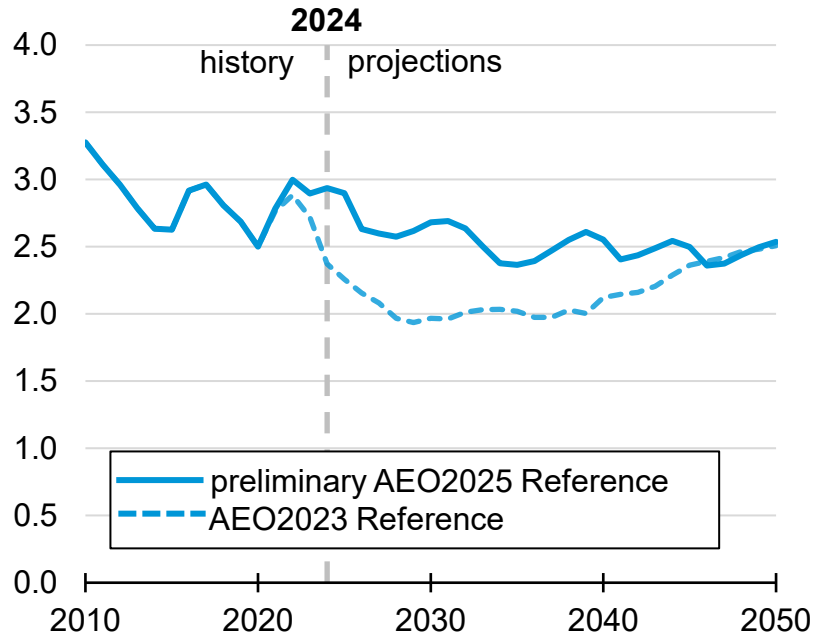
Net imports from Canada are higher in AEO2025 compared with AEO2023

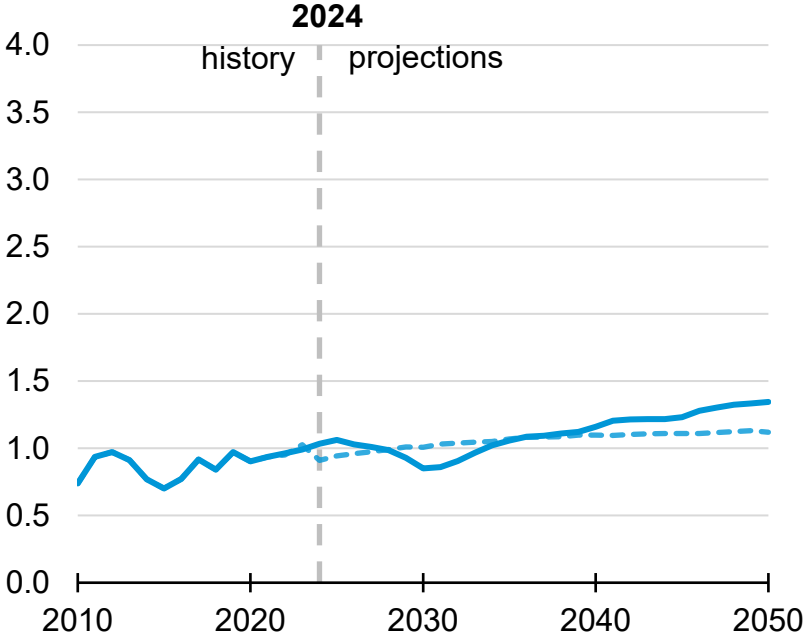
U.S. natural gas imports from Canada

trillion cubic feet



U.S. natural gas exports to Canada

trillion cubic feet

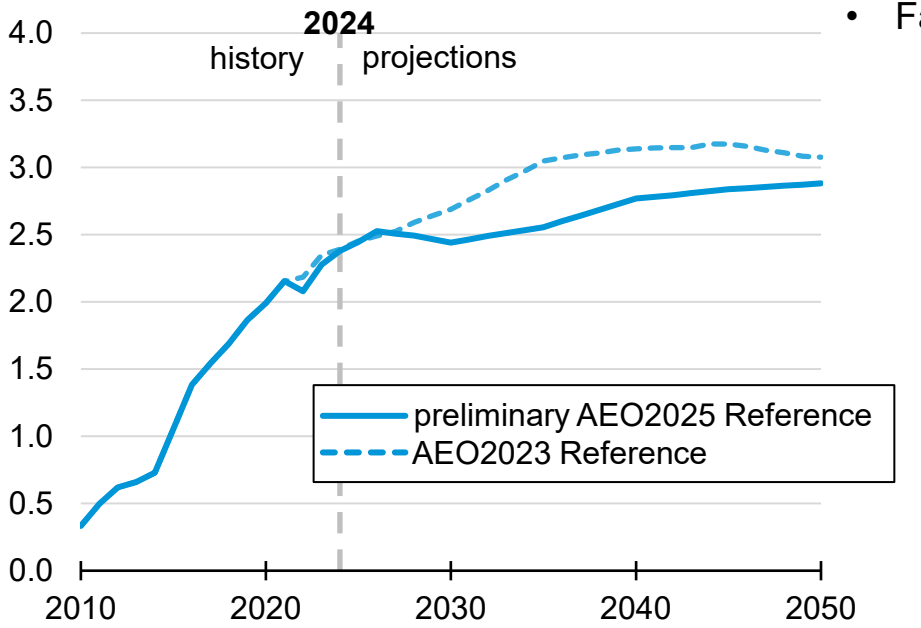


Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

AEO2025 pipeline exports to Mexico grow in the near term but finish the projection period lower than AEO2023

U.S. pipeline exports to Mexico

trillion cubic feet



- Factors affecting projected exports to Mexico:
  - Near-term growth in exports to Mexico reflects LNG facilities in Mexico coming online (Altamira and Costa Azul)
  - Less growth in Mexico's natural gas consumption reduces exports through most of the projection period (latest consumption outlook based on IEO2023)

Data sources: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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Updated LNG export assumptions for under construction projects

LNG project	AEO2023 assumed in-service date	AEO2025 assumed in-service date	Baseload capacity (Bcf/d)
Golden Pass Train 1–3	Dec. 2023	Dec. 2026 – Dec. 2027	2.04
Plaquemines Phase 1	Dec. 2024	Dec. 2024	1.32
Plaquemines Phase 2	N/A	Sep. 2025	1.32
Corpus Christi Stage III	Dec. 2025	Dec. 2024	1.32
Port Arthur Phase 1	N/A	Dec. 2027	1.58
Rio Grande Phase 1	N/A	Dec. 2027 – Dec. 2029	2.16

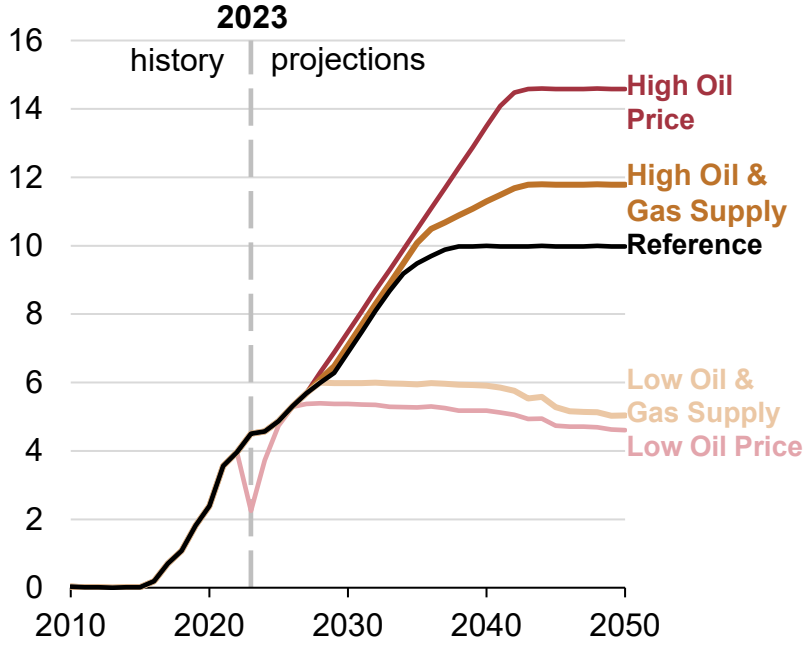
- Other updates:
  - Moved the first year that endogenous LNG builds can come online from 2027 to 2029

Note: Bcf/d = billion cubic feet per day

LNG exports are higher in AEO2025 compared with AEO2023, reaching a peak in the mid-2030s

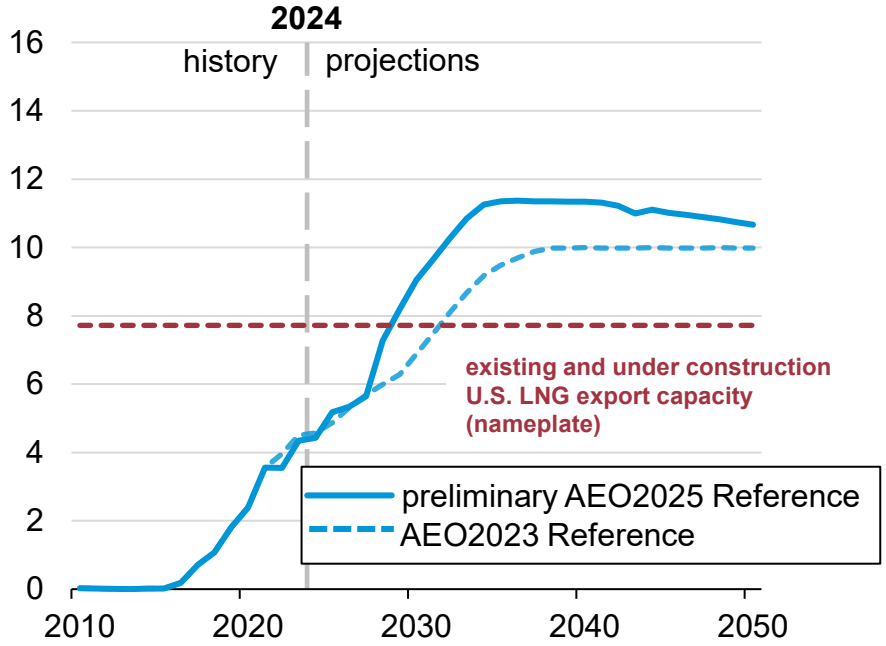
AEO2023 U.S. LNG exports by side case

trillion cubic feet



U.S. LNG exports in Reference case

trillion cubic feet



Data source: Preliminary AEO2025 run, dated October 11, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Liquid Fuels

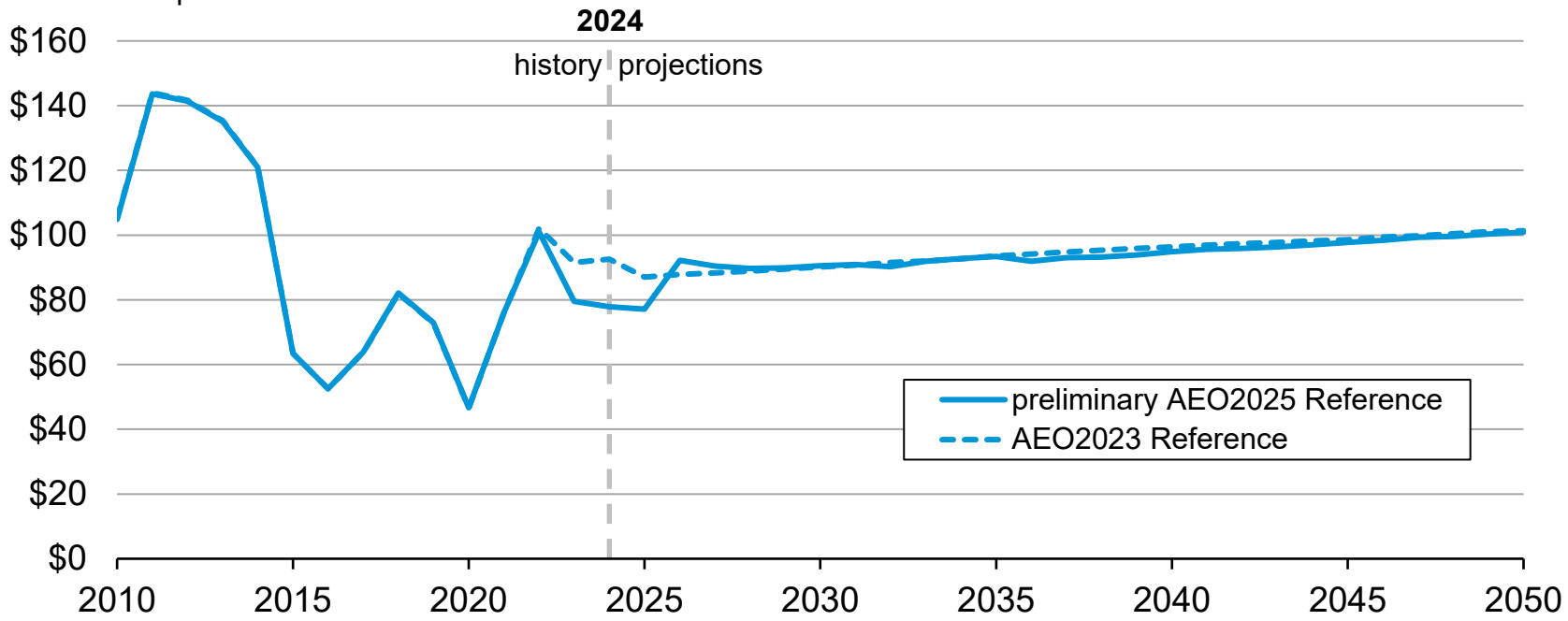
AEO2025 Liquid Fuels Market Module and International Energy Module updates

- International crude oil and petroleum product import and export curves
- Crude oil price differentials by crude oil type
- Pipeline capacity and transport costs
- State and federal fuel taxes
- Historical and *Short-Term Energy Outlook* (STEO) liquid fuels data
- Capacity updates for refineries, biofuels, and cogeneration
- Changes to representation of H_2 production and carbon capture and sequestration (CCS) retrofits for ethanol plants
- Renewable Fuel Standard update based on June 2023 EPA rulemaking
- Washington Clean Fuel Standard representation

Brent crude oil prices are lower in early projection years, then minimal change compared with AEO2023

Brent crude oil spot price

2022 dollars per barrel

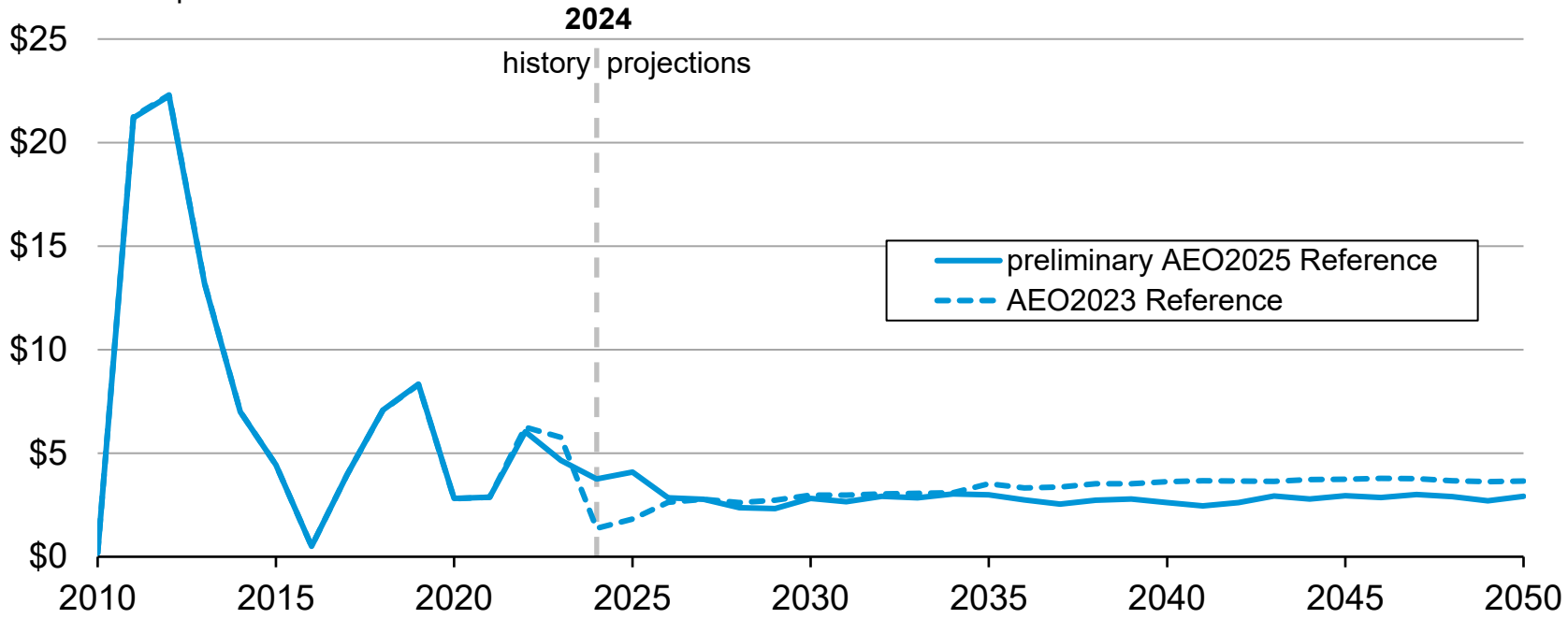


Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Brent-WTI price spread rises slightly based on STEO forecasts, then remains between $2/bbl - $3/bbl throughout the projection.

Brent-WTI price spread

2022 dollars per barrel



Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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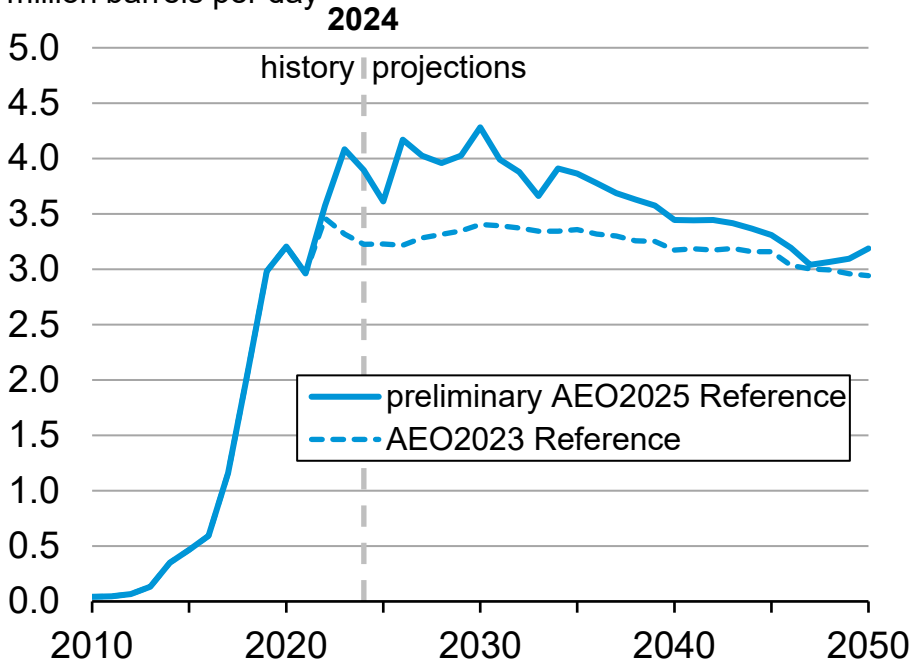
Crude oil exports decline over the projection period and are projected to remain between 25% and 30% of total crude oil production

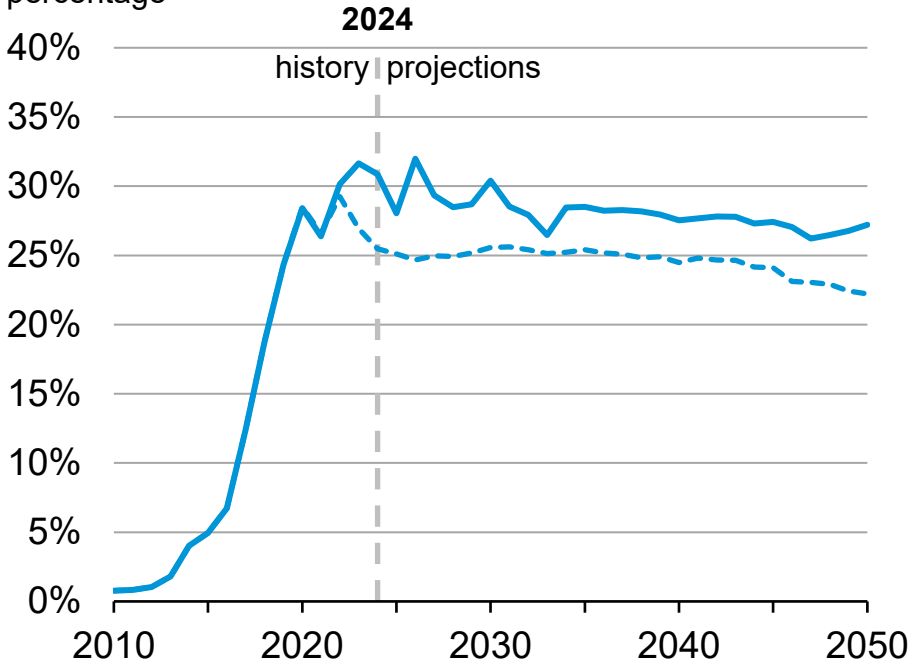
Gross crude oil exports

million barrels per day



Crude oil exports as a fraction of U.S. production

percentage



Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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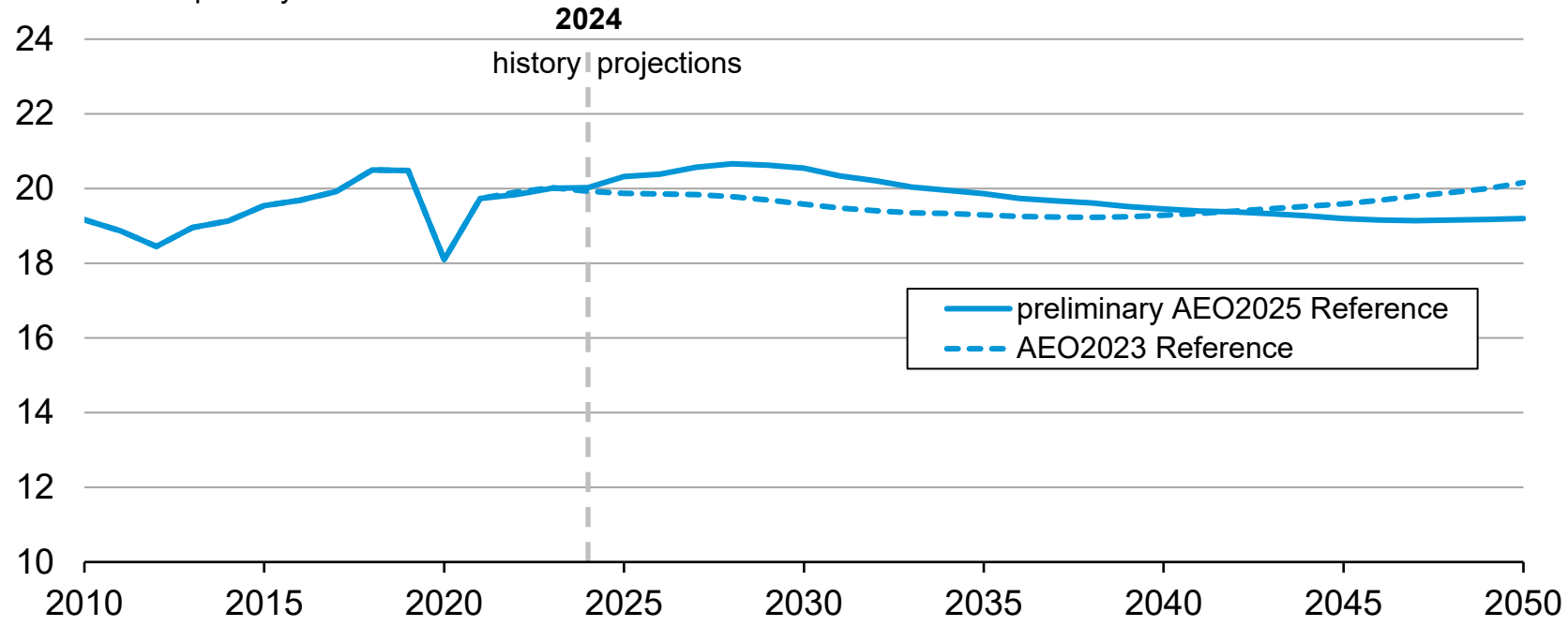
Consumption is met through a combination of domestic production and net imports of both crude oil-based and biofuels-based products

Domestic petroleum product consumption

million barrels per day



Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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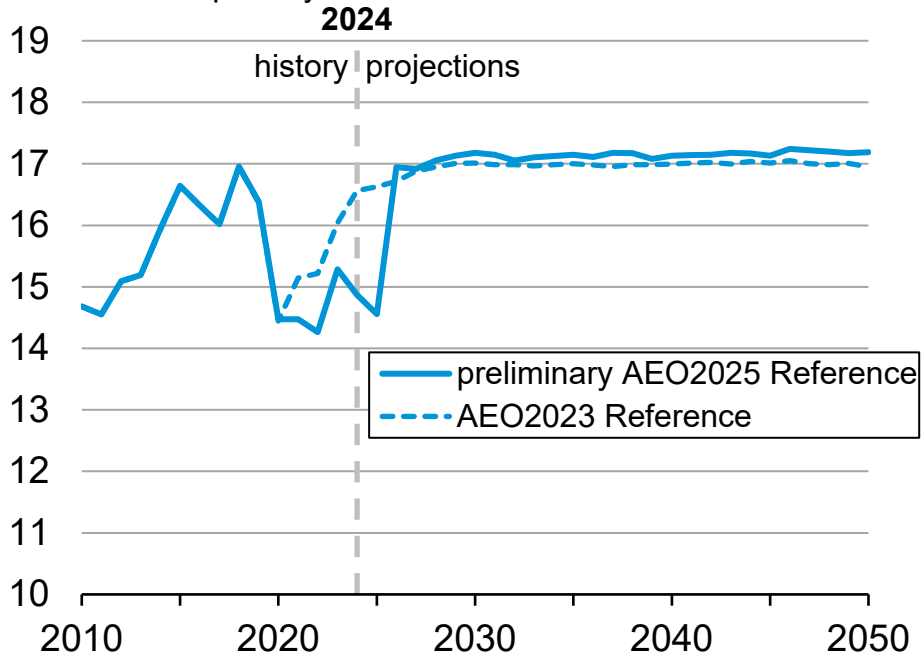
Total crude oil supply to U.S. refineries is similar over the projection period while refinery utilization rates are slightly lower

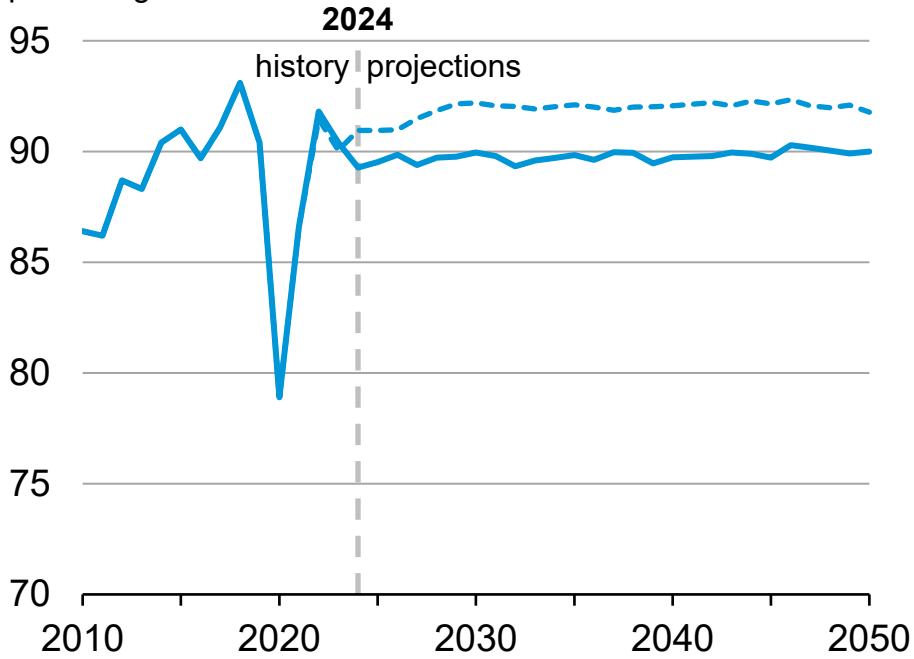
Total crude oil supply to U.S. refineries

million barrels per day



Average U.S. refinery utilization

percentage



Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

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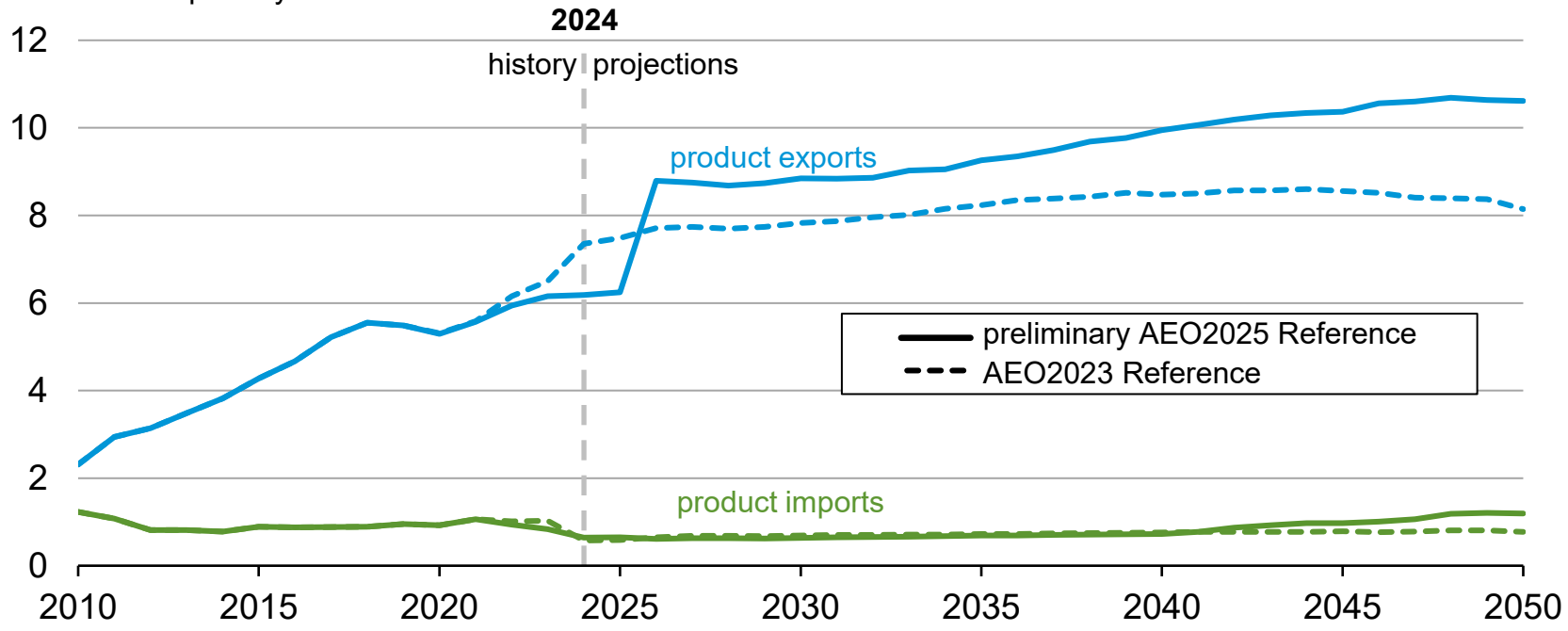
Gross exports of refined products are projected to be higher compared with AEO2023 in response to decreasing product demand

Gross product imports and gross product exports

million barrels per day

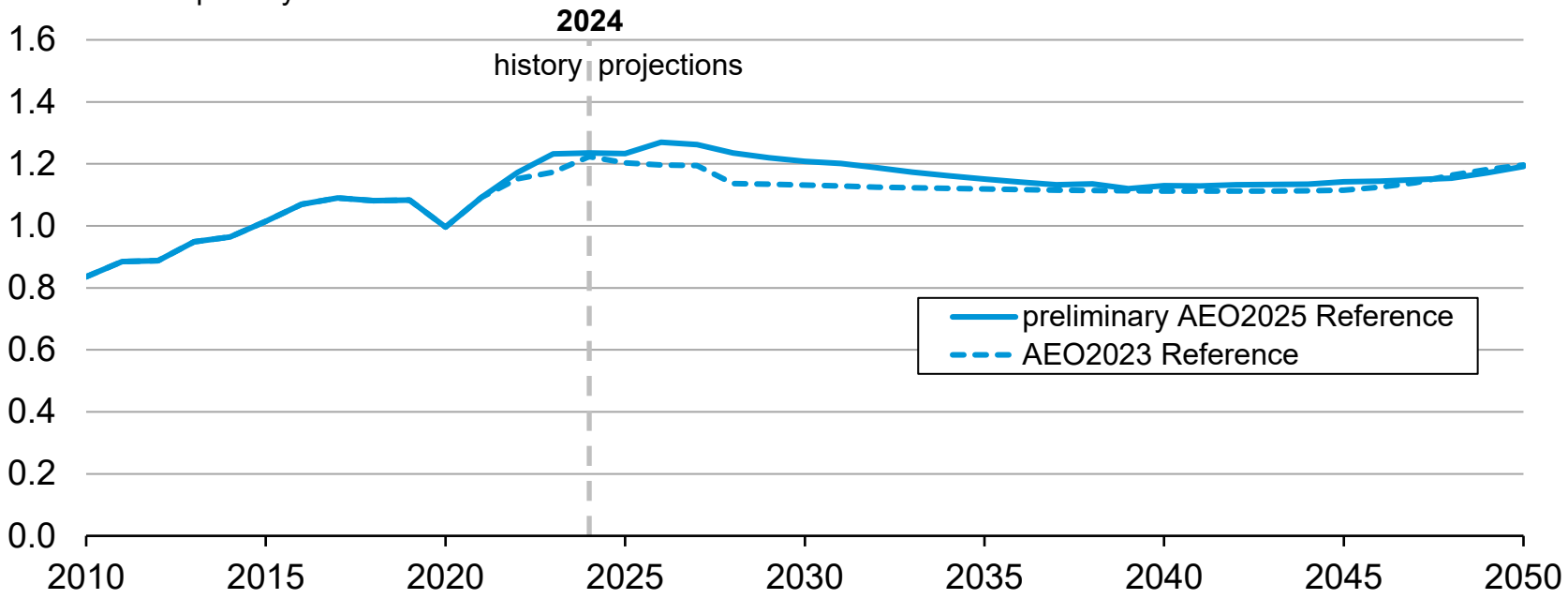


Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Biofuels supply receives a small boost due to provisions of the Inflation Reduction Act, then stabilizes at a higher level than AEO2023

Biofuels supply

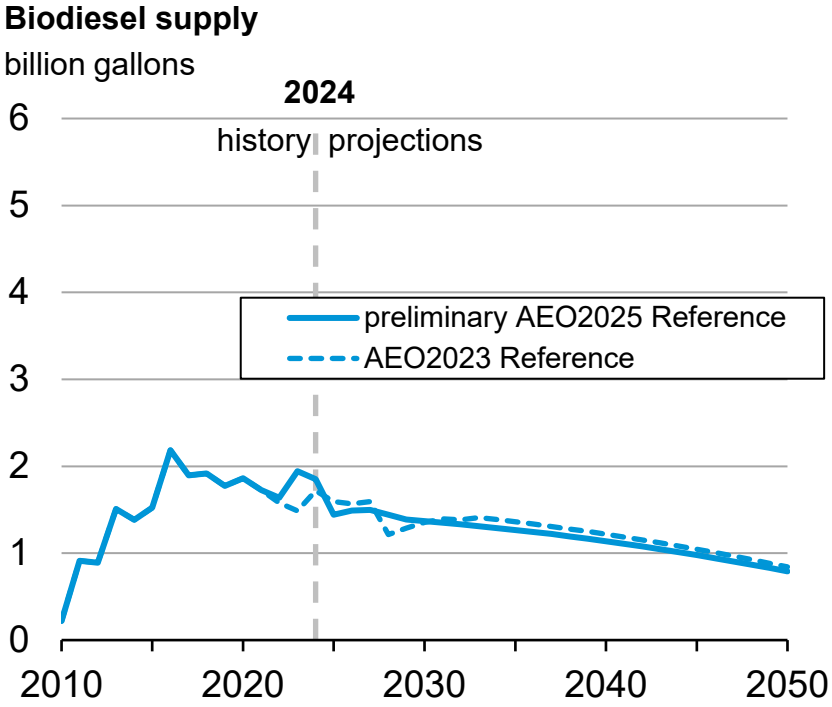
million barrels per day

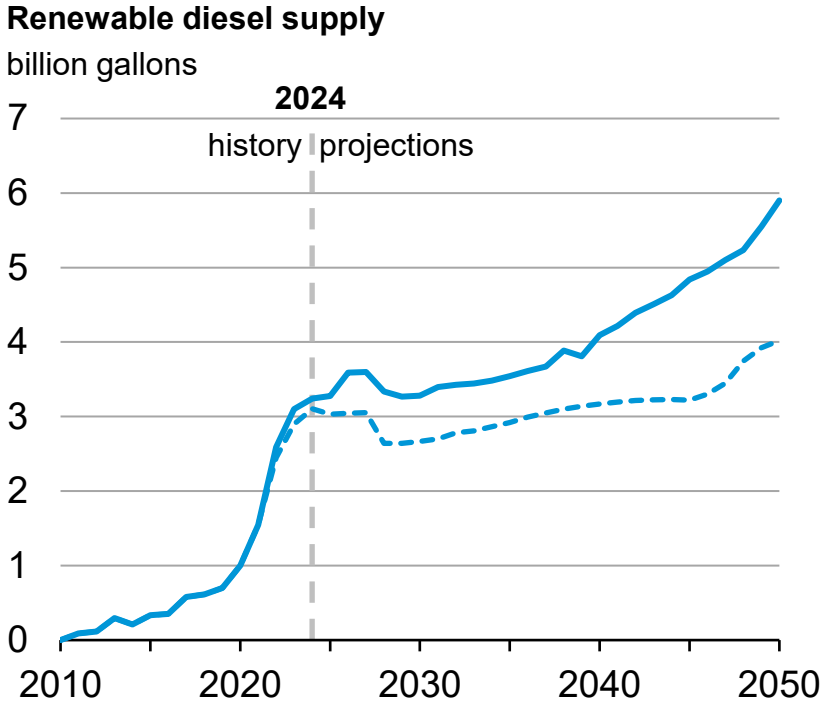


Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Note: Supply = domestic production plus net imports

Renewable diesel supply continues to outpace biodiesel due to increased current capacity and planned expansion





Data sources: Preliminary AEO2025 run, dated October 21, 2024; U.S. Energy Information Administration, *Annual Energy Outlook 2023*

Note: Supply = domestic production plus net imports

Hydrogen Market Module

Scope of new Hydrogen Market Module (HMM)

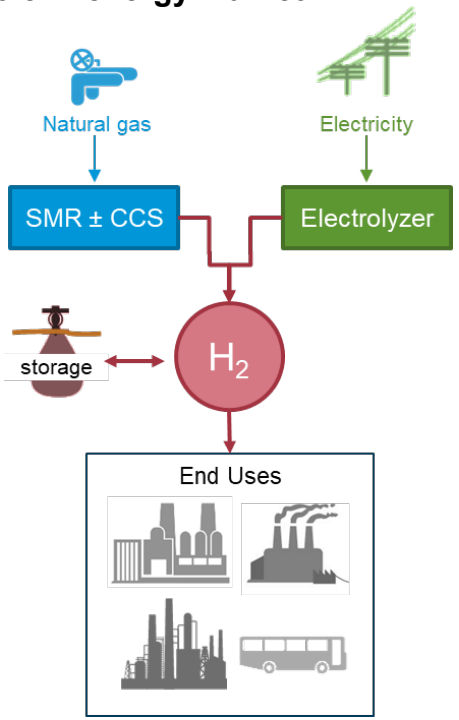
- EIA's long-term modeling capability had to expand to include H_2 given the Inflation Reduction Act (IRA) legislation, which includes specific policies to promote the growth of clean hydrogen as a fuel.
- In defining modeling scope, we first identified the key questions related to the role of hydrogen in the future.
  - How will hydrogen markets emerge and evolve over time?
  - What is the impact of policy and legislation on emerging markets and developing technologies?
  - What role will hydrogen play in deep decarbonization scenarios achieving net-zero emissions in the future?
- New module introduced 6/12/24 with assumptions and enhancements described in presentation* and memo**

Notes: * https://www.eia.gov/outlooks/aeo/workinggroup/hydrogen/pdf/IntroductionToHydrogenMarketModule_Presentation.pdf
** https://www.eia.gov/outlooks/aeo/workinggroup/hydrogen/pdf/IntroductionToTheHydrogenMarketModule.pdf

HMM will represent key production technologies and end uses of hydrogen

- Three hydrogen production pathways represented:
  - Grid-based electrolysis
  - Steam methane reforming (SMR)
  - SMR with carbon capture and sequestration (CCS)
- Production technology options allow HMM to analyze the mid- to long-term impacts of current policies, laws, and regulations governing hydrogen markets
  - Section 45V hydrogen production tax credits from the IRA
  - Section 45Q tax credits for capturing CO_2
- H_2 consumption in the industrial, electric power, refining, and transportation sectors

Simplified diagram of hydrogen's role in energy market



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Hydrogen supply modeled by HMM is termed *marketed hydrogen*

	Marketed hydrogen	Non-marketed hydrogen
Definition	Hydrogen that is supplied by HMM; its production is subject to economics and/or it is a supply source transported from supplier to end user	Hydrogen that is not supplied by HMM; it is a byproduct of other feedstock or energy used and self-consumed by the "producer" of Hydrogen
Included	Merchant hydrogen	Refinery byproduct hydrogen (catalytic reformer)
	Industrial byproduct supplied from catalytic crackers	Industrial byproduct hydrogen supplied from other sources
	Hydrogen produced by an SMR, including those co-located at ammonia/fertilizer plants and refineries	

Section 45V tax credits played a major role in HMM granularity and scope

- Section 45V eligibility assumes electrolyzers receive EACs (energy attribute certificates) by contracting power purchases from a grid-connected, third-party renewable generation facility.
- Eligible electrolyzers can receive $3/kg tax credit, but legislation limits how to qualify for the tax credit to specific situations.
- Credit can also be earned by using electricity that would otherwise be curtailed.

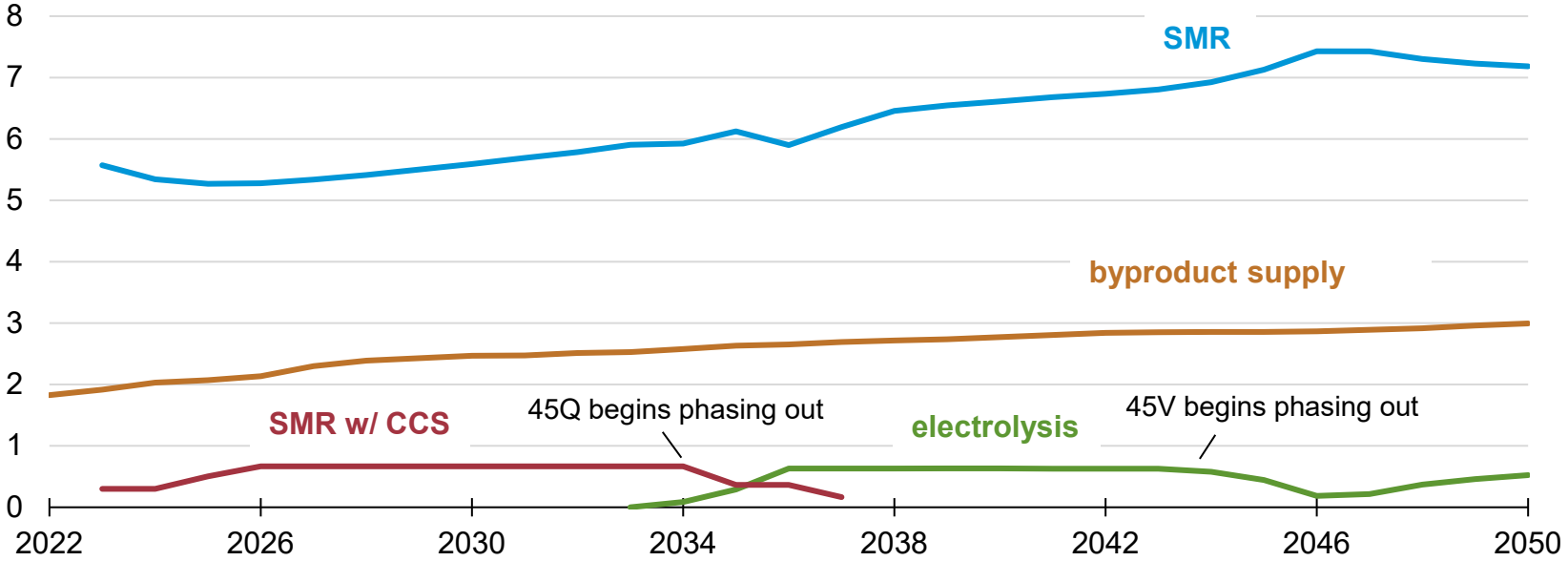
Summary of 45V implementation in HMM

	Incrementality	Deliverability	Time-matching
Requirement	Clean power generators must begin commercial operations **within 3 years of H_2 facility start-up**	EAC must be sourced in the same region as H_2 producer	EACs must match H_2 production on an hourly basis beginning in 2028, with time allowed for hourly tracking and EAC markets to become established
Implementation	Obtain hourly renewable generation data from EMM ***by year the capacity entered into service***, which constrains volume of qualified H_2 produced in a given hour	Assume H_2 facility and renewable generator are located in ***same EMM region***	EACs meet the ***hourly*** matching requirements because electrolyzers pay EMM's hourly electricity prices to produce H_2 in that hour

Working group presentation for discussion purposes.
Do not quote or cite because results are subject to change.

Most hydrogen is produced via SMR. SMR with carbon capture and electrolyzer production tapers off in response to credits sunsetting

Total marketed U.S. hydrogen production by technology
million metric tons of hydrogen

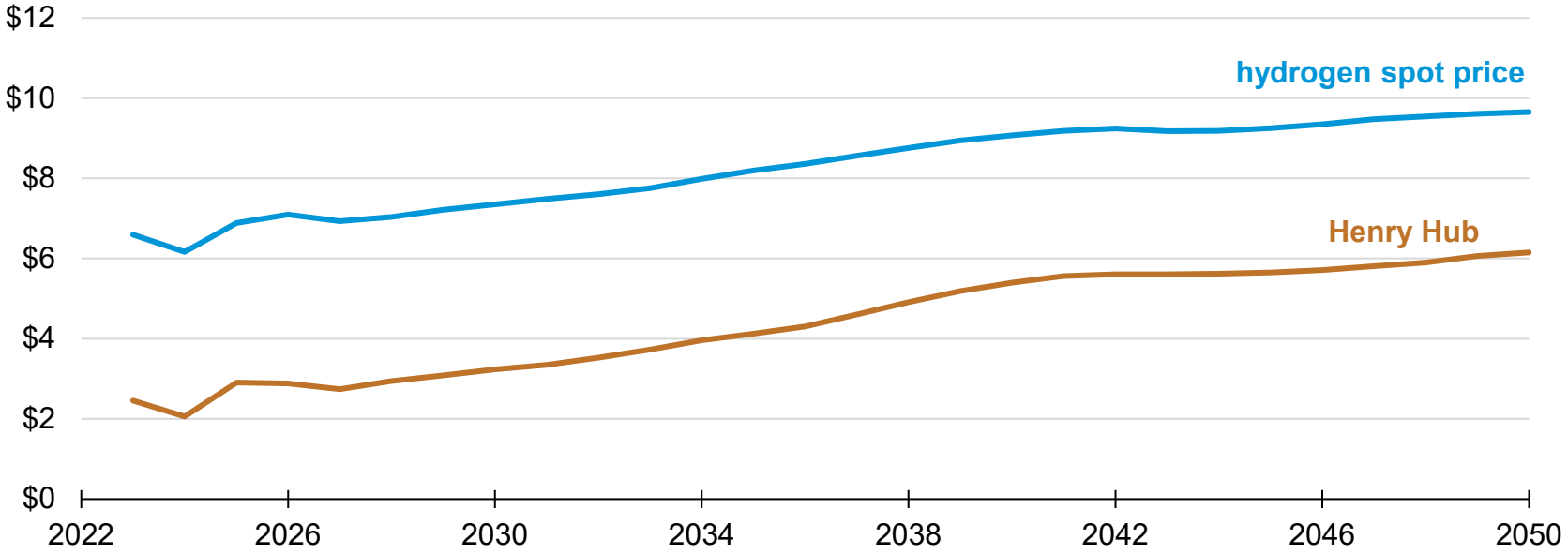


Data source: Preliminary AEO2025 run, dated October 18, 2024

Working group presentation for discussion purposes.
Do not quote or cite because results are subject to change.

Average hydrogen spot price increases through the projection period, trending with natural gas prices

U.S. average hydrogen spot price compared with Henry Hub price
2022 dollars per million British thermal units



Data source: Preliminary AEO2025 run, dated October 18, 2024

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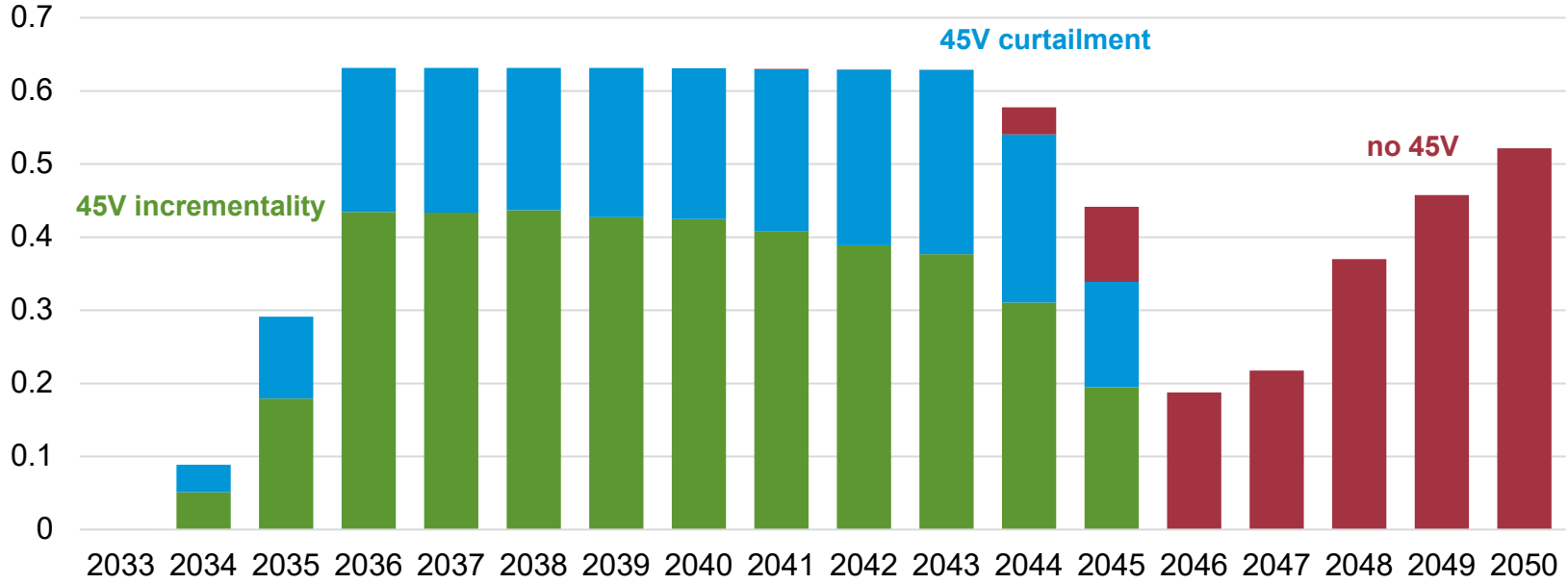
The vast majority of electrolyzer production is produced using the 45V credit if it is available

U.S. electrolyzer production by credit acquisition method
million metric tons of hydrogen

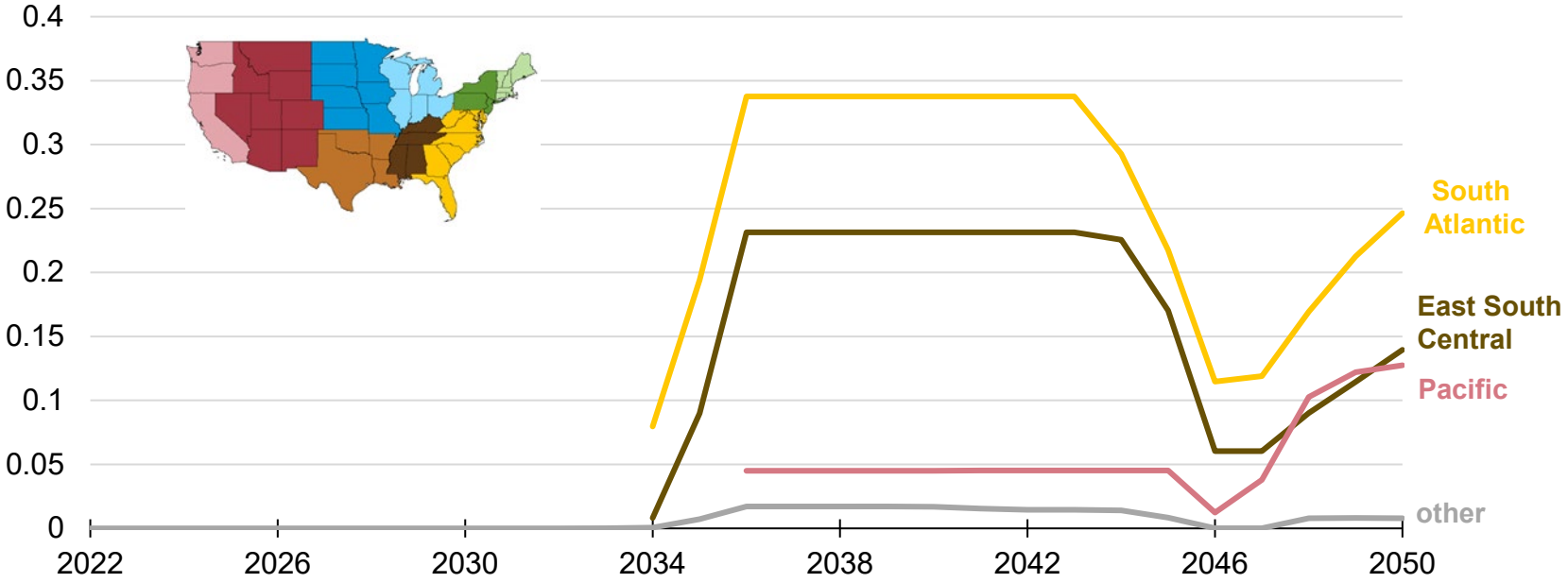


Data source: Preliminary AEO2025 run, dated October 18, 2024

Note: For more information on 45V credit, see https://www.energy.gov/articles/clean-hydrogen-production-tax-credit-45v-resources

Electrolyzers are generally most economical in the Southeast due to cheap electricity prices

U.S. hydrogen production from electrolyzers by census division
million metric tons of hydrogen



Data source: Preliminary AEO2025 run, dated October 18, 2024

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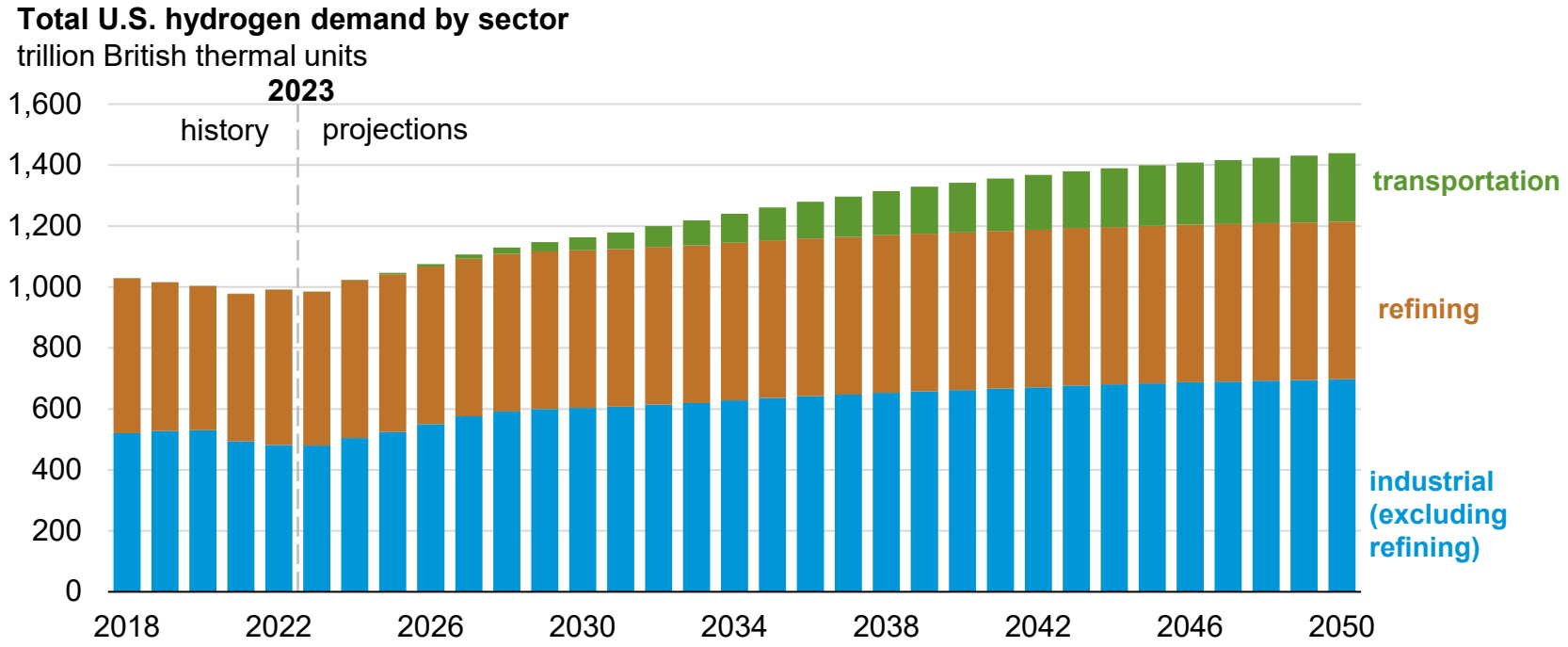
Hydrogen demand mostly comes from the industrial and refining sectors



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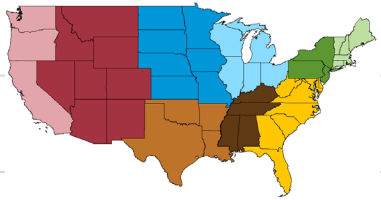
West South Central is by far the largest demand region for hydrogen

U.S. hydrogen demand by census division, 2050
trillion British thermal units



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We welcome feedback on our assumptions and documentation

- Working group meetings http://www.eia.gov/forecasts/aeo/workinggroup/
- The AEO Assumptions report http://www.eia.gov/forecasts/aeo/assumptions/
- NEMS Model Documentation
  - Natural gas market (NGMM)
    https://www.eia.gov/outlooks/aeo/nems/documentation/ngmm/pdf/ngmm(2022).pdf
  - Liquid fuels market (LFMM)
    https://www.eia.gov/outlooks/aeo/nems/documentation/integrating/pdf/integrating-2022.pdf
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  - Hydrocarbon Supply Module (HSM)
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Short-Term Energy Outlook | www.eia.gov/steo

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