Introduction to the Hydrocarbon Supply Module

AEO2025 Working Group

Internal and external stakeholders
Will Sommer, Matt Corne, Andrew Smiddy
*July 11, 2024 | Virtual*

Key takeaways

- EIA developed and tested the Hydrocarbon Supply Module (HSM) to replace the Oil and Gas Supply Module (OGSM).

- Representation of upstream petroleum and natural gas production allows insight into the impacts of policy and model assumptions.

- HSM functions much like OGSM, but changes include:

  - Written in Python

  - New modeling features (incl. federal/non-federal land, methane venting/flaring)

  - Streamlined representations

- Changes make HSM simpler to maintain and improve transparency of results.

Agenda

- HSM overview

- New features and methodology updates in HSM

- HSM performance and published results in AEO2025

AEO2025 will mark the introduction of three new modules in NEMS, one of which is the Hydrocarbon Supply Module (HSM)
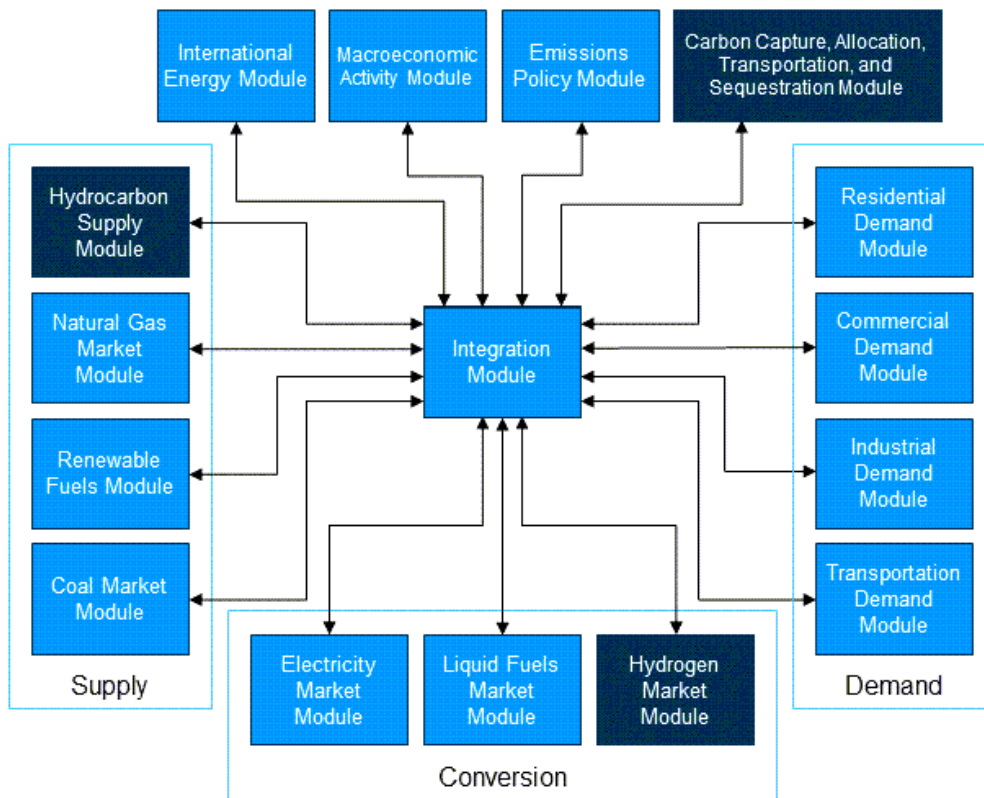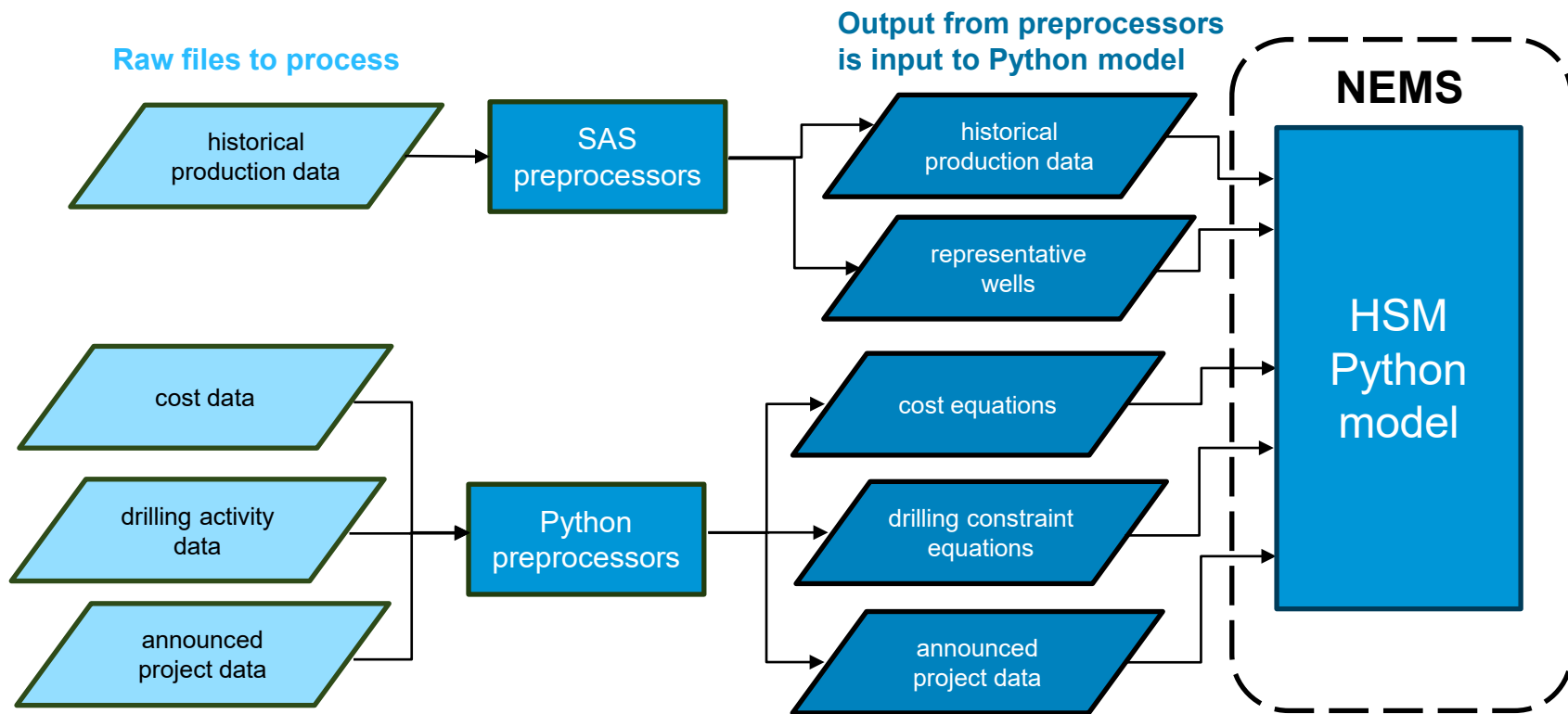
What is HSM?

- An econometric model for projecting long-term crude oil, natural gas, and natural gas plant liquid (NGPL) exploration, development, and production

- Organized into four main submodules:
    - Lower 48 Onshore
    - Lower 48 Offshore
    - Alaska
    - Canadian Natural Gas

- Includes submodule for carbon capture retrofit decisions at natural gas processing plants (NGPP)
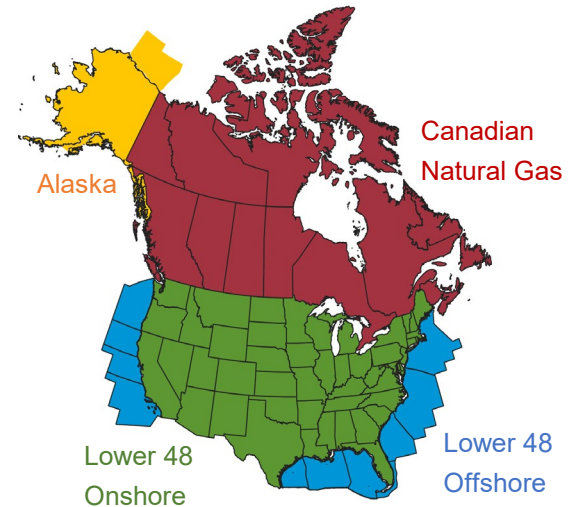
HSM is programmed in Python and uses Python and SAS preprocessors to prepare inputs outside of NEMS

HSM modeling process
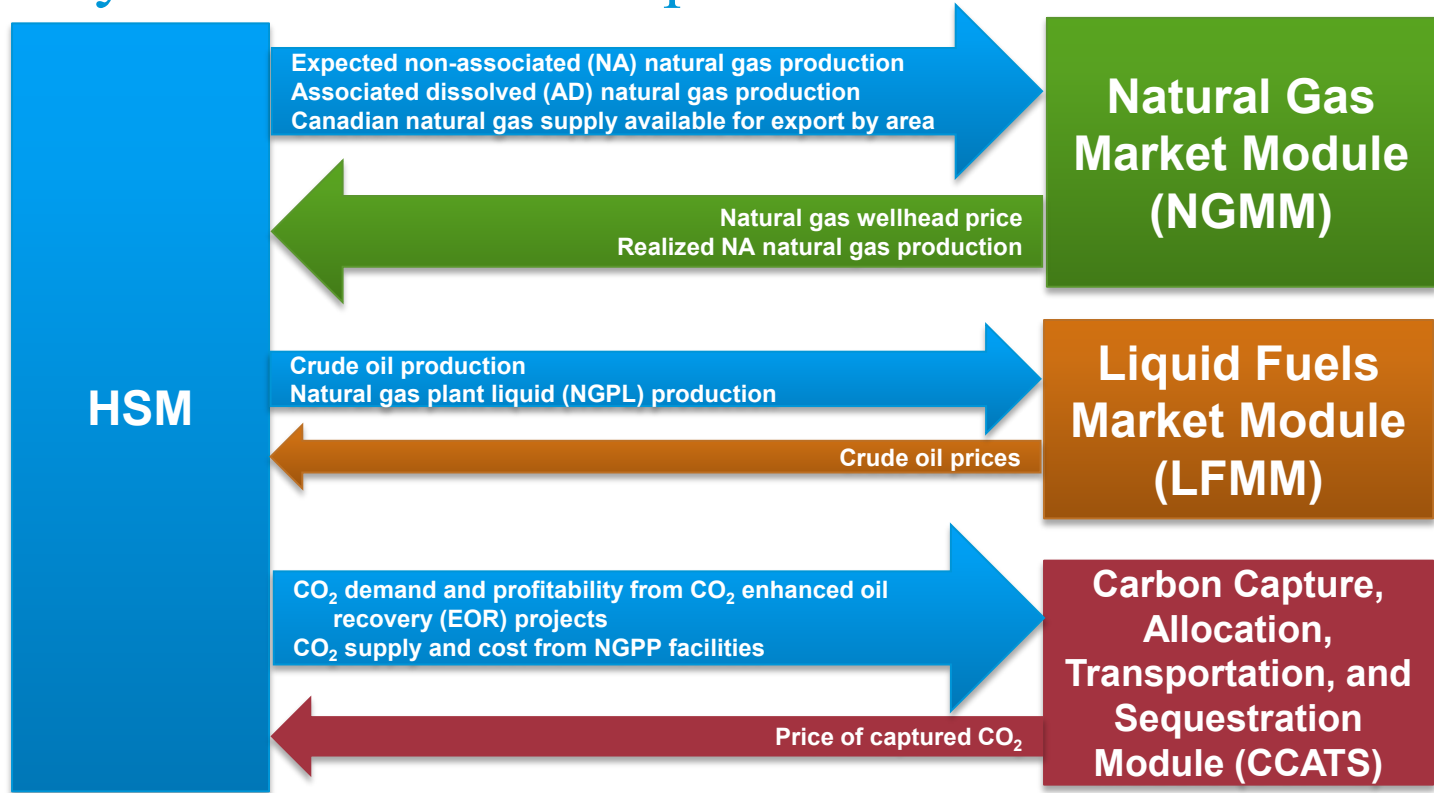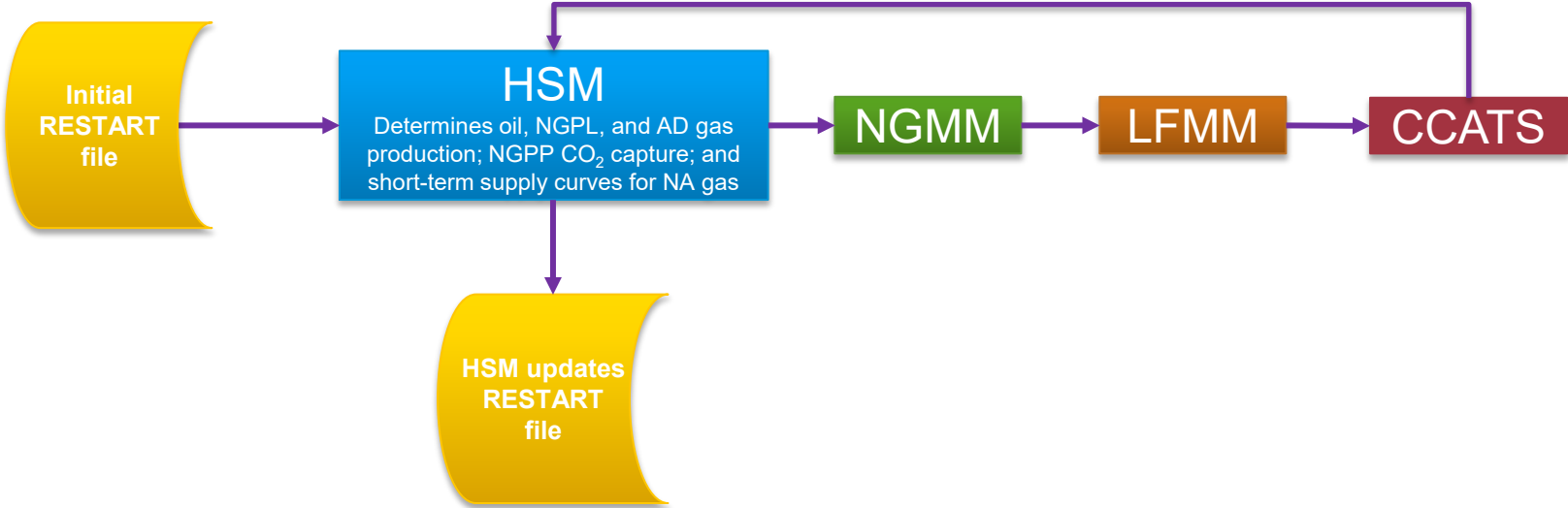
```
┌─────────────────────────┐      ┌─────────────────────────┐      ┌─────────────────────────┐
│ Submodules load inputs  │      │   Project attributes    │      │  Discounted cash-flow   │
│ for mix of project types:│─────▶│ adjusted for NEMS model │─────▶│ model determines well   │
│ • Existing              │      │    year parameters      │      │      economics          │
│ • Announced             │      │                         │      │                         │
│ • Continuous            │      │                         │      │                         │
│ • Undiscovered          │      │                         │      │                         │
└─────────────────────────┘      └─────────────────────────┘      └─────────────────────────┘
```

Select most profitable projects by region → Results aggregated and sent to NEMS
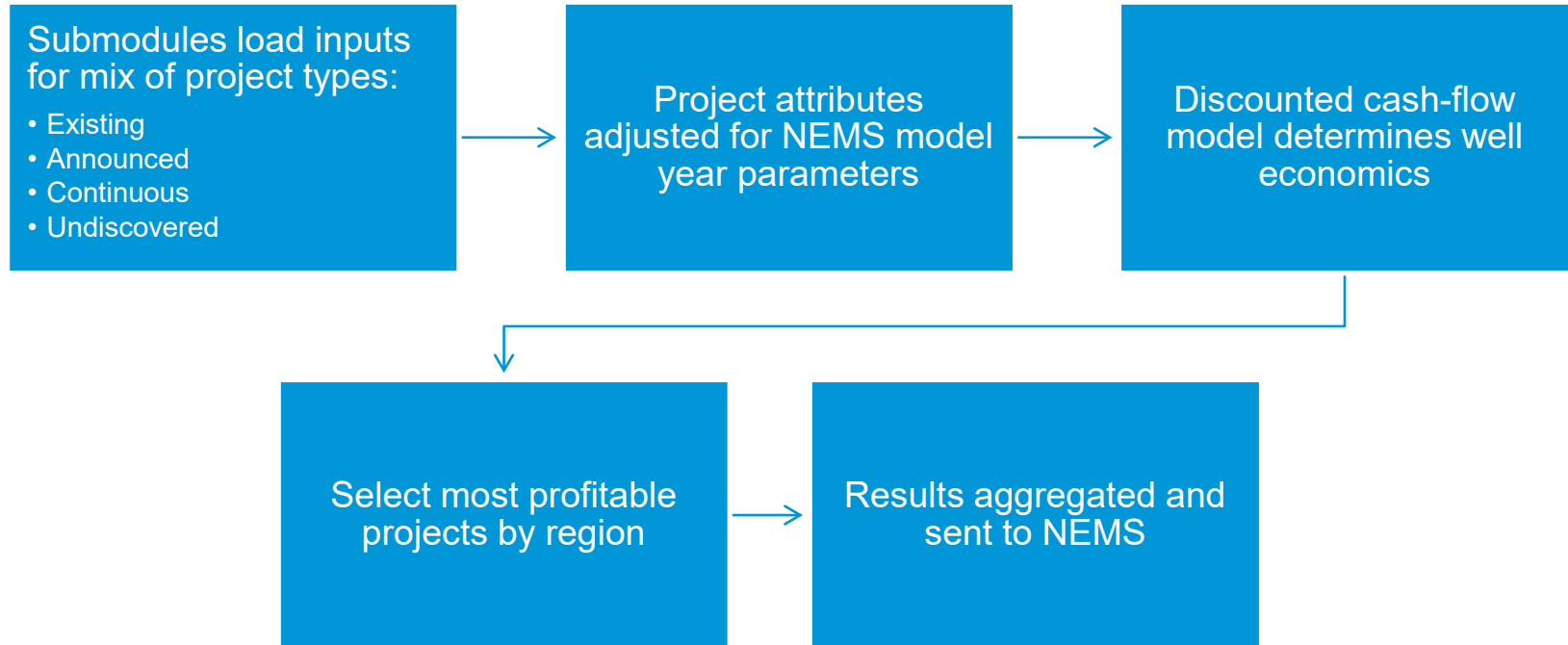
HSM key module relationships

HSM

Natural Gas Market Module (NGMM)

→ Expected non-associated (NA) natural gas production
Associated dissolved (AD) natural gas production
Canadian natural gas supply available for export by area

← Natural gas wellhead price
Realized NA natural gas production

Liquid Fuels Market Module (LFMM)

→ Crude oil production
Natural gas plant liquid (NGPL) production

← Crude oil prices

Carbon Capture, Allocation, Transportation, and Sequestration Module (CCATS)

→ CO_2 demand and profitability from CO_2 enhanced oil recovery (EOR) projects
CO_2 supply and cost from NGPP facilities

← Price of captured CO_2

Main HSM connections in NEMS

Decoupling the Carbon, Transport, Utilization and Storage (CTUS) representation from HSM

- In OGSM, there were large sections of code relating to CTUS:
  - Read in CO_2 supply from industrial sources
  - Aggregated CO_2 supplies and matched 1:1 with CO_2 EOR sites
  - Produced price for CO_2 used in CO_2 EOR

- This code has been removed in HSM, and replaced by CCATS

- CO_2 representations in HSM are limited to:
  - Endogenous carbon capture decision for NGPPs
  - CO_2 demand for CO_2 EOR

Key differences between HSM and OGSM

| Key difference	OGSM	HSM
Programming language	Fortran	Python
Model runs/cycle	First iteration and reporting iteration	Every iteration
Federal/non-federal land	Not represented	Represented
Methane venting/flaring	Not represented	Represented
CO_2 capture	2014 NETL static estimate for industrial sources	Carbon capture retrofit decision for NGPP
CO_2 sequestration	All sources of captured CO_2 matched 1-1 with EOR sites	Represented in CCATS
Split decline curves	Not represented	Represented

HSM introduces new features and improvements

- Distinguishes between hydrocarbon production on federal versus non-federal lands

- Incorporates charges related to venting and flaring of methane

- Represents carbon capture volumes from natural gas processing facilities

- Calculates secondary well production volumes independent of primary well production volumes

Federal vs. non-federal land representation

- Federal vs. non-federal distinction was a high priority development item

  – Improves representation of royalties in HSM

  – Enables side cases where federal and non-federal resources are treated differently

- Many onshore sites are only partially on federal land

- Collaborated with Department of Interior, Office of Natural Resources Revenue (ONRR) to identify wells partially on federal lands

- Used these data to produce federal land production ratios by play and county which are in turn used to project future federal vs. non-federal drilling

Federal lands and U.S. tight oil and shale gas plays
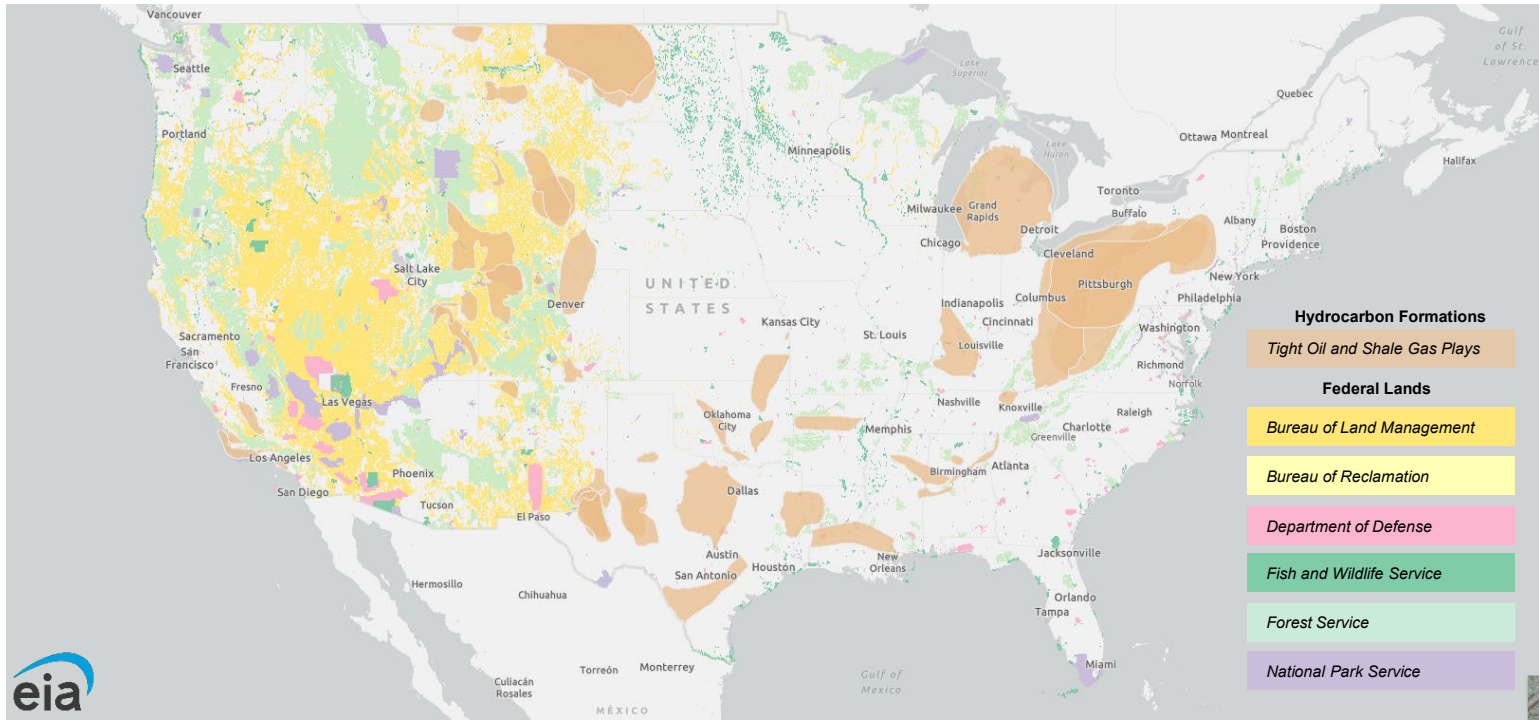
EIA Energy Atlas Shale Play Map

Methane emissions representation–policy and data

- Inflation Reduction Act of 2022 (IRA) updates regarding methane emissions:

  - $900/metric ton emissions charge in 2024, increasing to $1,500/metric ton over two years

  - Royalty of 16.6% on all natural gas vented, flared, or negligently released during upstream operations on federal land and the Outer Continental Shelf

- Data used:

  - EPA Greenhouse Gas Reporting Program (GHGRP) total methane emissions data

  - Production data derived from Enverus reporting

Methane emissions representation–methodology

- Methodology

  - Produced methane emissions factors linked to present dry natural gas production

  - Estimated methane emissions volumes from projected natural gas production

  - Applied penalties and royalties to vented/flared methane in the HSM discounted cash flow

- Methane emissions volumes from hydrocarbon production **will not** be published

- Representation of methane venting/flaring for measuring effects of IRA on well economics only

Representation of carbon capture from NGPPs–policy and data

- The IRA enhanced 45Q tax credits for carbon capture and sequestration

  - Increased credit for facilities or equipment meeting certain requirements

  - Extended construction start deadline to end of 2032 and eligibility to claim tax credits

  - NGPPs are eligible for 45Q tax credits

- Data used

  - EIA 64A, 757, 816 surveys

  - 2023 NETL Carbon Capture Retrofit Database

 - EPA acid gas removal facility-reported CO_2 emissions
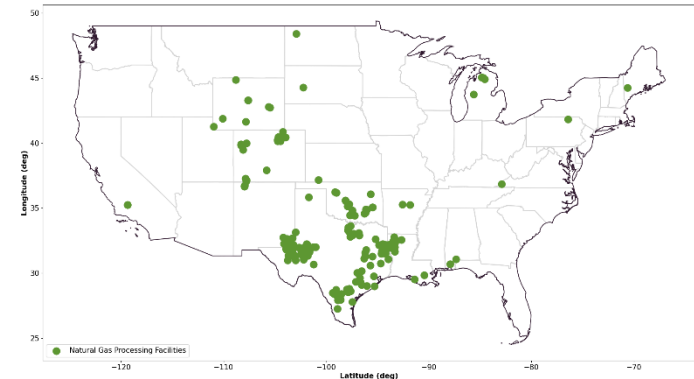
NETL Natural Gas Processing Plants eligible for carbon capture retrofit

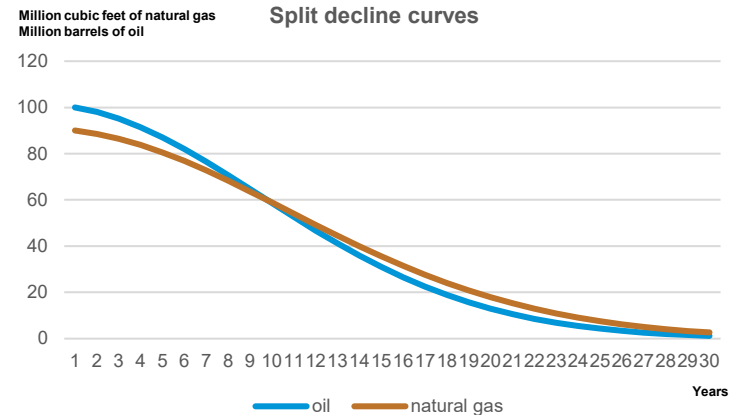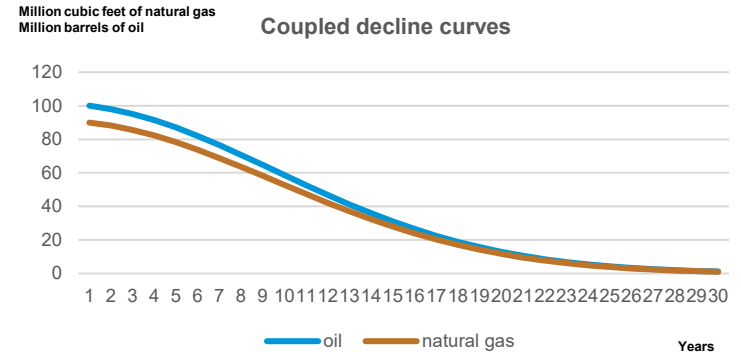# Representation of carbon capture from NGPPs–methodology

- Matched NGPP throughput from EIA datasets to CO_2 emissions from EPA dataset, producing an NGPP throughput/CO_2 emissions ratio

- Allocated projected natural gas supplies in HSM to representative NGPPs

- Used CO_2 price path provided by CCATS to make NGPP capture and retrofit decisions in HSM

- Reported captured CO_2 volumes to CCATS

# NGPP carbon capture and methane emissions visual
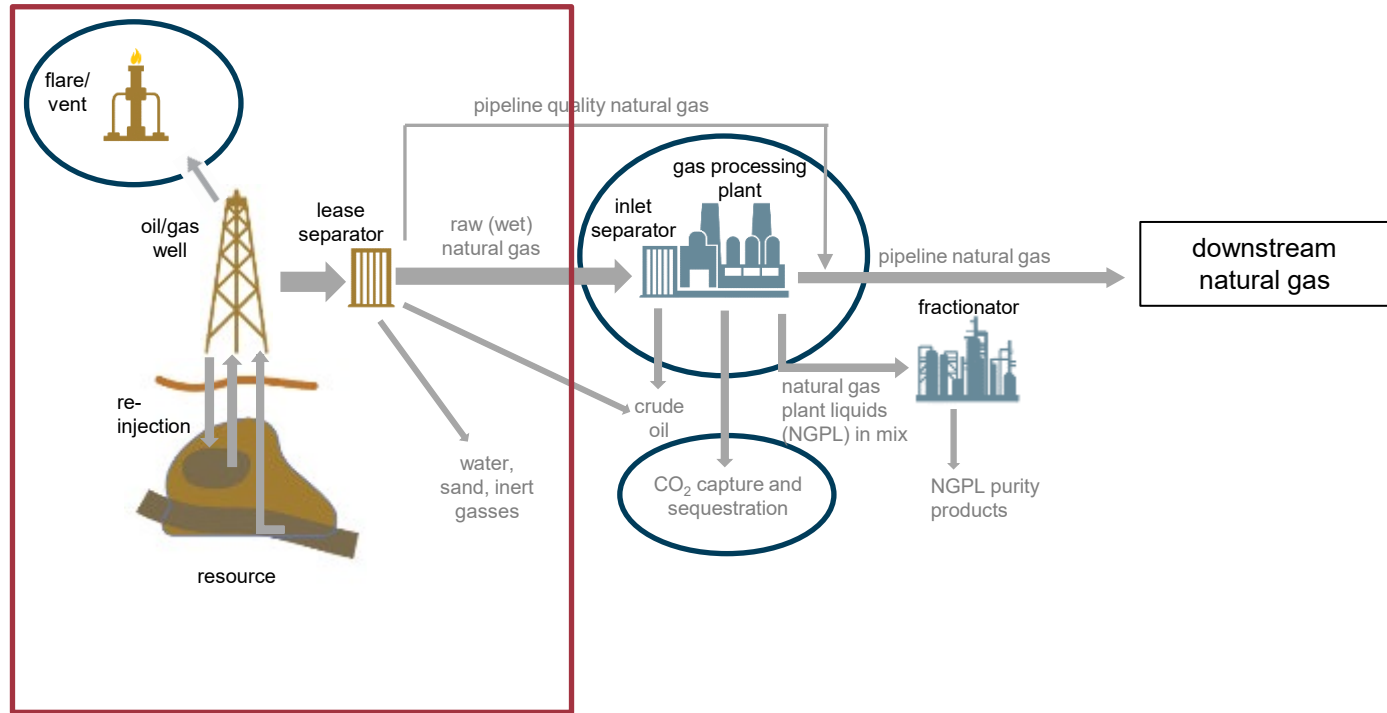
Project decline curve update

- ## Previous methodology

  - Obtained decline curve for primary production

  - Used primary production parameters to estimate secondary production

- ## Updated methodology

  - Obtain separate decline curves for primary and secondary production

- ## New methodology more accurately represents well dynamics

  - Wells typically produce relatively more natural gas over time

Coupled decline curves

Million cubic feet of natural gas
Million barrels of oil

oil   natural gas   Years

Split decline curves

Million cubic feet of natural gas
Million barrels of oil
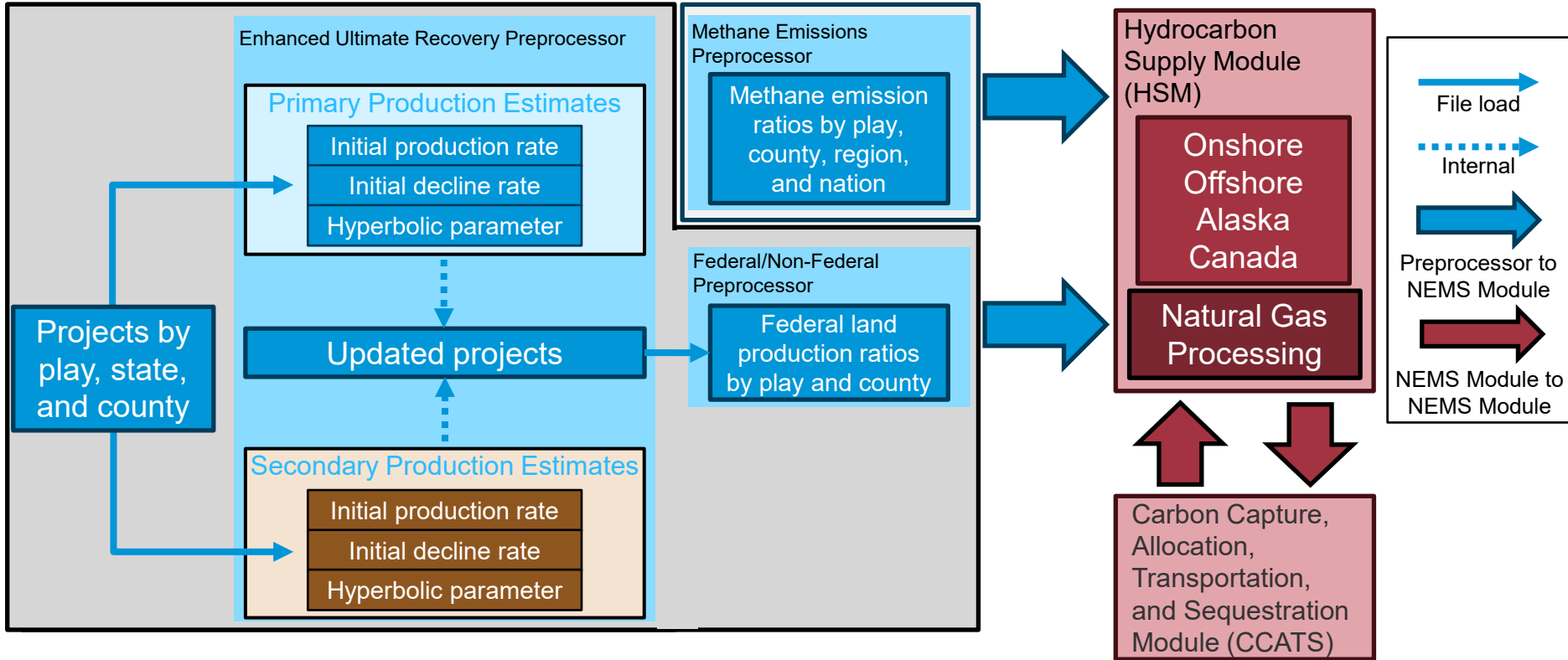
oil   natural gas   Years

AEO2023 and prior years obtained a primary production decline curve that was applied to the secondary production initial production rate
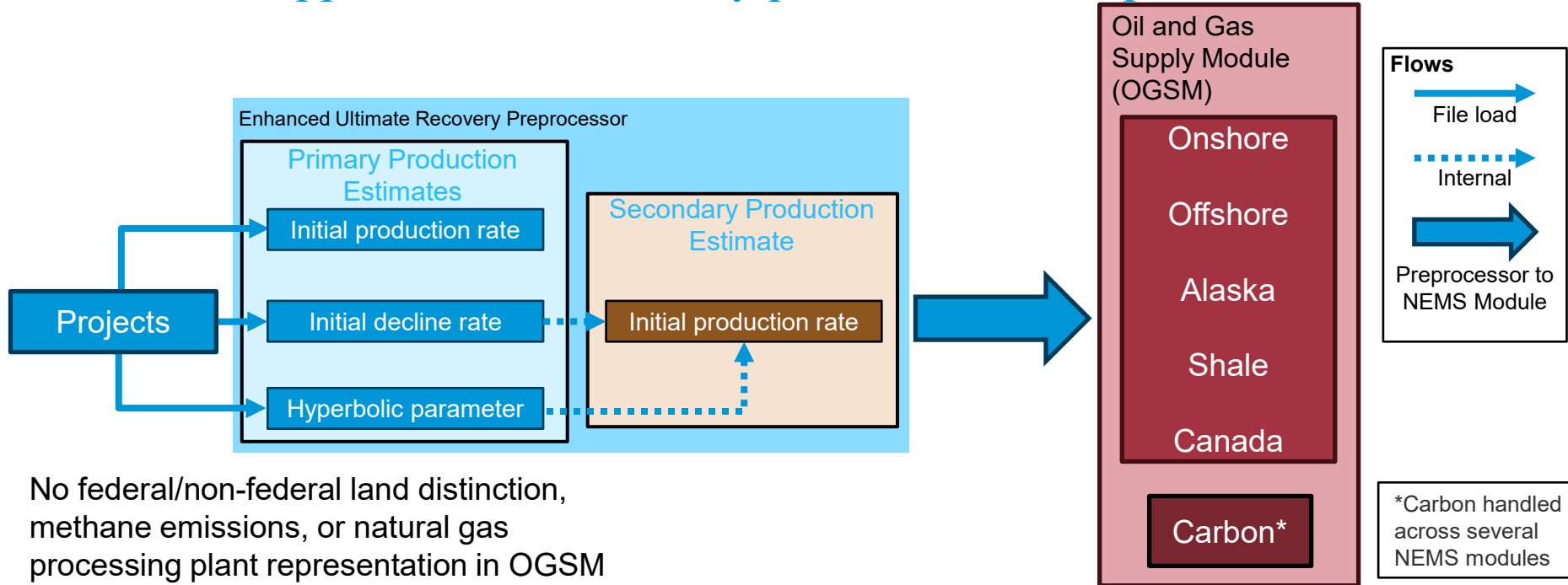
No federal/non-federal land distinction, methane emissions, or natural gas processing plant representation in OGSM

New and changed features in AEO2025

HSM contains some notable methodology updates

- Single discounted cash flow methodology across all submodules

- Simplified methodology for calculating EOR production volumes in Lower 48 Onshore Submodule

- Geology-specific cost equations for calculating economics of hydrocarbon production in Lower 48 Onshore Submodule

- Updated drilling equation in Canada Natural Gas Submodule

- Increased responsiveness to other NEMS module results

HSM performance relative to OGSM

- Significant testing performed comparing HSM results and performance to OGSM using AEO2023 dataset

- HSM results within 5% of OGSM results, differences explained by methodology updates and improvements to model representations

- Vectorization and methodology streamlining improved HSM model runtime relative to OGSM

New HSM-produced tables in AEO2025

- Federal and non-federal production by HSM region

- Non-associated and associated-dissolved natural gas production, by HSM Region

Crude oil production: federal/non-federal

	2024	2025	2026	2027	2028
Federal					
East Coast	X	X	X	X	X
Gulf Coast	X	X	X	X	X
…	X	X	X	X	X
Non-Federal					
East Coast	X	X	X	X	X
Gulf Coast	X	X	X	X	X
…	X	X	X	X	X
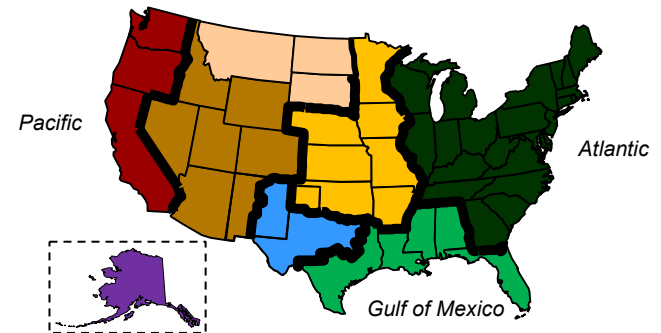
Pacific *Atlantic* *Gulf of Mexico*

Key takeaways

- EIA developed and tested the Hydrocarbon Supply Module (HSM) to replace the Oil and Gas Supply Module (OGSM).

- Representation of upstream petroleum and natural gas production allows insight into the impacts of policy and model assumptions.

- HSM functions much like OGSM, but changes include:

  - Written in Python

  - New modeling features (incl. federal/non-federal land, methane venting/flaring)

  - Streamlined representations

- Changes make HSM simpler to maintain and improve transparency of results.

For more information

HSM modeling team:

Will Sommer | william.sommer@eia.gov

Matt Corne | matthew.corne@eia.gov

Andrew Smiddy | andrew.smiddy@eia.gov

Annual Energy Outlook | www.eia.gov/aeo

Annual Energy Outlook 2025 Resources | https://www.eia.gov/outlooks/aeo/resources/

Model Development | https://www.eia.gov/outlooks/documentation/workshops/

Working Groups | https://www.eia.gov/outlooks/aeo/workinggroup/