Annual Energy Outlook 2025 Modeling Updates

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*April 4, 2024 | Virtual*

Before we get started…

- Feel free to add your questions in the chat throughout the presentation. We will hold a question-and-answer session at the end.

- The slides from this presentation and a recording of the event will be available on our website.

- This presentation is a preview of the work being done by our modeling team. We are still in the development phase of AEO2025; therefore, some of this information is subject to change.

- We will not be sharing results today.

- Teams will be holding working groups in the spring and summer, when more details will be provided.

- This presentation focuses on AEO2025 model development and will not cover Project BlueSky, which is a separate longer-term effort to build a Next Generation EIA modeling platform.

Agenda

Topic	Speaker
AEO2024 and AEO2025	Mala Kline
Hydrogen Market Module	Katie Dyl
Carbon Capture, Allocation, Transportation, and Sequestration Module	Will Sommer
Hydrocarbon Supply Module	Will Sommer
End-Use Demand Modules	Erin Boedecker
Power Modules	Cara Marcy
Upcoming Events	Mala Kline
Questions	All Panelists

AEO2024 and AEO2025

- Where is AEO2024?

  - Last summer, we [announced](#) that we would not publish an AEO in 2024 to give the team more time to incorporate major enhancements into the National Energy Modeling System (NEMS).

- What is AEO2025?

  - AEO2025 is slated for spring 2025.

  - Like past AEOs, we will publish a range of materials on release day: tables, write-ups, assumptions reports, etc.

  - The main difference between AEO2025 and past AEOs is the **major leap** in enhancements to NEMS
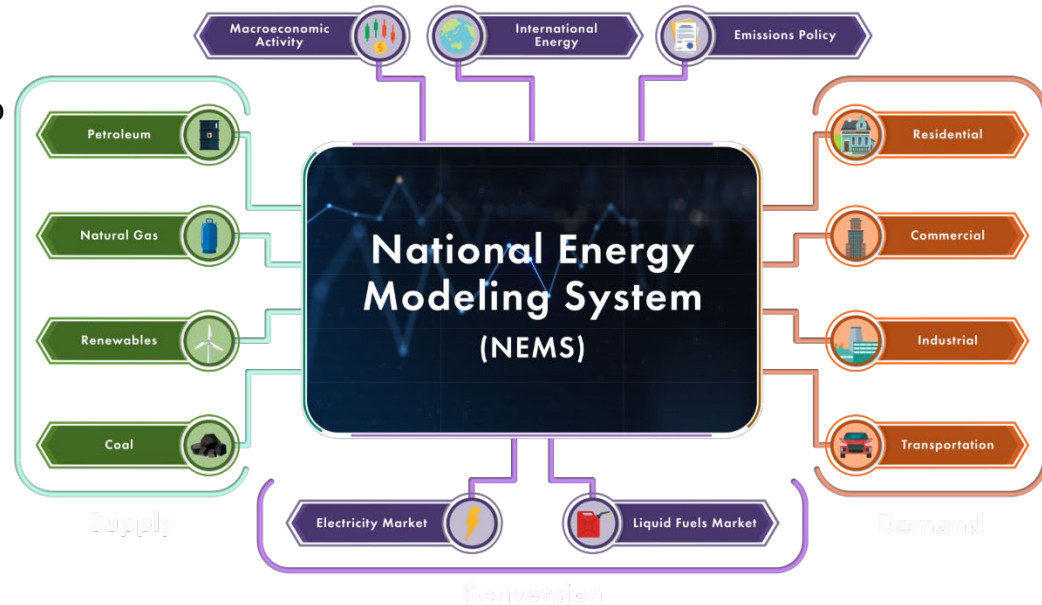
Hydrogen Market Module

# EIA is introducing a Hydrogen Market Module (HMM)

- Mid- to long-term impacts of current policies, laws, and regulations governing hydrogen markets, specifically the Inflation Reduction Act
    - Section 45V hydrogen production tax credits from the IRA
    - Section 45Q tax credits for capturing CO_2

- Hydrogen's potential role in deep decarbonization scenarios

- Three hydrogen production pathways represented:
    - Electrolysis
    - Steam methane reforming (SMR)
    - SMR with carbon capture and sequestration (CCS)

- Consumption of hydrogen in the industrial, electric power, refining, and transportation sectors

Simplified diagram of hydrogen's role in energy market
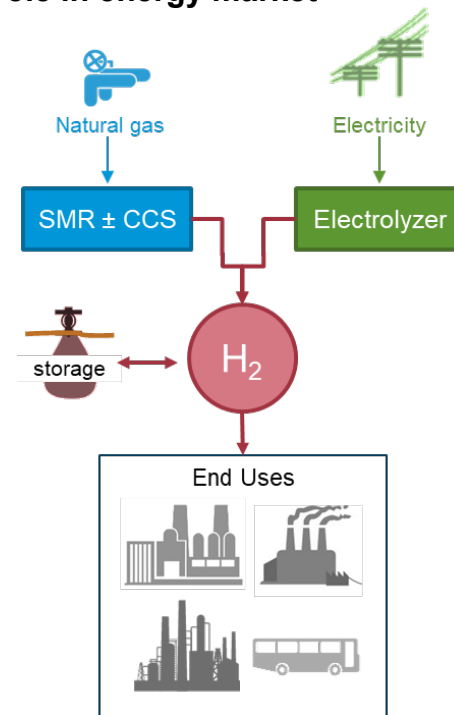
Hydrogen production pathways and end-use consumers require HMM interaction with several energy sector modules

- Receives CO_2, natural gas, and electricity prices as inputs for hydrogen production

- Sends end-use hydrogen prices to the electricity, liquid fuels, industrial, and transportation sectors

- Balances quantity of hydrogen demand from end-use sectors with hydrogen produced by HMM

- Sends quantity of CO_2 captured during hydrogen production to CO_2 market


HMM's role within NEMS
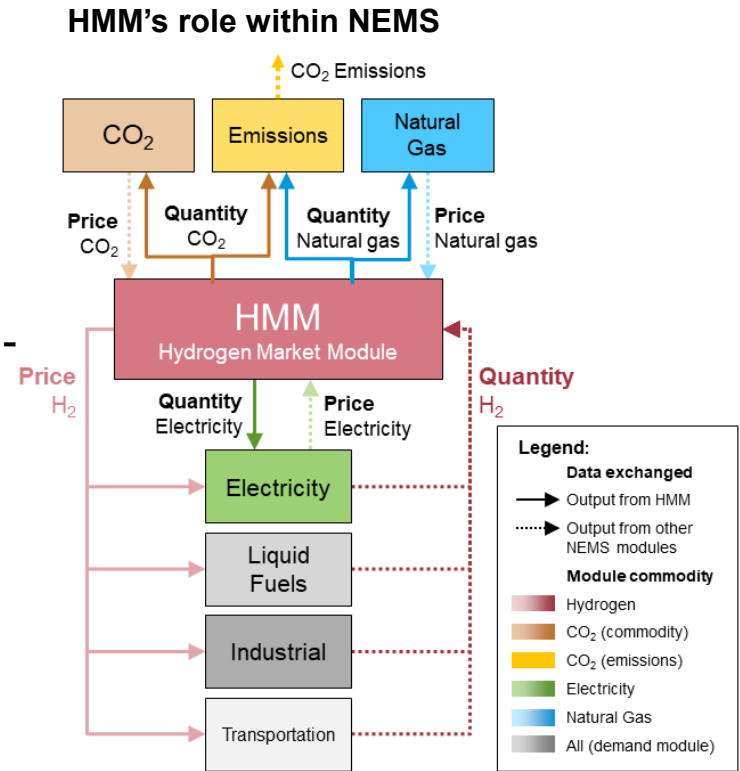
With blended regionality and detailed temporal resolution, HMM will project hydrogen production at a granular level

- Electrolysis production decisions represented at the Electricity Market Module (EMM) region level

- Non-electrolysis production and regional hydrogen market balances represented at census division level

- Four seasons modeled independently, with electrolysis production decisions made at hourly resolution

Electricity Market Module regions

U.S. census divisions
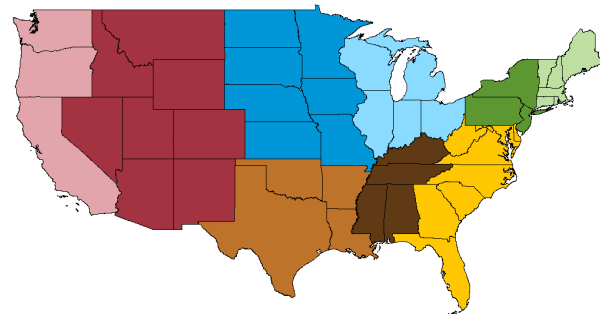
Seasonal and hourly representation in HMM

| season 1	season 2	season 3	season 4

representative hours

HMM allows potential growth in hydrogen infrastructure

- Pipelines can move hydrogen to a neighboring census division.

- Geological formations accommodate the seasonal storage of hydrogen.

- Hydrogen transportation network and storage capacity can expand if economic to do so.

Potential inter-regional hydrogen pipeline transportation arcs
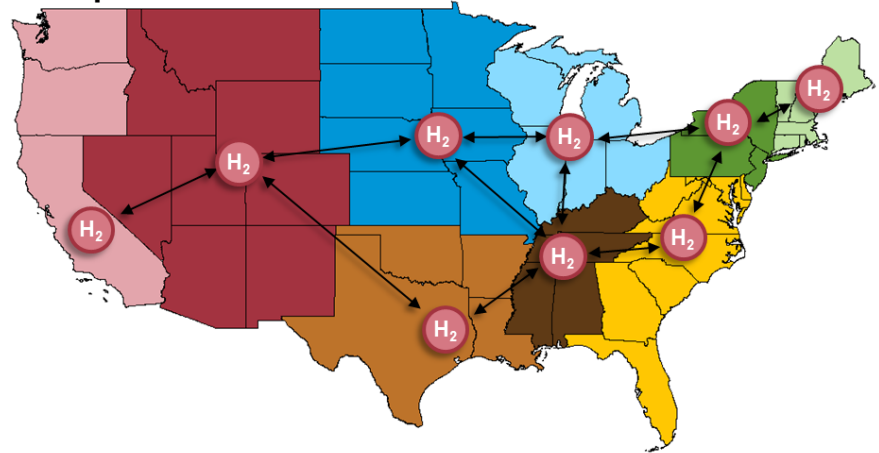
Carbon Capture, Allocation, Transportation, and Sequestration Module (CCATS)
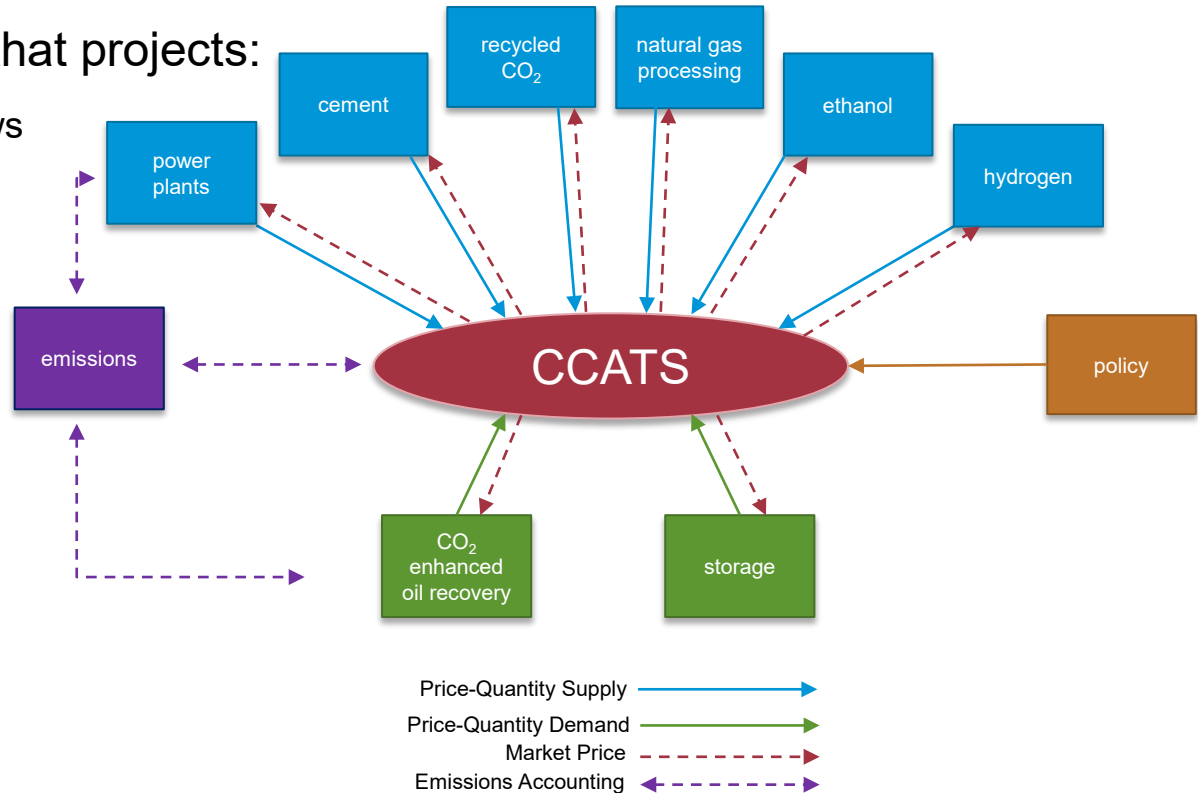
NEMS needs a new module to represent carbon capture

- NEMS currently represents carbon capture in the Capture, Transport, Utilization, and Storage Submodule (CTUS).

- CTUS is very difficult to update and maintain:

  - CTUS code is distributed across multiple NEMS modules.

  - Sources of CO_2 supply are not modeled consistently.

  - CTUS does not model a centralized market.

  - CTUS is written in Fortran and GAMS.

- CCATS provides an opportunity for EIA to start from a blank slate, incorporating novel methods and data that were unavailable when CTUS was written.

What is CCATS?

- An optimization model that projects:

  - CO_2 Transportation Flows

  - CO_2 Demand

  - CO_2 Storage

  - CO_2 Prices

Price-Quantity Supply →
Price-Quantity Demand →
Market Price →
Emissions Accounting ←→

CO_2 supply will be responsive to 45Q tax credits

- CCATS will represent 45Q tax credits for carbon capture, as legislated in the Inflation Reduction Act:

    – CO_2 capture projects must begin construction by 2033 to qualify for tax credits.

    – CO_2 capture projects must meet minimum CO_2 capture volume thresholds.

- CCATS design will be flexible to support any future policy changes.

Hydrocarbon Supply Module (HSM)

EIA is replacing the Oil and Gas Supply Module

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

- Although HSM is functionally similar to OGSM, improvements include:

    - Written in Python.

    - Several major updates and streamlined representations.

- These changes will make HSM easier to maintain and improve the transparency of results.

Canadian Natural Gas

Alaska

Lower 48 Onshore

Lower 48 Offshore
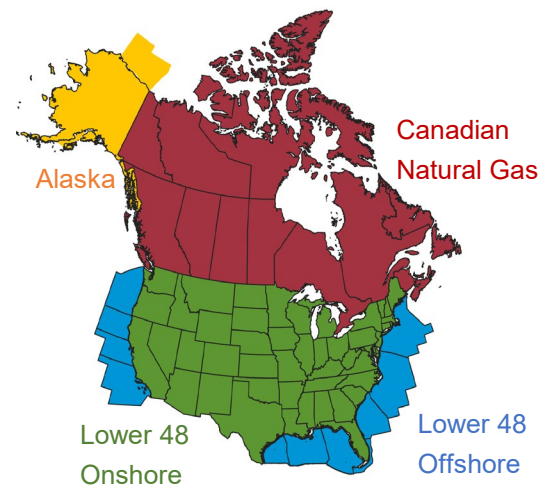
HSM contains several major updates and improvements

- Incorporates costs related to penalties for venting and flaring of methane

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

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

- Represents carbon capture volumes from natural gas processing facilities

HSM also contains some notable methodology updates

- Single discounted cash flow methodology across all submodules

- Simplified methodology for calculating enhanced oil recovery production volumes in the Onshore Submodule

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

- Updated drilling equation in the Canada Submodule

- Increased responsiveness to other NEMS module results

End-Use Demand Modules

NEMS end-use sectors have new capabilities to model deep decarbonization pathways

- The new features of the industrial module focus on electrification, carbon, and hydrogen.

  - Industrial heat pumps

  - Recycling in the plastics and glass industries

  - New technology choices including carbon capture and limited hydrogen options

- Residential and commercial modules are adding behind-the-meter storage.

- The transportation module is adding regional electric vehicle charging infrastructure and detailed modeling of fuel cell freight trucks.

… and have improved policy representation

| Inflation Reduction Act Refinements and Additions | New Average Fuel Efficiency and Emissions Standards | Zero Emission Vehicle (ZEV) programs; Internal Combustion Engine (ICE) Bans |

Inflation Reduction Act Refinements and Additions

- Electric vehicle tax credits
- Clean energy and energy efficiency tax credits
- Industrial demonstration projects–pending award of funding
- Energy efficiency rebates/ building energy code adoption–pending funding to states

New Average Fuel Efficiency and Emissions Standards

- March 20, 2024 EPA final rule for light-duty and medium-duty vehicles
- March 29, 2024 EPA final rule for heavy-duty vehicles - Phase 3

Zero Emission Vehicle (ZEV) programs; Internal Combustion Engine (ICE) Bans

- Current state-level ZEV requirements
- Heavy duty vehicle ICE bans

New regional model structures improve modeling of transportation preferences and policies

- Regional consumer choice model for light-duty vehicles

  - Captures regional differences in consumer preferences

  - Increases ability to represent the impacts of ZEV requirements

- Regional heavy-duty vehicle sales/stock model

  - Needed to accurately account for Advanced Clean Truck Rule and potential additional policies

U.S. Census Divisions
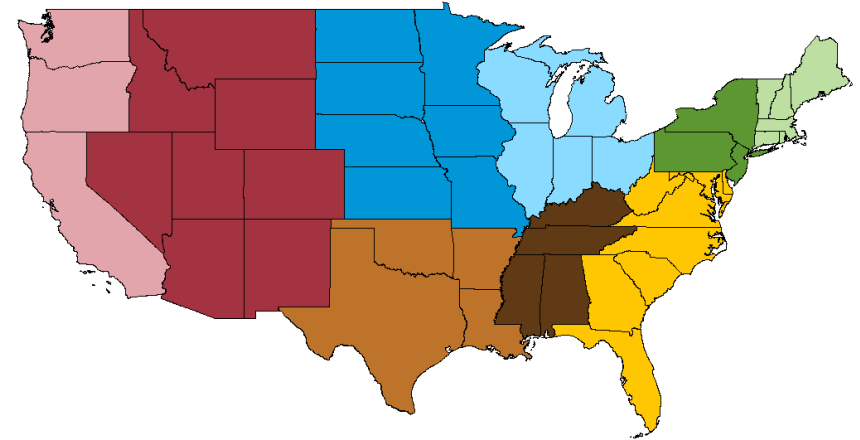
Industrial module improvements also focus on potential decarbonization pathways

- A recently completed technology assessment updates the technology slate for energy-intensive industries.

- Added flexibility in steel and other industries allows evaluation of potential electrification technologies.

- Addition of more specific industries provides more accurate representation of industrial sector trends.

- Industrial sector process emissions are being calculated for potential use as a source of CO_2.

- Collaboration between modules allows industrial sector participation in hydrogen and carbon markets .

Buildings sector improvements take advantage of the latest available survey and technology information

- NEMS defines the sectors using the latest EIA end-use consumption surveys.

    – The residential sector uses the *2020 Residential Energy Consumption Survey.*

    – The commercial sector uses the *2018 Commercial Building Energy Consumption Survey.*

- Consumer purchase decisions are based on available technologies.

    – Updated end-use equipment cost and performance characteristics.

    – Updated technology parameters for distributed generation and combined heat and power applications.

- Federal standards, tax credits, and regional/utility energy efficiency program incentives are included in technology choice decisions.

Power Modules

Updating our baseline to represent more of the IRA, better reflect current market trends, and improve performance

- Cost and policy updates:

  - Releasing our capital cost report

  - Updating electricity pricing estimates

  - Continuing improvements for representation of the Inflation Reduction Act related provisions

  - Preparing to include finalized federal power sector policies from the Environmental Protection Agency

  - Updating state renewable portfolio and clean energy standards (RPS/CES) and other state-level policy changes as they become available

- Model performance improvements:

  - Converting code from Fortran into AIMMS

  - Investigating parallelization of our model solve and other performance related tasks

IRA Provision	Description	Modeling Implementation
Clean Electricity Investment and Production Tax Credit (CE ITC/PTC)	Up to 30% ITC and 10-year $25/MWh PTC for new projects that meet wage and apprenticeship requirements	Assume wage and apprenticeship requirements are met for all qualifying facilities
CE ITC/PTC Qualifying facilities	Facilities that produce electricity and have a GHG emission rate no greater than zero	Applicable for new nuclear, solar, wind, geothermal, hydro, batteries, land-fill gas, municipal solid waste
CE ITC/PTC Availability and phase out	Phases out after 2032 or after a 75% reduction of CO_2 emission from 2022-levels, whichever comes later	Will model phaseout endogenously, initial modeling suggests the 75% reduction occurs after 2032
CE ITC/PTC Domestic Content Bonus Credit	Tax credit increases by 10% if iron, steel, or other manufactured products are produced in the U.S.	Some representation of domestic content credit for wind and solar and possibly other technologies
CE ITC/PTC Energy Community Bonus Credit	Tax credit increases by 10% if in community with a brownfield, coal closure, or a loss in fossil-based employment	Representation of energy community credit for wind, solar, and geothermal through resource availability curves
Zero-Emission Nuclear Power Production Credit	Up to $15/MWh PTC for existing nuclear that meets wage and apprenticeship requirements and meets electricity revenue requirements	Assume wage and apprenticeship requirements are met and calculate revenue requirement endogenously

Building out the capability to model potential zero-carbon power sector policy mechanisms

- Fuel supply and renewable resource availability improvements:

  - Enhancing the representation of resource availability for wind, solar, and geothermal

  - Updating the representation of coal supply

  - Including the option for nascent generating technologies like bioenergy carbon capture (BECCS) and seasonal storage through hydrogen

- Examination of power sector operations under deep decarbonization:

  - Reevaluating limitations on variable renewable energy (VRE) generation at high penetrations

  - Running production cost models to benchmark NEMS performance at higher VRE penetrations

Solar and wind resource potential

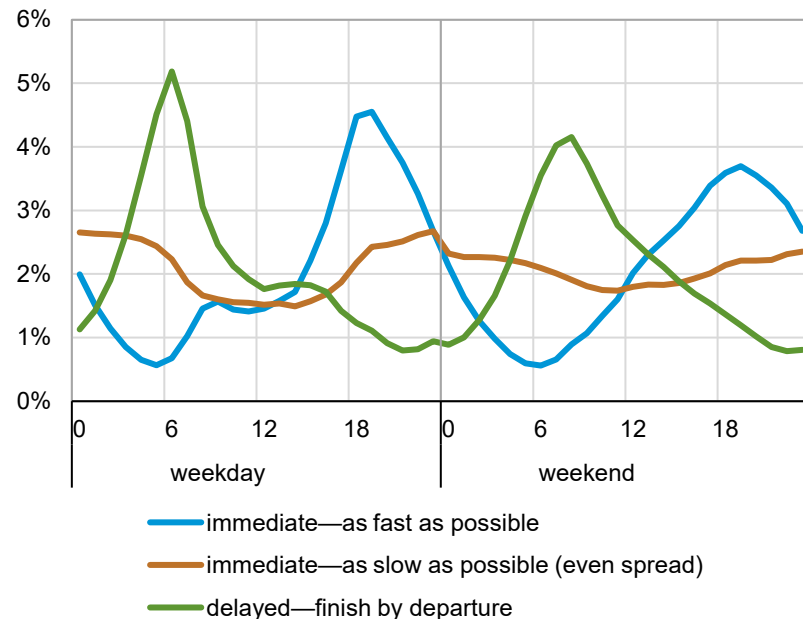https://www.nrel.gov/gis/wind-supply-curves.html; https://www.nrel.gov/gis/solar-supply-curves.html
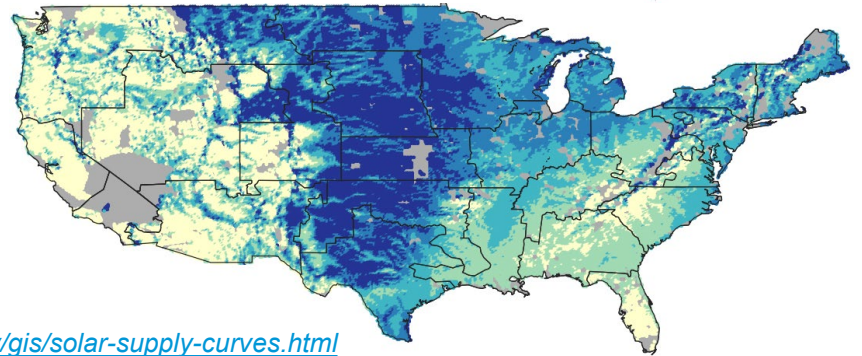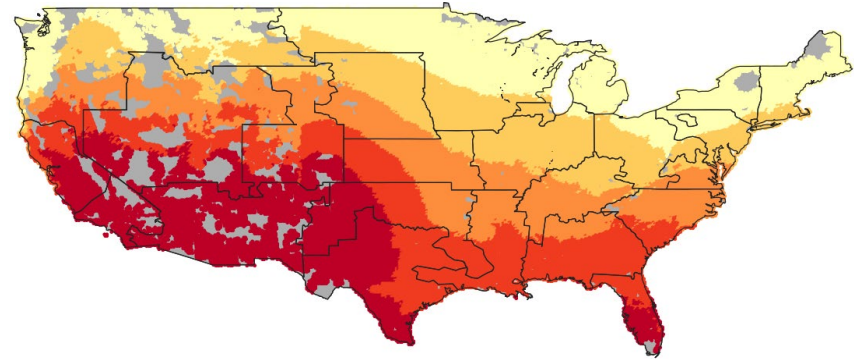
Improving power sector interactions with the rest of the energy economy

- End-use demand sector interactions:

  - Creating new hourly electricity system shapes and end-use load profiles, including new representation of end-uses such as storage, hydrogen production, and alternative EV charging profiles

  - Evaluating potential price feedbacks from hourly electricity profiles to end-user demands

  - Examining the potential for cross-sector battery learning between vehicles and the power sector

- Other sector interactions:

  - Creating all the connections necessary to interact with the new hydrogen market and carbon capture market modules

Illustrative vehicle charging profiles

share of demand in each representative hour

immediate—as fast as possible

immediate—as slow as possible (even spread)

delayed—finish by departure

https://afdc.energy.gov/evi-x-toolbox#/evi-pro-ports

Upcoming Events

Topic	Date	Time*
Macroeconomic-Industrial	April 24, 2024	2:00 p.m.
Residential and Commercial Buildings	May 8, 2024	2:00 p.m.
Electricity, Renewables, Coal, and Nuclear	May 15, 2024	2:00 p.m.
Transportation	May 22, 2024	1:00 p.m.
Introduction to the Carbon Capture, Allocation, Transportation, and Sequestration Module	June 5, 2024	11:00 a.m.
Introduction to the Hydrogen Market Module	June 12, 2024	11:00 a.m.
Petroleum and Natural Gas	July 2024	TBD

All times listed are Eastern Time.

Questions and Answers

Type your question in the chat. We will answer questions as time permits. If we aren't able to get to your question today, email us at: AnnualEnergyOutlook@eia.gov.

Resources:

- U.S. Energy Information Administration home page | www.eia.gov

- Annual Energy Outlook | www.eia.gov/aeo

- AEO2025 Resources | https://www.eia.gov/outlooks/aeo/resources/

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

- Project BlueSky | https://www.eia.gov/totalenergy/data/bluesky/

- Sign up for email updates | https://www.eia.gov/tools/emailupdates/