Independent Statistics and Analysis
U.S. Energy Information Administration

May 28, 2024

MEMORANDUM FOR: Angelina LaRose
Assistant Administrator for Energy Analysis

FROM: Jim Diefenderfer
Director, Office of Long-Term Energy Modeling

SUBJECT: Summary of first AEO2025 Macroeconomic and Industrial Working Group, held on Wednesday, April 24, 2024

This memorandum summarizes the presentation and discussion at the first *Annual Energy Outlook 2025* (AEO2025) Macroeconomic and Industrial Working Group meeting. The macroeconomic and industrial groups presented preliminary AEO2025 results and planned module updates. A question-and-answer discussion followed the presentation.

The presentation slides are available in a separate document on our website. All slides, charts, and discussions for AEO2025 are preliminary and, therefore, should not be quoted or cited. We will release the final AEO2025 report in early 2025.

Macroeconomic Activity Module (MAM) updates

We discussed the key updates to the MAM this year, which included the following models:

- S&P Global's U.S. Macroeconomic Model
- Industrial Output Model and real value of shipments data
- Additional disaggregation for select industries in the Industrial Output Model

Industrial Demand Module (IDM) updates

We briefly summarized top-level industrial results from AEO2023. We then discussed the key updates for the IDM this year, including:

- Implementing technology updates for energy-intensive industries, including new technology options and recycling mechanisms
- Modeling H_2 supply and demand in NEMS, including by:
  - Moving H_2 production out of the IDM and modeling it in the new Hydrogen Market Module (HMM)
  - Explicitly representing existing H_2 feedstock demand in the IDM (for demand that already exists, such as fertilizer plants)
  - Adding H_2-based direct reduced iron as a technology option in steel (a potential new source of H_2 demand)

  - Developing base year (2018) supply and demand values for H_2 based on EIA and U.S. Geological Survey data
- Determining process emissions for all relevant industries
- Adding a mechanism for retrofitted carbon capture and storage (CCS) capacity in the cement industry, in coordination with the new Carbon Capture, Allocation, Transportation, and Sequestration Module (CCATS)
- Creating more flexibility and price dependency in the steel industry's decision to switch from blast furnace and basic oxygen furnace capacity to electric arc furnace and direct reduced iron capacity
- Adding electric boilers and industrial heat pumps for certain industries
- Splitting the balance of manufacturing industry into four separate industries
- Benchmarking purchased electricity by industry to the U.S. Census Bureau's *Annual Survey of Manufactures*
- Incorporating new *Short-Term Energy Outlook* series for marketed petroleum coke into IDM benchmarking
- Using new macroeconomic series for petrochemicals and industrial gases to better model hydrocarbon gas liquids demand and H_2 demand, respectively

Discussion

An attendee asked what the MAM's assumptions were on workforce participation and projections of immigration affecting the available labor pool. We replied that the underlying S&P Global population estimates include immigration, and S&P Global is constantly monitoring data it gets from the U.S. Census Bureau and incorporating the data into the macroeconomic series underlying the MAM.

An attendee asked if existing steam methane reformer (SMR) capacity would be retired if alternative sources of H_2 meet demand for ammonia. We said we will not track SMR capacity.[1] At first, in 2018, the only supply will be from SMRs and byproduct H_2, but we are not linking existing capacity to any one demand source. We will then be calculating supply sources based on the economics of each H_2 technology each projection year.

An attendee asked if carbon capture for cement would capture both process and combustion emissions, and if so, how the emissions accounting would be done. We responded that combustion and process emissions from the clinker kilns are combined in the kiln so they will be captured together. We don't know yet if we're going to break those out separately or not in our tables, but breaking out captured process versus combustion emissions would be relatively simple to do—just take 95% of process emissions and 95% of kiln emissions. Capture costs will be based on estimates from recent National Energy Technology Laboratory reports. We assume retrofit emissions capture facilities will include natural gas boilers. We also assume a 95% capture rate for process emissions and kiln fuel emissions.

[1] Although IDM will not be tracking SMR capacity, HMM will be tracking it. But HMM will not be retiring any capacity. For more information, you can attend the HMM working group on June 12.

An attendee asked what baseline we use for the electricity needed to produce H_2. We replied that this baseline is not a parameter in the IDM but rather in the HMM.[2]

An attendee asked what "Balance of Manufacturing" was. We said it is all the energy consumption that is not allocated to the industries we specifically define in the IDM. It was previously a fairly large chunk of energy consumption, and it was hard to determine from it how the energy was used, so now it has been broken into four separate industries.

An attendee asked which elements in the Bipartisan Infrastructure Law (BIL), the CHIPS Act, and the Inflation Reduction Act (IRA) are included in both NEMS and the IDM. We said we include the extension of the cogeneration tax credit from the IRA. The CHIPS Act is not explicitly included in the IDM, although it is implicit in the macroeconomic shipments we get from the MAM. We confirmed the MAM accounts for BIL and IRA effects. The 45V tax credit is included in HMM to calculate H_2 costs, and the 45Q tax credit is included in CCATS to calculate CO_2 costs and values. In the IDM, we have been looking at funding (about $6 billion) from the IRA for demonstrating novel low-carbon industrial technologies. The funding is for specific projects, however, so it isn't something that is easy to model explicitly. We are instead mostly looking at what projects are finalists for funding. A lot of those projects are technology options we have added to the IDM for AEO2025, such as no-process-emissions clinker for cement.

An attendee asked how the 45X advanced manufacturing production tax credit and the U.S. Department of Energy's Industrial Demonstrations Program were being represented in NEMS. We said that as far as the IDM goes, these items weren't being explicitly represented, but again, we are monitoring the projects that are being funded. The 45X tax credit is incorporated implicitly in the MAM.

An attendee asked if we assumed any shadow price of CO_2 that may drive electrification shifts and whether European Union CO_2 requirements (scope 1, 2, and 3) factored into our assumptions. We responded that we don't account for the European Union CO_2 requirements, nor do we really have implicit CO_2 costs. Sometimes, a small CO_2 cost is associated with technology choice, but it isn't heavily weighted in the IDM. The CO_2 price factor is more of a tiebreaker; if all other costs are equal, the model will choose the lower-emissions technology. We do want to link those technology adoption decisions explicitly to any potential CO_2 price so that the IDM is more responsive in potential carbon-cost side cases. For example, right now, the no-process-emission clinker technology won't really get built because it is generally more expensive than traditional clinker capacity. This technology would only become advantageous if a carbon price existed and if technology choice were tied to that carbon price.

An attendee mentioned other IRA programs of interest might include the 48C manufacturing investment tax credit and programs at the U.S. Department of Transportation and the General Services Administration for procurement of low-carbon construction materials.

An attendee asked if we could clarify where the demand and supply for H_2 and CCS would be determined; how IDM, HMM, and CCATS would interact; and what variables will be transferred between the modules. We explained the end-use modules will specify their demand for H_2 and provide it to the

[2] We later sent an email to the stakeholder quoting the value of 55.5 kilowatthours of electricity per kilogram H_2 produced, the value used in the HMM.

HMM. IDM and the Liquid Fuels Market Module (refining) will initially be the main sources of H_2 demand. Industrial H_2 will have a price that will be used for technology choice calculations— only relevant in steel for AEO2025. Other (end-use) industries are locked into using specific H_2 volumes. For chemical production, you sometimes need H_2, which has no alternatives. In that case, we work backward from the MAM to calculate how much H_2 is required in those industries and basically pay any price. In terms of CO_2, CCATS will provide a value of CO_2, and IDM will provide a cost of capture and the volume of CO_2 captured. We referred the attendee to the CCATS team and working group on June 5 for more information.

An attendee asked about the difference in energy use between greenfield, IRA-induced manufacturing capacity compared with existing manufacturing capacity. We explained technology choice in the IDM is not predicated on existing manufacturing versus greenfield builds. Rather, industrial capacity retires over time, with newer capacity generally being more efficient. For technology choice (process flow) industries, this transition happens on the process-step level, and we track the capacities of different technologies; for end-use industries, this transition occurs more generally on the industry level. End-use industries also have incremental increases in the efficiency of existing capacity. One exception to this trend is feedstock efficiency, which does not increase because of stoichiometric limitations. In terms of greenfield metal-based durables (such as electrical equipment and transportation equipment manufacturing), we do have unit energy consumption parameters for existing equipment to help model electrification.

An attendee asked for a high-level summary of how industrial heat pump adoption is being modeled. We replied that heat pumps are aimed at industries such as food and wood products as well as other industries that can use lower-temperature heat to replace natural gas boilers and other fossil fuel-based heat sources. We will introduce a lever of sorts that uses the electricity-to-natural gas price ratio to help determine which technologies are chosen. High-temperature heat pumps are just beginning to become commercially viable; they are still more expensive than boilers or cogeneration and may need hot and cold loops to make sense economically.

An attendee asked if we considered the blending of low-carbon fuels such as H_2 into natural gas pipelines (as is the plan for some states and utilities) when considering industrial emissions. We replied we had no plans to model natural gas and H_2 pipeline blending in AEO2025.[3]

An attendee asked how demand for cement is projected and whether demand is segregated by government and public projects versus private projects. We replied that demand is not segregated by project type. As far as projecting cement demand, we get shipments (output) information from the MAM. The IDM has data for physical production of cement in 2018, and we use that data to create a ratio of metric tons to macroeconomic shipments, which is used with the MAM series throughout the projection to determine the amount of cement produced each year. The energy needs and mass flows through the different steps of cement production are back-calculated to meet that production level.

[3] The Electricity Market Module may model consumption of natural gas and H_2 blends in the electric power sector, but the blends will not come from a pipeline.

Attendees

Guests (WebEx/phone)	*Affiliation*
Martha Moore	American Chemistry Council
Hellen Chen	American Council for an Energy-Efficient Economy
Neal Elliott	American Council for an Energy-Efficient Economy
Andrew Hoffmeister	American Council for an Energy-Efficient Economy
Anna Johnson	American Council for an Energy-Efficient Economy
Paul Balserak	American Iron and Steel Institute
Brett Smith	American Iron and Steel Institute
David Shin	American Petroleum Institute
Alyssa Leibold	Bureau of Labor Statistics
Gabi Diner	Canada Energy Regulator
Carlos A. Murillo	Canada Energy Regulator
Maxwell Brown	Colorado School of Mines
Paula Ham-Su	DNV
John Laitner	Economic and Human Dimensions Research Associates
Megan Mahajan	Energy Innovation, LLC
Robbie Orvis	Energy Innovation, LLC
Sandeep Alavandi	GTI Energy
Ram Dharmarajan	GTI Energy
Matthew Ives	GTI Energy
Douglas Kosar	GTI Energy
Ansh Nasta	GTI Energy
Derek Wissmiller	GTI Energy
Nick Karki	Lawrence Berkeley National Lab
Prakash Rao	Lawrence Berkeley National Lab
John Meyer	Leidos
Charalampos Avraam	National Renewable Energy Laboratory
Rebecca Hanes	National Renewable Energy Laboratory
Colin McMillan	National Renewable Energy Laboratory
Amogh Prabhu	OnLocation, Inc.
Richard Fullenbaum	RFF Consulting LLC
Ben King	Rhodium Group
Hannah Kolus	Rhodium Group
Emma Rutkowski	Rhodium Group
Colin Cunliff	U.S. Department of Energy
Jun Shepard	U.S. Department of Energy
Peri Ulrey	U.S. Department of Energy
Morgan Browning	U.S. Environmental Protection Agency
Robert L. Hershey, P.E.	

EIA attendees (WebEx/phone)

Monica Abboud
Tuncay Alparslan
Jose Benitez
Erin Boedecker
Richard Bowers
Singfoong Cheah
Peter Colletti
Anna Cororaton
Jim Diefenderfer
Rosalie Dubbohlke
Mike Dwyer
Kathryn Dyl
Mindi Farber-DeAnda
Timothy Hess
Kevin Jarzomski
Angelina LaRose
Tom Lorenz
John Maples
Kevin Nakolan
Boon Teck Ong
Phalon, Brittany
Elizabeth Sendich
Estella Shi
Sauleh Siddiqui
Courtney Sourmehi
Manussawee Sukunta
Greg Vance
Neil Wagner
Mary Webber
Stephen York
Daniel Agee
Peter Gross
Kelly Perl
Nicholas Skarzynski
Matt Skelton
Russ Tarver