

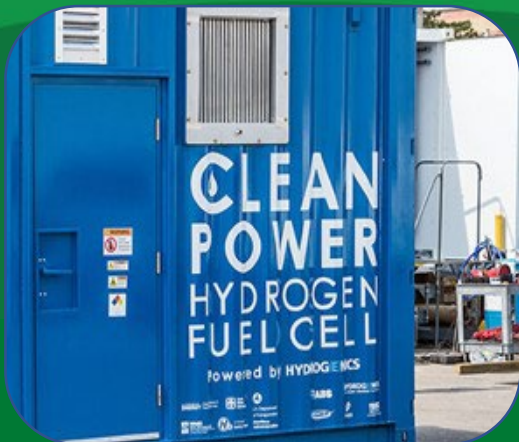


U.S. DEPARTMENT OF
ENERGY

Fossil Energy and
Carbon Management

Hydrogen Market Module

Component Design Report and Project Update
May 12, 2022
USEA CONSENSUS Webinar



Agenda

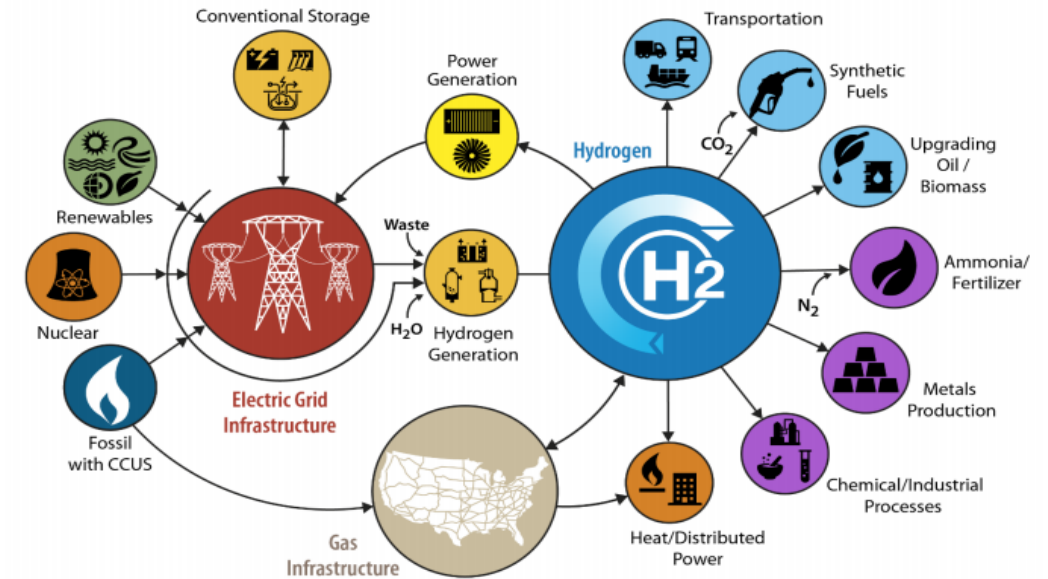
- Introductions & FE-261 Analysis Overview
- National Energy Modeling System
- Hydrogen Market Module (HMM)
 - Overview
 - Component Design Report
 - Technologies and End Use
 - Proposed Structure
- Next Steps and Schedule

DOE FECM Sponsored NEMS Enhancements

- Industrial carbon capture, utilization and storage (CCUS) Enhancements
 - New pipeline network representation - Completed
 - Endogenous capture at ethanol, hydrogen production at refineries, and natural gas processing - Completed
 - Industrial CO2 Resource Inventory – Contractor Re-Task, Underway
 - Cement Carbon Management – Component Design Review Completed, Development Underway
 - Steel Production Decarbonization – Planning
 - Wood and Paper Production Decarbonization – Planning
- Biomass with carbon capture and storage (BECCS)
 - Co-Firing and Retrofits – Completed
 - New Plants – Planning
 - Bio-Refineries Enhancements – Planning
- Hydrogen Market Model – Component Design Report Completed, Development Underway
- Integration of Carbon Dioxide Removal (CDR)
 - Direct air capture (DAC) – Completed
 - Mineralization, Land Use, Coastal Sequestration – Planning
 - Indirect GHG Modeling – Planning
- Macroeconomics of Decarbonization – Early Planning
- Cases with Deep Decarbonization and Full Carbon Capture – Underway

H₂ Activities and Modeling Need

- Significant development in H₂ production technologies, end use, transportation and other sectors
- Discussion of H₂ PTC
 - Key Metric: GHG Footprint of Production
- IIJA: H₂ Hubs, Clean Hydrogen Manufacturing Program
- Strong need for integrated modeling of H₂ pathways and ability to assess the impact of H₂ policies

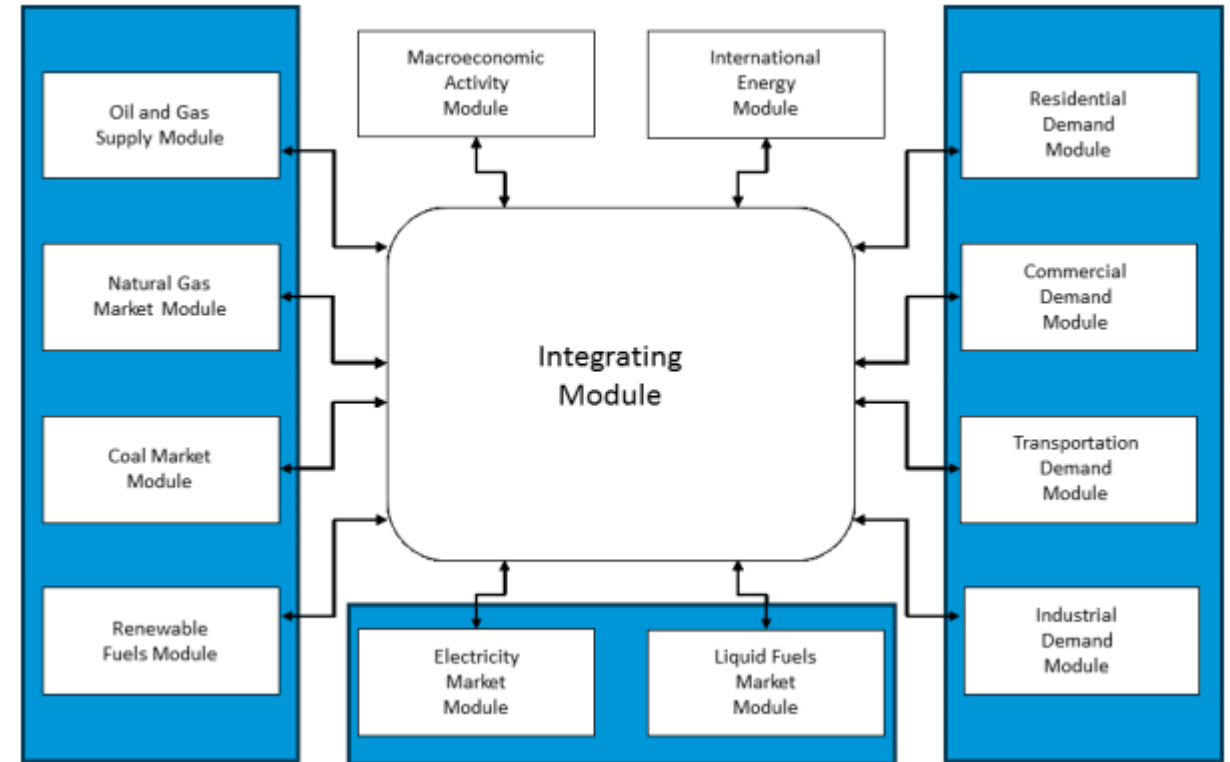


Project Organization

- FECM and EERE are joined by EIA efforts to develop new Hydrogen Market Module (HMM) which could be fully integrated in NEMS in future AEOs. EIA Has:
 - Engaged in preparation and review of Requirements Document, completed November 2021
 - Actively reviewed Component Design Report (CDR), completed in February 2022
 - Specified preference for Knowledge-Based Modeling and
 - Programming language – AIMMS/Python (not Fortran)
 - Transport pure hydrogen through its own pipelines, low blends through natural gas pipelines
 - Exclude hydrogen export and fuel conversion aboard ships
 - Will need to modify other NEMS modules to incorporate hydrogen
- Currently developing a submodule within NEMS Electricity Market Module to use hydrogen for seasonal storage and reliability

National Energy Modeling System (NEMS)

- NEMS projects the **production, imports, conversion, consumption, and prices of energy**, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, **behavioral and technological choice criteria, cost and performance characteristics of energy technologies**, and demographics.
- NEMS is used by EIA to project the impact that energy, economic, environmental, and security factors can have on the U.S. energy system.
- The projections in the **Annual Energy Outlook** are from the present through 2050



H₂ Modeling: The Challenge

- Hydrogen is proposed as an **energy carrier**
- Current representation in some parts of the model
 - H₂ for storage in the Electricity Market Module (EMM)
 - H₂ within refineries in the Liquid Fuels Market Module (LFMM)
- Multiple technologies and fuel inputs can generate hydrogen
- Many methods of transporting hydrogen
- Integration of hydrogen as an energy source in multiple end use modules

Hydrogen Market Module (HMM):

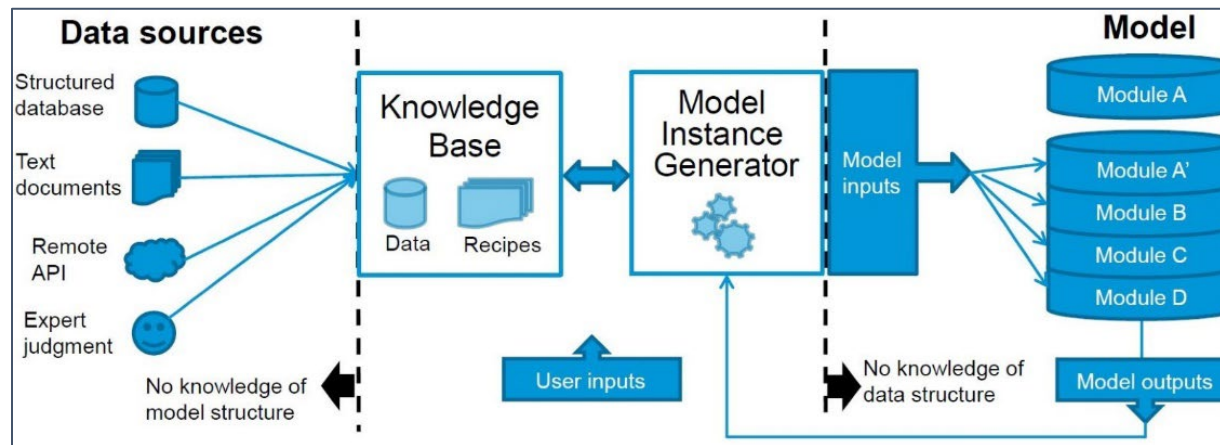
- Goal is to identify key pathways to introduce hydrogen, even if they may not be economic outside of a role in deep decarbonization
- Delineate production and end use technologies
 - The requirements document separates production technologies from transportation routes in the section 'Technologies Modeled'
- Sources of information: DOE H₂ programs, H₂A cost models by the National Renewable Energy Laboratory (NREL), National Energy Technology Laboratory (NETL) technology baselines – Other Public data sources

Component Design Report (CDR)

- Report that outlines the approach to developing code for new components within the National Energy Modeling System (NEMS)
- CDR General Outline:
 - Required enhancements to model H₂ Pathways
 - Metrics to measure impact
 - Policies that will influence development
 - Design Philosophy, including capabilities
 - Technologies to be characterized (Production and End Use)
 - Potential Modeling Approaches
 - Proposed Module Layout
 - Enhancements needed for integration with existing modules

Model Structure

- Enough flexibility to account for a wide variety of policy designs
- Track production from all technologies and energy input into production
- Use knowledge-based modeling (KBM) architecture that separates model algorithms from data



- New model development should interface with standard EIA reporting tools
- Domestic representation is a priority but leave placeholders for import and export

Hydrogen Accounting

- Hydrogen production will be distributed across several modules.
 - EMM production for power use (Internal production and use as storage)
 - HMM large-scale production
 - Small-scale production will be characterized in demand modules
 - E.g., Industrial Demand Module – H₂ within Refineries
- The HMM will track production from all technologies and energy input into production
- **Accounting is not straight forward.**

Production Technologies

- Technologies should be prioritized by near-to-midterm path to commercialization
- All possible technologies should be represented
- Consider hydrogen production in Liquid Fuels Market Module (LFMM), and Electricity Market Module (EMM)
 - Note: Integration with current work on H₂ storage in the EMM.
- Carbon Capture (CCS) quantities should be handled appropriately
 - Present in section on Carbon Transportation Utilization and Storage (CTUS) module of NEMS integration section

HMM: Proposed Production Technologies

Hydrogen Type	Fuel Source	Technology
Fossil	NG	Steam methane reforming
Fossil	NG	Autothermal reforming
Fossil	NG	Steam methane reforming with CCUS
Fossil	NG	Autothermal reforming with CCUS
Fossil	NG	Pyrolysis
Fossil	Refinery Byproduct	Steam Cracking
Fossil	Coal	Gasification with CCUS
Fossil	Coal	Gasification
Renewable	Biomass	Gasification
Renewable	Biomass	Gasification with CCUS
Renewable	Biomass	Bio-oil Reforming
Renewable	Solar Thermal	Solar Thermochemical
Renewable	Solar Thermal	PEM electrolysis
Renewable	Solar	Direct Solar Water Splitting
Renewable	PV/Wind/Hydro	Alkaline electrolysis
Renewable	PV/Wind	PEM electrolysis
Electricity	Grid	Alkaline electrolysis
Electricity	Grid	PEM electrolysis
Nuclear	Nuclear	PEM electrolysis
Nuclear	Nuclear	Solid Oxide electrolysis

Transportation

- Keep separation pathway open for blended H₂/Natural Gas methods
- Blended pipelines in the Natural Gas Market Module (NGMM)
- Dedicated H₂ pipelines in the Hydrogen Market Module (HMM)

End Use

- Flexibility to add other energy carriers in addition to conversion to ammonia
- Small scale hydrogen is lower priority
 - (except Medium-Heavy Duty Vehicles (MHDV) refueling stations)
- End use representation should be in the respective demand modules and may include self-production
- Future work: Transportation module modelers for maritime and aviation pathways (Not intended for early modeling)

HMM: Draft Structure

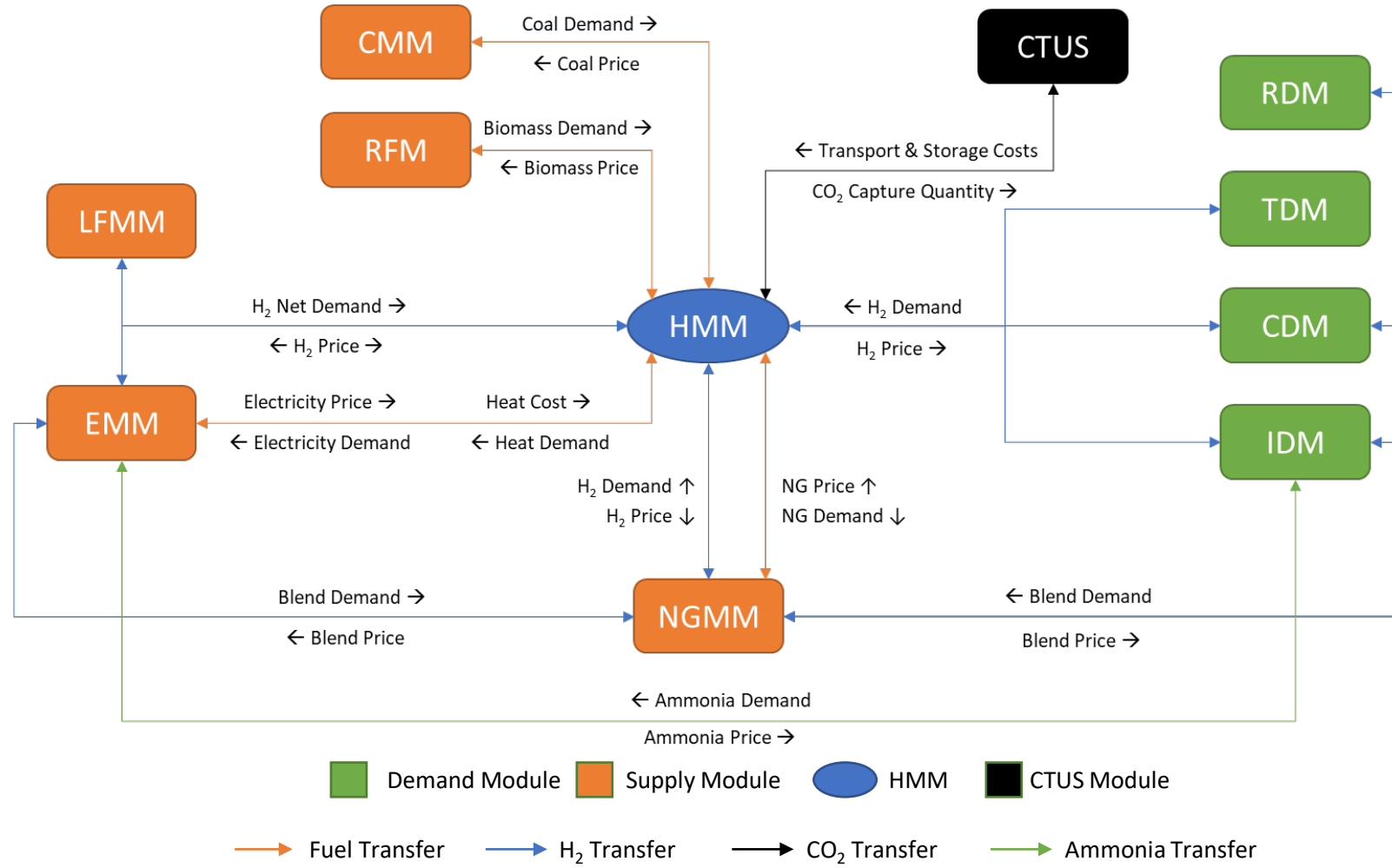
Key:

MM = Market Module
 LFMM - Liquid Fuels
 EMM – Electricity
 CMM – Coal
 HMM – Hydrogen
 NGMM – Natural Gas

DM = Demand Module
 RDM – Residential
 CDM – Commercial
 TDM – Transportation
 IDM – Industrial

RFM – Renewable Fuels Module

CTUS – Carbon Transportation
 Utilization and Storage



Next Steps

- Beginning work on HMM Development
- Intending to have additional Hydrogen modeling workshops
- Initial draft coding and modules: Fall 2022

- Follow up studies:
 - Deep Decarbonization Pathway Studies
 - IIJA Impact Analysis
 - 45Q Deployment

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Questions?