Energy Technology Data: Sources and Challenges

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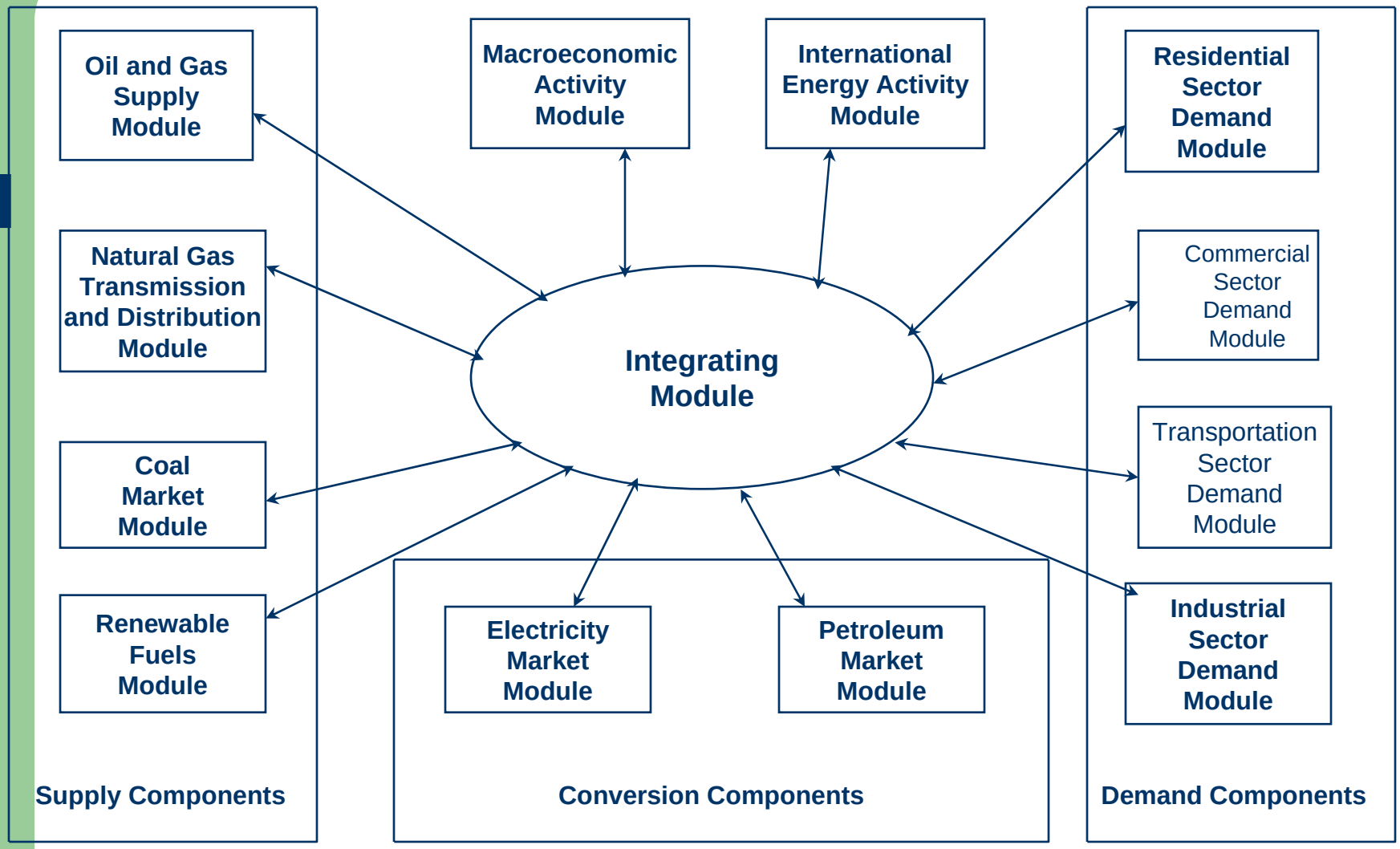
National Energy Modeling System

- Designed and developed by the Energy Information Administration
- Large, regional energy-economy model of the United States, including international trade of energy
- Represents all energy supply, conversion, and demand in a unified, but modular system
- Technology detailed
- Designed for both baseline energy projections and policy analysis
- Provides *likely* projected energy future, under a given set of assumptions, not an *optimal* energy future

NEMS Structure

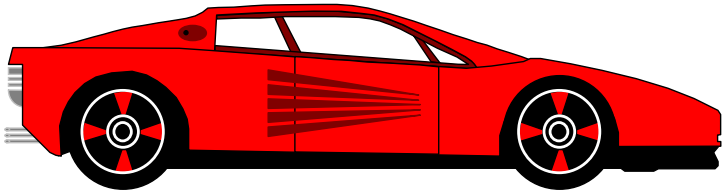


Technology Representation

- Explicit technology representation, e.g., capital and O&M costs, efficiencies, capacity factors, equipment life, year of availability
  - Residential, commercial, transportation demand
  - Electricity capacity expansion and generation
  - Natural gas transmission and distribution
  - Refineries
- Indirect representation
  - Oil, natural gas, and coal supply
  - Industrial demand, except for cogeneration and motors

Residential and Commercial Demand

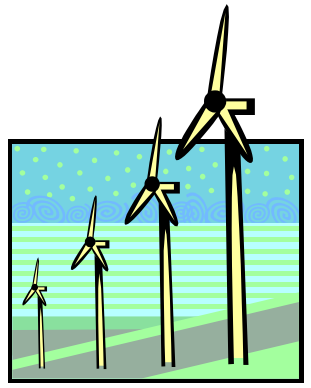
- Track building stock by type and region
- Residential module tracks appliance stock and accounts for trends in housing size
- Choose new or replacement equipment for each service demand by building type based on cost and performance characteristics and observed, implied discount rates
- Technology characteristics account for future cost reductions, efficiency improvements, and new equipment as a function of time and price
- Accounts for distributed generation and commercial cogeneration
- Technology data from Navigant Consulting and Discovery Insights, for distributed generation



Transportation Demand

- Tracks light-duty vehicles by type, vintage, and size class
- Vehicle-miles traveled estimated based on cost of driving, income, and demographics
- Fleet vehicles represented separately
- Alternative-fuel and advanced technology vehicle sales are a function of technology attributes, costs, and fuel prices
- Fuel-saving technologies selected for cost effectiveness
- Freight truck and air are also vintaged stock models
- Air module accounts for freight and passenger use, narrow- and wide body aircraft, aircraft parking, and infrastructure limits
- Technology data from Energy and Environmental Analysis – light-duty vehicles, Argonne National Laboratory – freight trucks, and Oak Ridge National Laboratory - aircraft

Electricity Generation



- Represents generation, transmission, and pricing
- Capacity planning looks 6 years ahead based on expected electricity demand, load shapes, fuel prices, technology, trade, and regulations
- Technology characterized by costs, capacity factors, commercialization status, and efficiencies, compared on 20-year total costs
- Technological optimism, learning, and risk are included
- Dispatch determined by merit order, current demand, trade, fuel prices, and regulations
- Technology data from various sources – industry, Offices of Fossil Energy, Nuclear Energy, and Energy Efficiency and Renewable Energy, National Laboratories, and Distributed Utility Associates

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Petroleum Markets

- Petroleum markets are represented by regional, linear programs of refinery operations, including more than 40 refinery processes
- Refineries select among five crude oil types, both foreign and domestic
- Accounts for ethanol production and blending and oxygenates blending, as well as gas-to-liquids, coal-to-liquids, and biofuels
- Includes all fuel specifications
- Petroleum products are projected at the regional level based on production costs, distribution charges, taxes
- Technology data from WORLD – World Oil Refining Logistics and Demand model

Industrial Demand

- Heat and power and feedstock energy projected for 21 industries
- “Technology bundles” characterize process steps or end uses for 7 energy-intensive manufacturing industries and 2 non-energy-intensive manufacturing industries
- Bulk chemicals are disaggregated into 4 components
- Energy intensity for each bundle declines based on time, rate of capacity additions, and energy prices
- Motor model included for 4 manufacturing industries
- Fuel switching, cogeneration, recycling, byproducts, and buildings use of energy included
- Nonmanufacturing demand includes construction, agriculture, and mining industries
- Technology data from Focis, Energy and Environmental Analysis for boilers, and Discovery Insights for cogeneration

Oil, Natural Gas, and Coal Supply

- Oil and natural gas supply technology represented by improvements over time in costs per well and finding and success rates, but more technology detail for unconventional natural gas with data from Advanced Resources, Inc.
- Coal production technology is represented by increases in productivity
- Both the natural gas and coal modules include aggregate transportation networks
  - Natural gas transportation represents off-peak and on-peak use, seasonal storage, tariffs, and foreign sources, including pipeline and LNG, with LNG technology data from the Gas Technology Institute
  - Coal includes a world coal trade model

Some Challenges

- Aggregation into technology clusters
- Level of optimism
- Consistency of various data sources
- Long-term trends vs. short-term adjustments
- Technology choice in modeling
- Learning

Technology Improvement or Learning

- Many factors cause improvements in cost and performance:
  - Economies of scale as fixed costs are shared
  - Economy-wide growth in science and technology
  - Differences across firms, industries, and products
  - New techniques to manage processes and apply existing technologies
  - Private and public research and development
  - Technology learning
- NEMS represents learning in 3 ways:
  - Time trend in efficiency and/or cost improvements
  - Specified cost and performance improvements over time for specific technologies, which can be accelerated by higher prices.
  - Explicit model of endogenous learning-by-doing

Endogenous Learning in NEMS

- Electricity generation
  - Adopted 3 piece-wise nonlinear curves to allow more rapid learning rates at earlier stages of deployment
  - Incorporated autonomous minimum learning rate to reflect international learning and R&D
  - Implemented component-specific learning, e.g., additions of advanced natural gas combined-cycle capacity results in learning for the advanced turbine component of IGCC and advanced biomass technologies.
- Building technologies include an accelerated time menu based on significant price changes and endogenous learning for other technologies like CHP and motors

Additional Factors for Generation Technology Choice

- Adjustments to first-of-a-kind costs for technological optimism
- Risk and uncertainty – potential to adjust discount rates by technology or investment class
- Use of reduced costs to provide portion of market for technologies which are nearly competitive in heterogeneous market
- Limits to “learning” from simultaneous capacity additions
- Year-to-year capacity expansion supply curve
- Choice of fuel price expectations for decisionmaking

Thank you!

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