EIA Buildings Analysis of Consumer Behavior in NEMS

Behavioral Economics Experts Meeting

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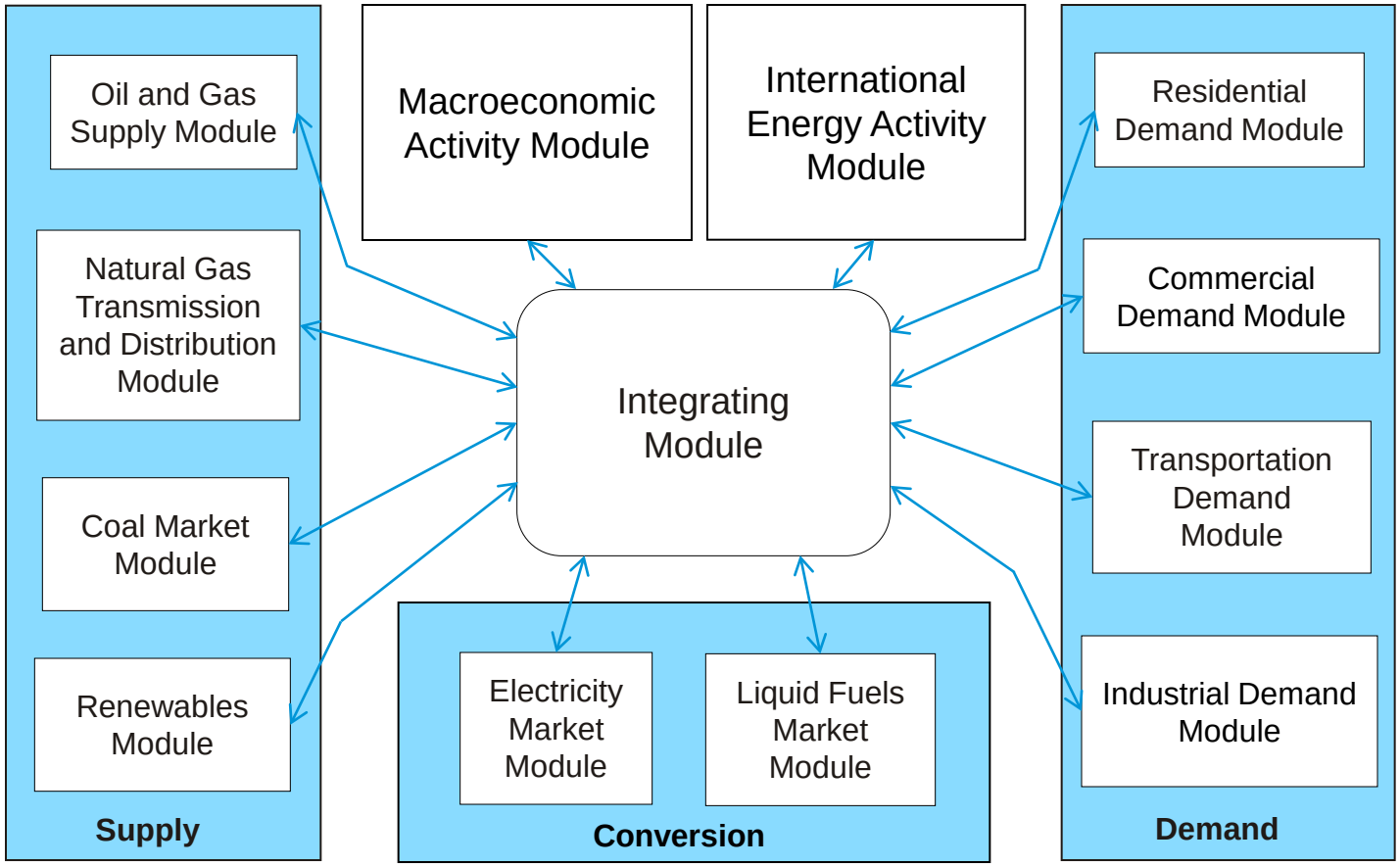
Buildings Energy Consumption and Efficiency Analysis

Overview

- NEMS Structure
- Housing/floorspace and service demand in Residential Demand Module (RDM) and Commercial Demand Module (CDM)
- Market share calculation for equipment in RDM and CDM
- Price responses / elasticities
- Distributed generation (DG) & combined heat and power (CHP)

NEMS Structure

- Represents energy supply, conversion, and demand in a unified, but modular system
- Detailed structural and process models in most energy sectors



Housing/floorspace and service demand in RDM and CDM

- Base years built from consumption surveys
  - Residential Energy Consumption Survey (RECS), updating to 2009 in AEO2014
  - Commercial Buildings Energy Consumption Survey (CBECS), latest 2003
- Housing starts (residential sector) and commercial floorspace growth rates (commercial sector) provided to the RDM and CDM each year by the Macroeconomic Activity Module (MAM)
- Removals
  - RDM: housing demolished at a constant rate (by housing type)
  - CDM: uses survival algorithm to determine floorspace removals (age of construction, median lifetimes of building types, etc.)

Housing/floorspace and service demand in RDM and CDM (continued)

- After determining housing/floorspace, RDM and CDM calculate end-use service demand
- Equipment meets service demand
- Technology menus contain all equipment options for major end-uses and equipment characteristics
  - Availability
  - Capital costs
  - Installation costs
  - Operating and maintenance costs
  - Removal/disposal costs
  - Efficiency
  - Equipment lifetimes

Market share calculation for equipment in the RDM

$$Weight_{equipment} = e^{B1*CapitalCost+B2*OperatingCost}$$

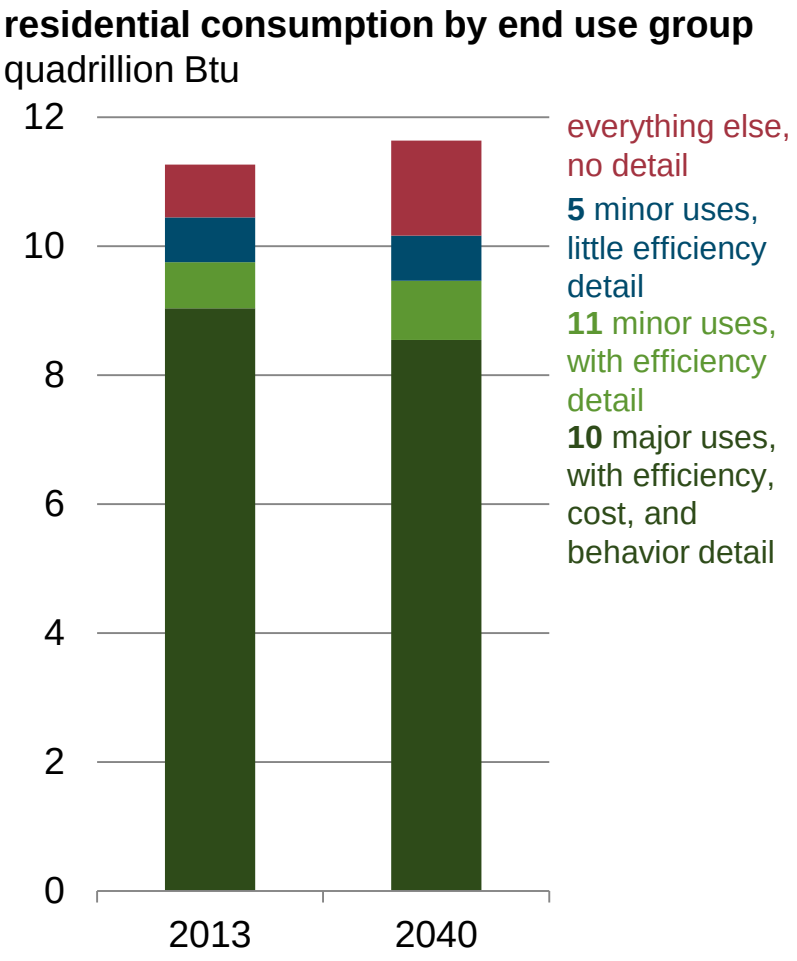
$$Weight_{Total} = \sum Weight_{equipment}$$

$$MarketShare_{equipment} = (Weight_{equipment}) / (Weight_{Total})$$

B1, B2
Bias parameters
Implicit discount rate

- Gives share of an equipment type within an equipment type class
  - End uses: heating, cooling, water heating, cooking, refrigeration, etc.
  - Classes (heating, for example): electric furnace, gas furnace, distillate furnace, LPG furnace, etc.
  - Types: different models of electric furnace, different models of gas furnace, etc.

Market shares (RDM continued), technology detail in the residential sector



- Major equipment and shell measures (80% in 2013)
  - Cost, efficiency, behavior, equipment interaction, fuel switching
- Minor uses (13%)
  - ENERGY STAR electronics
  - Some have efficiency detail (TVs, PCs) and some don't (secondary heating, coffee makers, security systems)
- "Everything else" (7%)
  - Essentially a remainder from bottom-up approach

Market share calculation for equipment in the CDM

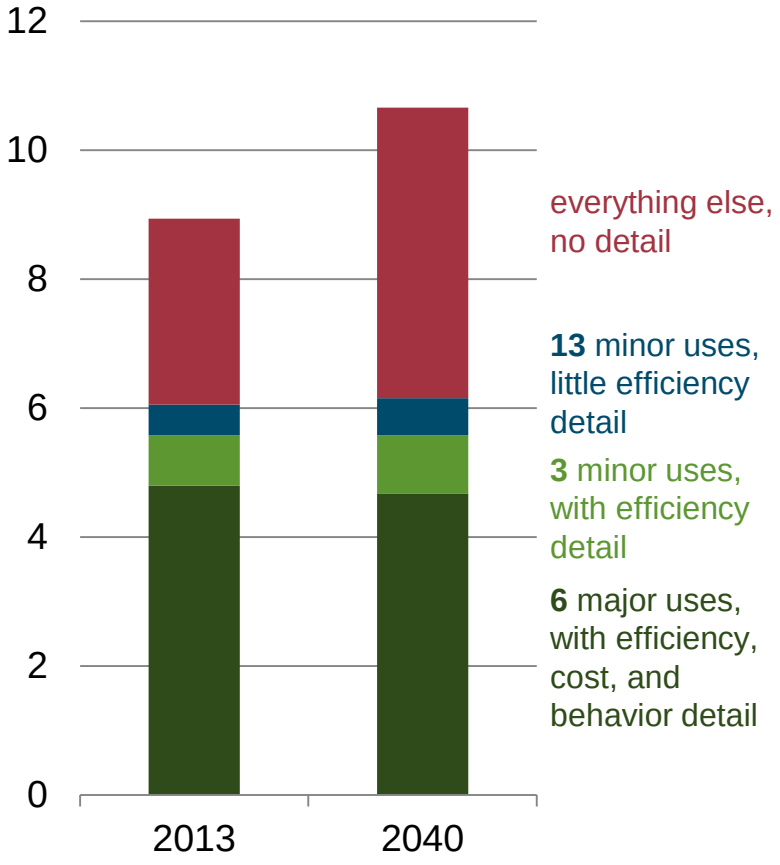
- Behavior rules (least cost, same fuel, same technology type)
  - Ownership and occupancy characteristics form basis of calculations to determine market share following each rule
  - CBECS data
- Decision types (new, replacement, retrofit or surviving)
  - Satisfy service demand, new/retiring floorspace depends on MAM
- Hurdle rates
  - Used in life-cycle cost calculation
  - Distribution (segments the market according to how consumers value future cost savings)
- Behavior rules, decision types, hurdle rates, and technology interact to determine the market shares of equipment

Market shares (CDM continued), example of replacement with a same-technology rule

- Consumers pick among same equipment class
  - For an natural gas boiler example: between 1 gas boiler and another type of gas boiler
- Life-cycle costs of the options (natural gas boiler 1, natural gas boiler 2, etc.) calculated across hurdle rate distribution
- Market shares divided by proportion of consumers at each hurdle rate (i.e. buying according to the different energy savings criteria)

Market shares (CDM continued), technology detail in the commercial sector

commercial consumption by end use group
quadrillion Btu



- Less homogenous
- Major equipment (54% in 2013)
- Minor uses (14%)
- “Everything else” (32%)

Fuel price response in both RDM and CDM

- Fuel prices provided each model year to RDM and CDM by the other NEMS modules
- Elasticities by fuel
- RSELAST (in RDM) and KELAST (in CDM)
  - Effect of each elasticity-induced change spread over the current model year and the following two years
  - Elasticity for efficiency (de facto “rebound effect”, increases in efficiency can lead to increased amount of service demand)
  - Option for price-induced technology change, but not used in Reference case

Distributed generation (DG) & combined heat and power (CHP)

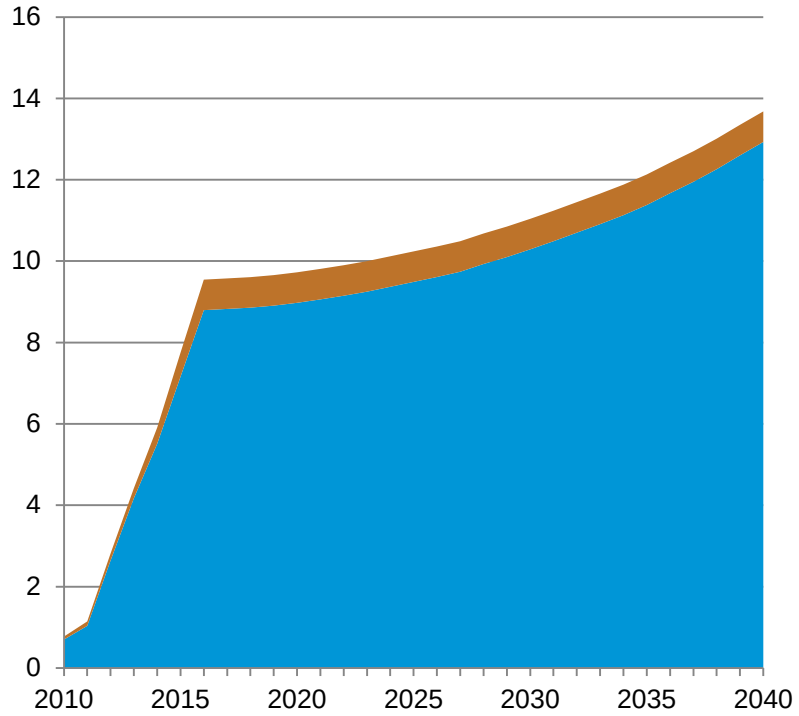
- Cost and performance data, as well as tax credits, included in technology menu
- 30-year cash-flow analysis used to calculate payback period and years to positive cash flow or internal rate of return (IRR) on investments, which determines DG penetration in new construction
  - Existing construction penetration a percentage of new construction penetration
- Depreciation allowances in NEMS represent initial costs, including material and labor installation costs, divided by the tax life of the equipment.
  - User-chosen depreciation methods: straight-line or accelerated depreciation

DG & CHP (continued)

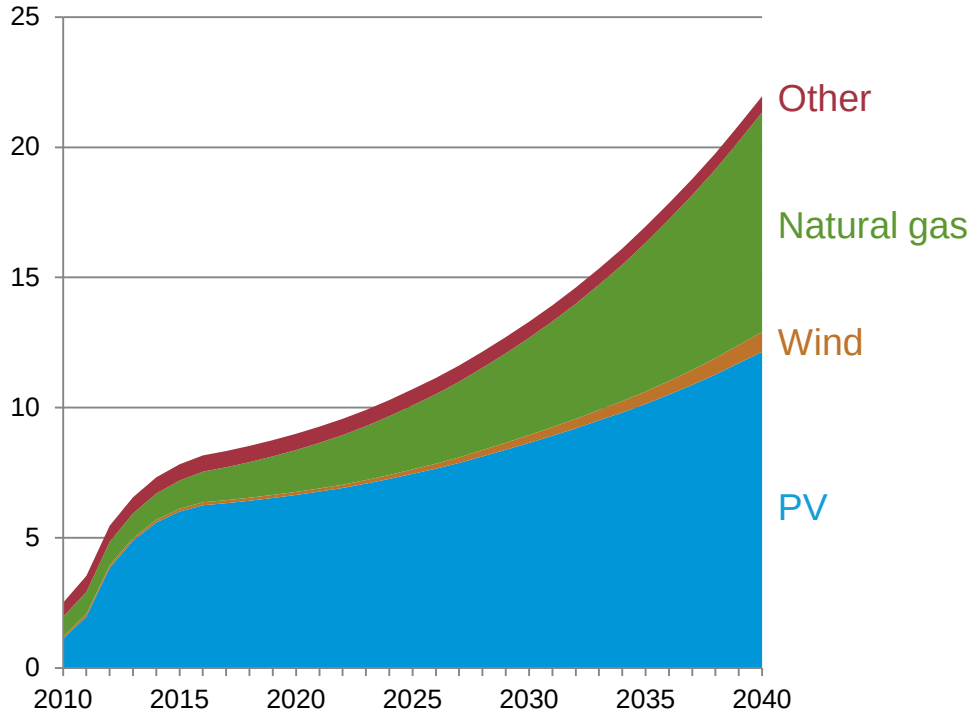
- Interconnection limitations
- Projected increases in DG technologies in buildings yield reduced purchases of electricity from the supply-side of NEMS (i.e., the power sector)
- Exogenous capacity is input to account for lack of state and local incentive consideration in NEMS, as well as to capture historical installed capacity

DG & CHP in AEO2013

generating capacity, GW



residential



commercial

For more information

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

Annual Energy Outlook | www.eia.gov/aeo

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Supplemental

NEMS buildings technologies have the opportunity to "learn" in four ways

- Learning for conventional technologies is exogenously specified by technology "menus" that include availability of cost and performance improvements over time
- Costs for less mature technologies can decline from menu costs over time based on parameters for the total anticipated price reduction, and the rate of price decline
- Menu availability of technologies can be accelerated with a sustained substantial increase in fuel prices
- CHP and distributed generation include potential for endogenous "learning" with declining technology costs as shipments increase in addition to menu-driven improvement