Modeling Energy Use

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Climate Change and the Role of End Use Technologies

Climate change is a long-term, global challenge.

The role of end use technologies:

- Reducing the energy required to provide energy-related services.
- Facilitating substitution to low- or no-carbon fuels.

Electricity as a fraction of global final energy:

- Non-Annex 1
- Annex 1
- 450 ppmv stabilization

Emissions:

- 450 ppmv stabilization
- Non-Annex 1
- Annex 1

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The aggregate approach
Aggregate Approach to Energy Demand

- Three end use sectors in each region: buildings, industry, and transportation.
- Each sector demands a single aggregate service which increases as a function of income.
- AEEI reduces energy demands; demand responds to prices.
- Fuel shares based on prices and income.
The Value of End Use Technologies

Value of Various Technological Advances and Combinations to Meet 2 Degree C Target
Detailed End Use Sectors
Unpacking End-Use Demands

MiniCAM now includes detailed end use representations of buildings, industry, and transportation in the U.S.
- Other regions are next – that’s a challenge

Attempting to better understand:
- Evolution of end use demands
- Value of end use technologies
- Response of end use demand to climate policy, targeted policies
- Response of end use demands (heating/cooling) to climate change
Detailed U.S. Buildings Sector

- Building Characteristics & Floor Space
  - Residential Buildings
  - Commercial Buildings
  - U.S. Region

- Service Demands
  - Heating
  - Cooling
  - Lighting
  - Hot Water
  - Appliances
  - Other

- Technologies
  - Heating
  - Cooling
  - Lighting
  - Hot Water
  - Appliances
  - Other
  - Heating Techs
  - Cooling Techs
  - Lighting Techs
  - Hot Water Techs
  - Generic Tech

- Fuels
  - Natural Gas
  - Fuel Oil
  - Electricity
  - Wood
Heating and Cooling Service Demands

**HEATING**

\[ d_H = \sigma_H u \cdot HDD \cdot P_H^{-\beta_H} - G \]

**COOLING**

\[ d_C = \phi_C \left( \sigma_C u \cdot CDD \cdot P_C^{-\beta_C} + G \right) \]

- Heat Transfer Coefficient
- Calibration Parameter
- Heating Degree Days
- Price of Heating Service
- Internal Gains
Illustrative Buildings Scenario
Demand for Floorspace

Floorspace growth drives demand for building services
Population grows by roughly 40% over the century
Total floorspace roughly doubles over the century
Service Demands

Factors influencing service demand evolution

- Price response (fuel & technology)
- Assumed expansions in demands
- Shell efficiency improvements
- Internal gains

Residential Service per Square Foot

Commercial Service per Square Foot
Fuel Consumption & Stabilization

- Plenty of electrification without climate policy
  - Increasing penetration of largely electric demands
  - Some fuel switching in heating and water heating
- Limited change in electricity consumption under stabilization
  - Moderate fuel switching in heating and water heating

![Graph showing fuel consumption trends for residential and commercial sectors.](image)
Understanding Technology Evolution

- Heating is affected more by climate policy than cooling.
- Electrification in heating is already in place in this scenario without emissions constraints.
Modes compete based on service costs and value of travel time. Technologies compete on the basis of service cost.
The Demand for Transportation Fuels

- Passenger transportation is not the only demand for transportation fuels, but it is the biggest.
- Passengers value time, imposing an increasingly, affecting both modal shares and total demand for passenger transportation.
- Indications are for an increasing trend toward air travel.
- The opportunities to reduce carbon differs by mode and service.
ObjECTS End-Use and Technology Structure: the Chemicals Industry as an Example

End-Uses

Chemicals Industry

- Boilers (Steam)
- Process Heat
- Machine Drive
- HVAC
- Other End-uses

Competing Technologies

- Steam-only Boilers
- Cogeneration (CHP)

Produced

- Electricity

Feedstocks

- Biomass
- Coal
- Oil
- Gas
A Couple of Challenges

- Understanding evolving growth in service demands
  - Including uncertainty in the possibility for new demands
- Ensuring consistency between evolution in different sectors
- Getting baseline data
- Technology adoption (particularly in developing economies)
- Future technology characteristics
Questions