GTSP

Global Energy Technology Strategy Program

Data Needs for Long-term, Global, Energy-Service-Based Scenarios

Global Energy Demand Collaborative

Developing Energy Service Based Scenarios

Jae Edmonds, Steve Smith and Leon Clarke

11 January 2005

Washington Marriott

1221 22nd Street NW

Washington, DC

Battelle
Office of Science U.S. Department of Energy
JGCRI Joint Global Change Research Institute
University of Maryland
Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

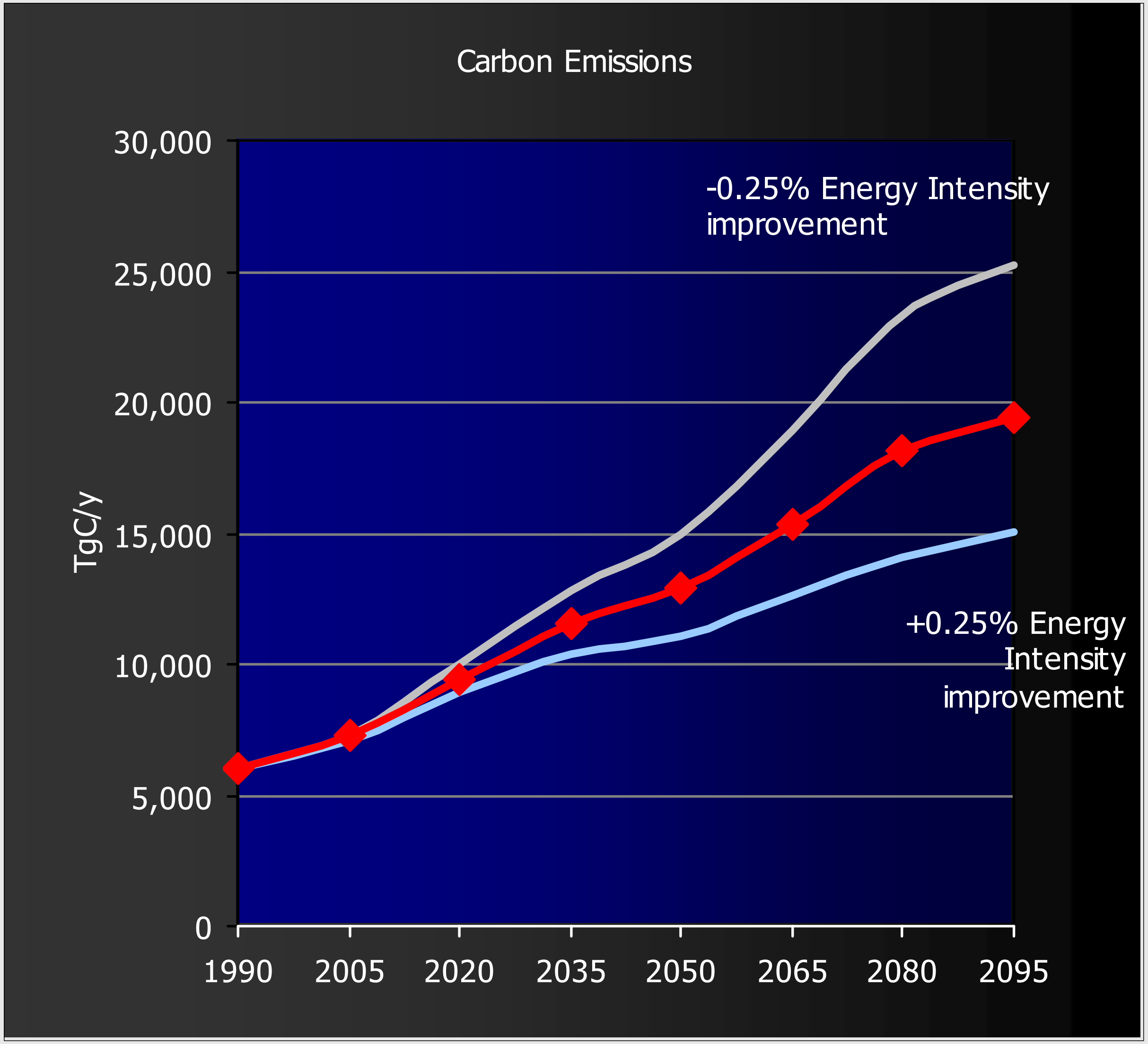
Acknowledgements

- Mark Levine—initiating this activity
- Lynn Price—organizing this activity
- U.S. DOE, EPRI and the other sponsors of the Global Energy Technology Strategy Program for supporting the research.
- My colleagues for developing the MiniCAM-SGM modeling systems.

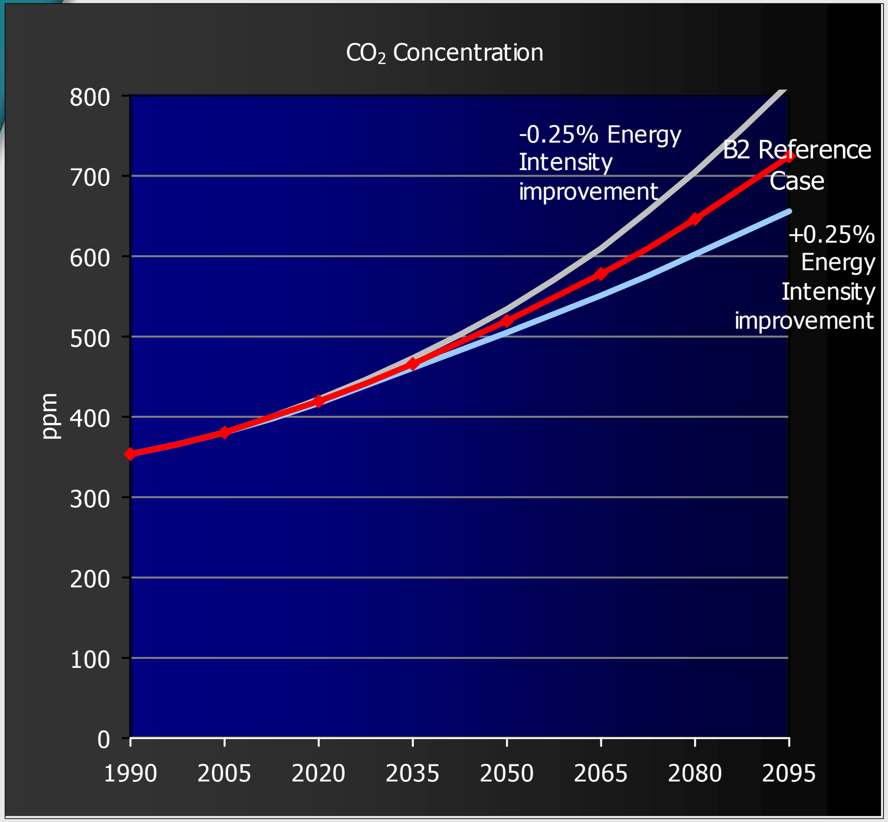
Motivation

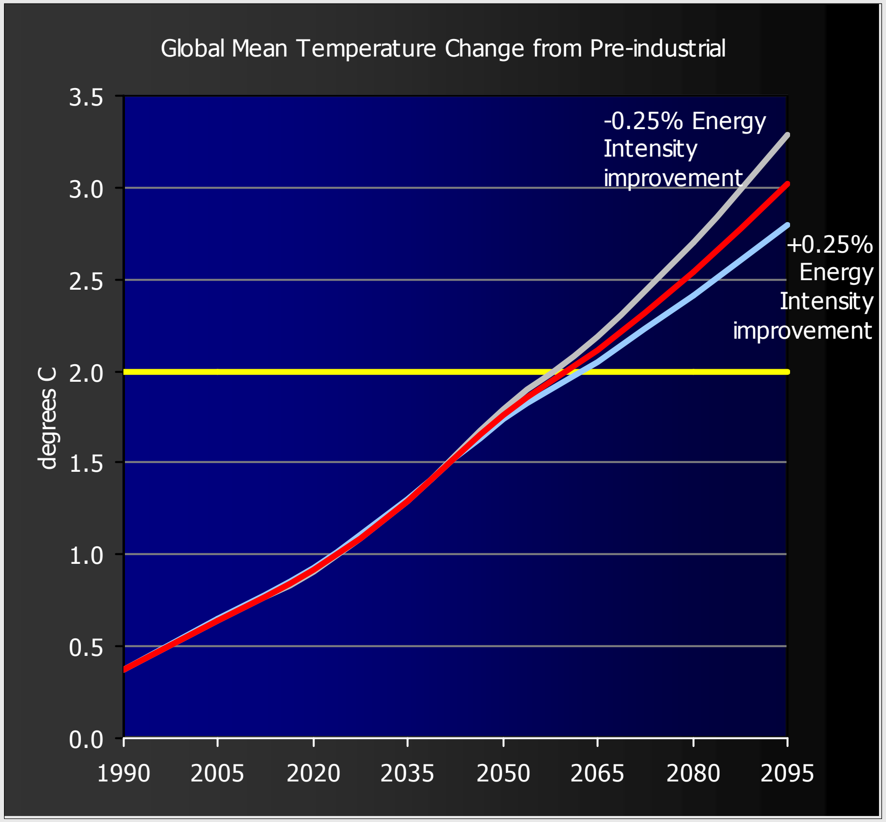
- Technological change in end-use energy is central to determining future greenhouse gas emissions and the cost of meeting environmental goals.
- Present long-term, global, energy-economy scenarios do not address end-use energy adequately.
- New scenarios are being developed. This is a particularly good time to improve the quality of long-term, global scenarios of energy, economy, agriculture, land-use, and GHG emissions.
- Goal: To develop both long-term, global non-climate-policy, counterfactual scenarios by region and year, and stabilization scenarios with explicit consideration of end-use energy technologies and technological change.

End-use Energy Services and CO_2 Emissions



End-use Energy Services, CO_2 Concentrations, and Global Mean Surface Temperature Change





Objects.MiniCAM

- Energy-Agriculture-Economy Market Equilibrium
- 14 Global Regions
- 15-Year Time Steps
- Multiple Greenhouse Gases
- Demographics Module
- Land Resource Constraints
- Flexible Number of Energy Technology Options

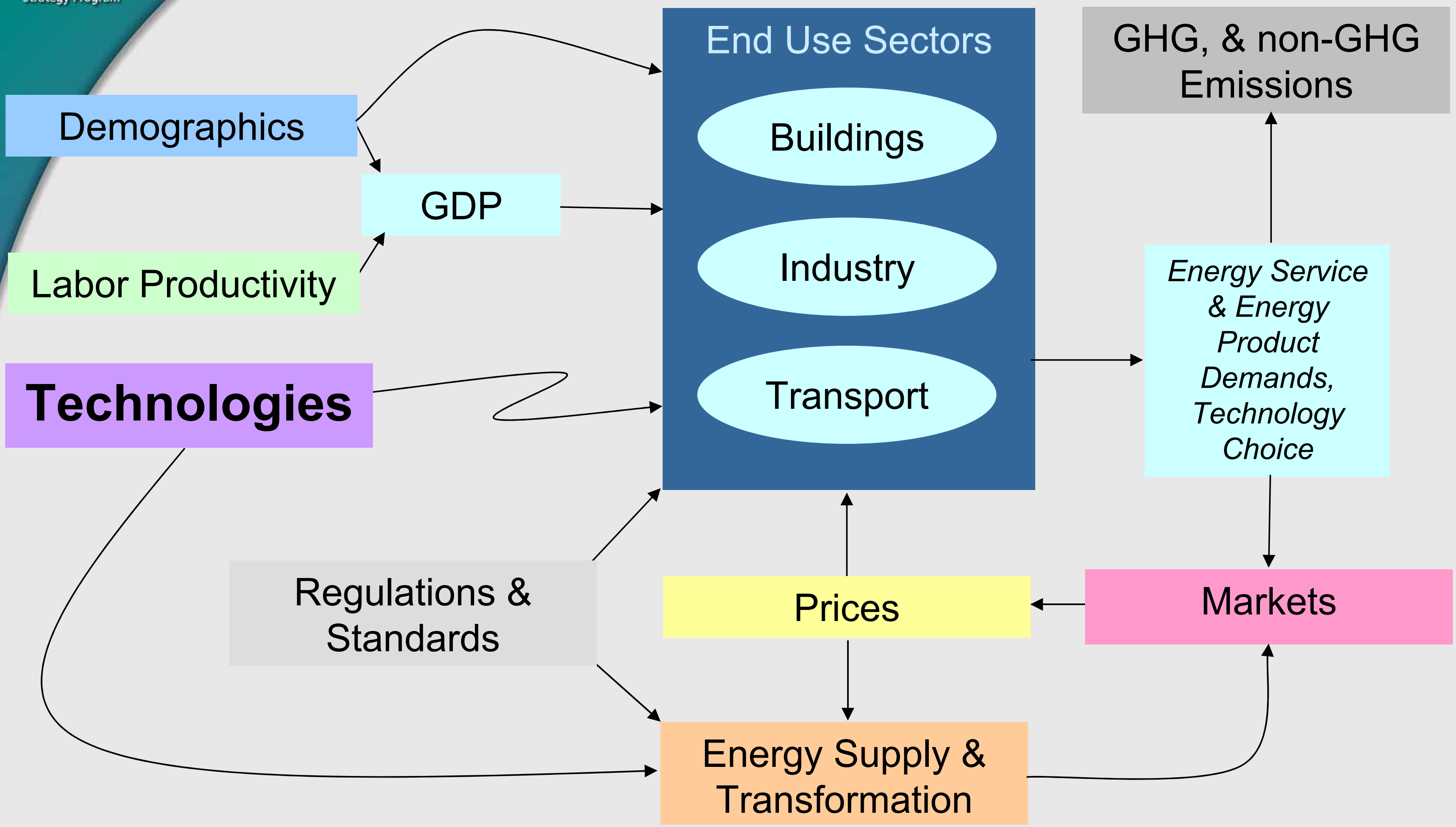
Objects.MiniCAM

15 Greenhouse Related Gases Tracked

- **Carbon Dioxide**
- **Methane**
  - 15 Source Sectors
  - Energy, Human Wastes, Agriculture, Land-Use
- **Nitrous Oxide**
  - 12 Source Sectors
  - Energy, Human, Industrial, Agriculture, Land-Use
- **Halocarbons, etc.**
  - 15 Source Sectors (7 gases)
- **Reactive Gases**
  - NOx, VOC, CO
- **Sulfur Dioxide**
- **Carbonaceous Aerosols**
  - Black Carbon & Organic Carbon
  - 19 Source Sectors each (Energy & Land-Use Combustion)

GHG concentrations and radiative forcing calculated using MAGICC (Wigley et al.)

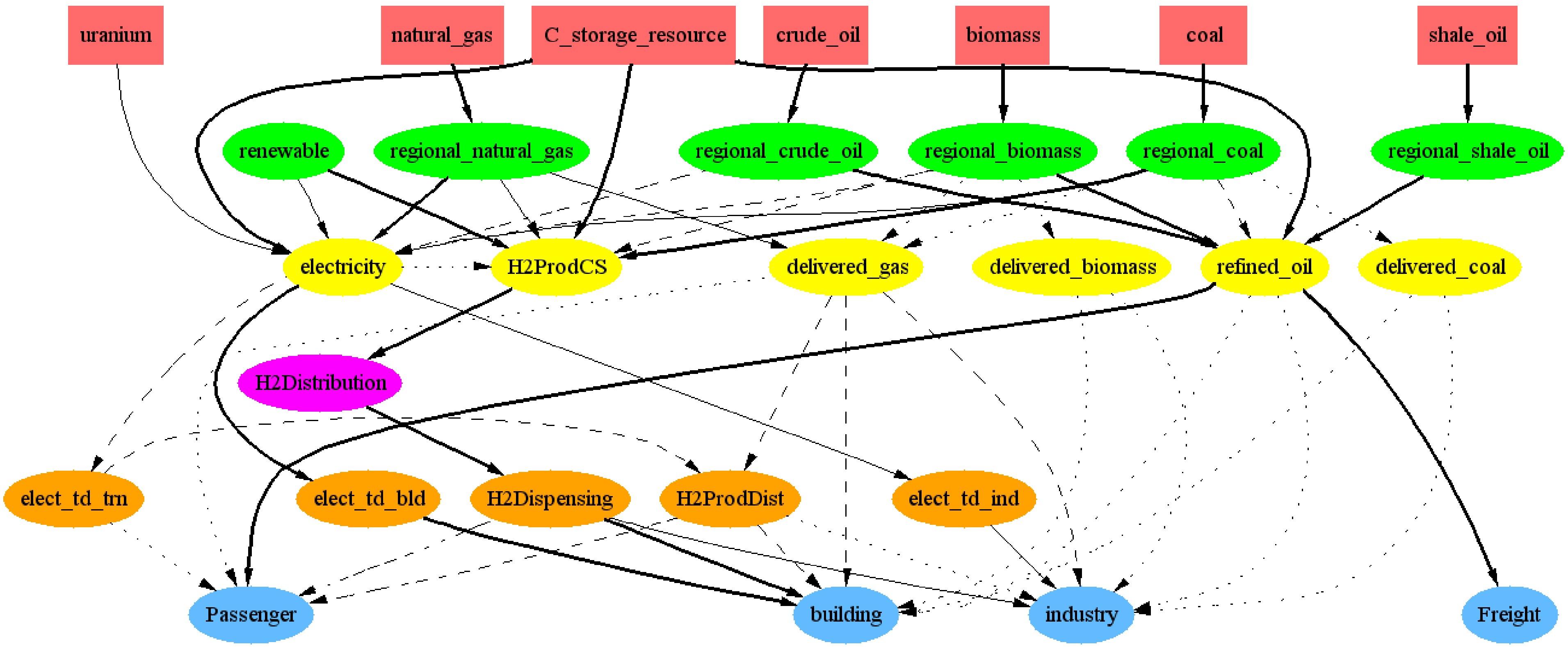
End-Use Energy Scenarios



Objects.MiniCAM Supply and Transformation

Data Determines:
Sectors
Linkages
Markets

1990 Energy System Structure



Implemented for 14 World Regions

Objects.MiniCAM

- United States
- Canada
- Western Europe
- Eastern Europe
- Former Soviet Union
- Japan
- Australia & New Zealand
- South Korea
- China
- India
- Other South & East Asia
- Middle East
- Africa
- Latin America

Key Data Needs

- End-use energy technology descriptions
  - The energy service (e.g. lumens, passenger km, steam)
  - Calibration data
    - Present supply of energy services
    - Present deployment of energy-service technologies
  - Efficiency of energy transformation (present and future)
    - E.g. fuel to vehicle km or
    - Fuel flexibility (e.g. can biofuels substitute for fossil fuels?)
  - Non-energy inputs (present and future)
    - (e.g. capital, labor (i.e. time), materials, etc.)
  - Joint products (e.g. heat & power, health, safety, convenience, non-GHG emissions)
  - Emissions coefficients or inventories by sector & fuel
    - GHG and non-GHG's

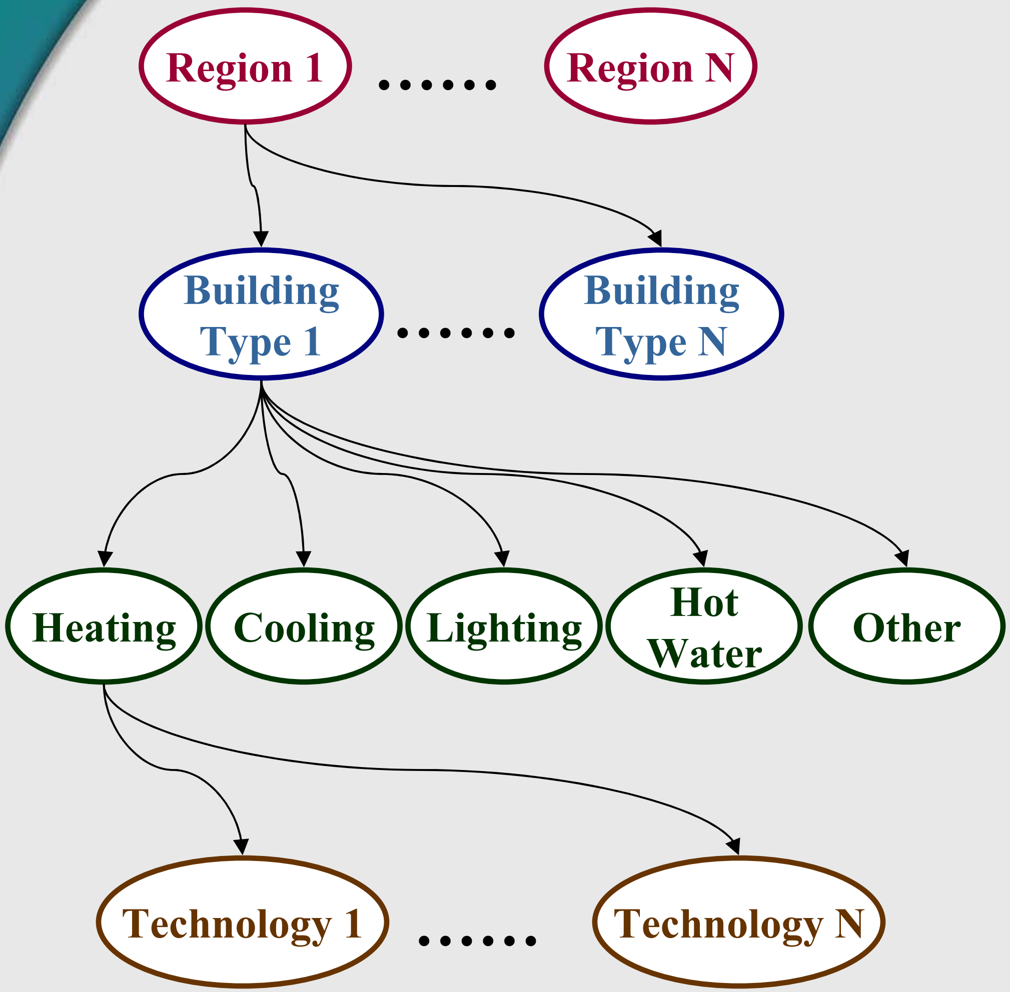
Key Data Needs

- Behavioral information
  - Income effects (e.g. saturation?)
  - Price effects (sensitivity of aggregate energy service demands to cost; sensitivity of technology share of market to energy service cost)
  - Relationship to other variables (e.g. demographic profile, rural-urban split)
- Over time
  - How is the suite of technology options changing?
    - Change that is in the pipeline
    - Potential change—technologies beyond those presently in the pipeline.
- By Region

What will determine future technology demand and availability in different regions?

Buildings

Overview of General Structure of Building Sector in ObjECTS



Regions are characterized by variables such as heating degree days, cooling degree days, population, and GDP.

Multiple **building sectors**, representing different types of buildings (e.g., type of use, shell efficiency, etc.) can be implemented **depending on available data**.

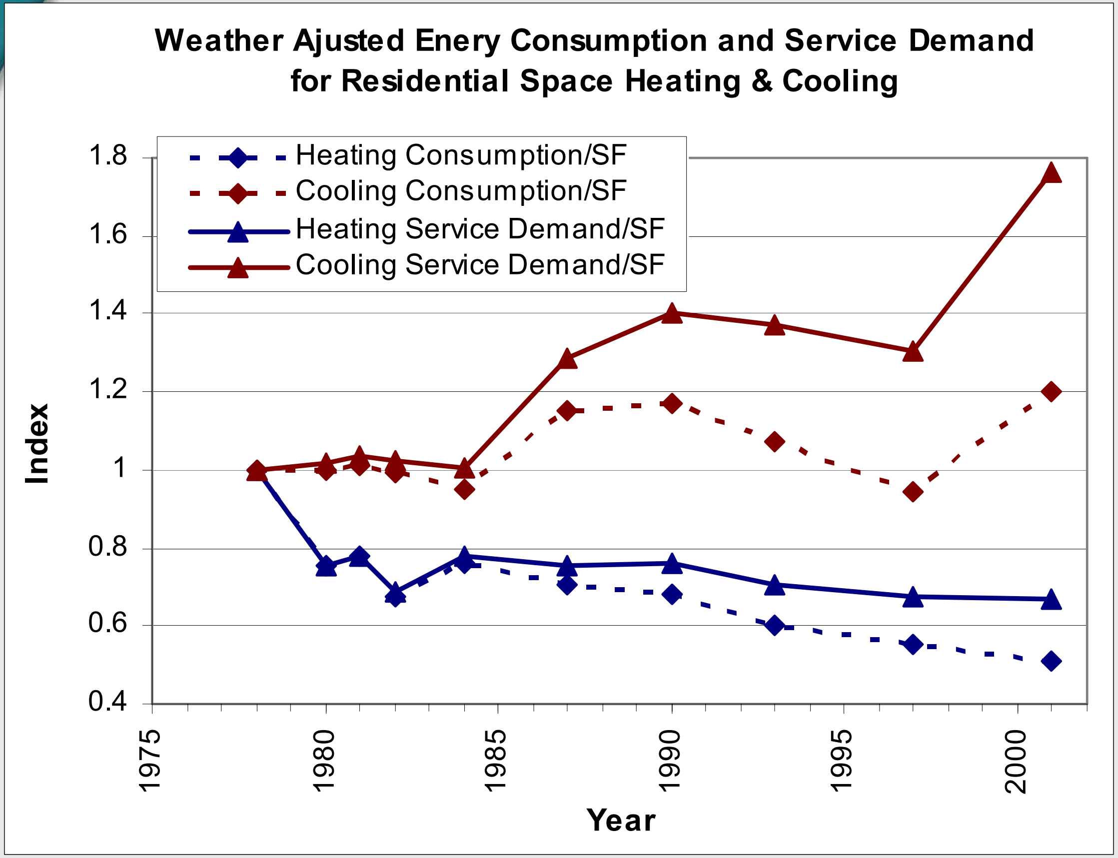
Each building sector has **service demands** such as heating, cooling, lighting, and hot water. Demands are based on building characteristics (e.g., shell thermal efficiency), regional characteristics (e.g., heating degree days), and service prices.

Each service demand can be met by a range of **service technologies**. The model allocates between these technologies using a price-based logit to capture heterogeneity in application.

Status: *Currently being implemented for the US. Will begin other world regions in 2005.*

Residential Heating & Cooling

Historical Analysis to Guide Model Construction

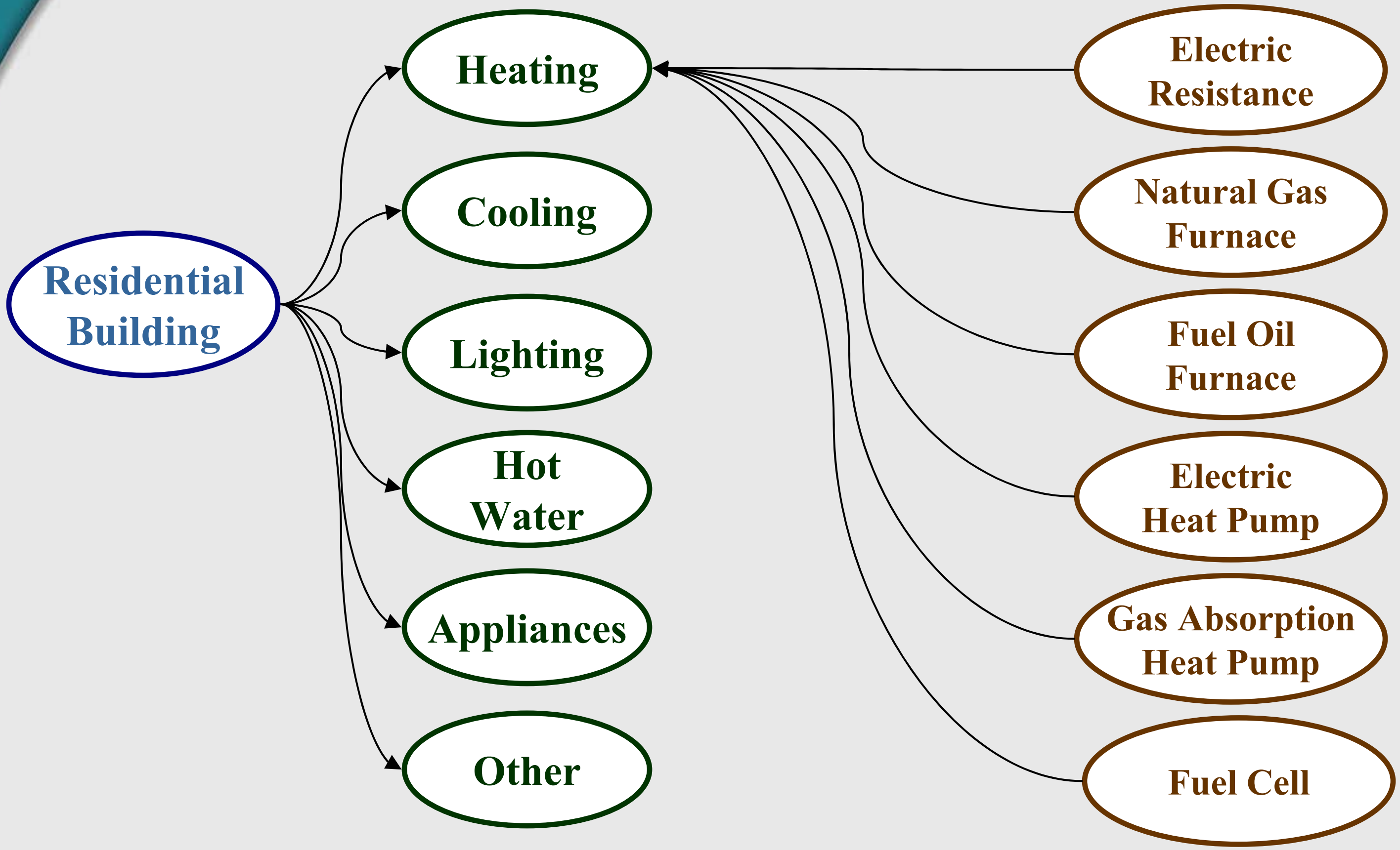


* Source: Annual Energy Review 2003, EIA.
* Service demands calculated using unpublished NEMS database of equipment efficiencies over time .

- Service demands diverge from consumption through energy efficiency
- Heating service demand intensity has been decreasing or constant over time
- Cooling service demand intensity has been increasing over time, consistent with increasing penetration

Historical data on energy service trends provides very important guidance for scenario development.

Residential Service Technologies: Heating Example



The century-long timescale calls for technologies that may not be important contributors today.

GTSP

Global Energy Technology Strategy Program

ObjECTS Technology Information Needs

Financial Basis Year	1990	$US	*Change Units columns as necessary*
Region	USA		
Sector	RESIDENTIAL HEATING		***Cells in BLUE represent the Minimimum data needed. Cells in yellow are requested but n***

Technologies

	UNITS	Gas Furnace	Gas Heat Pump	Electric Resistance Heat	Electric Heat Pump	Fuel Oil Furnace	Regional Total	
Fuel		Natural Gas	Natural Gas	Electricity	Electricity	Fuel Oil		
Output Units		joules (net)	joules (net)	joules (net)	joules (net)	joules (net)		
Input Data								
Data Year:		**1990**						
Capital Cost	*$/kW of output*	$8.00	$40.00	$20.00	$30.00	$8.00		
Lifetime	*years*	10	10	10	10	10		
Capacity Factor	-	0.10	0.10	0.10	0.10	0.10		
Total O&M	*per output*	$0.50	$0.50	$0.50	$0.50	$0.50		
Efficiency	-	0.70	1.20	0.98	1.64	0.76		
Year Available	-							
Total Energy Input Per Region	*EJ (net)*	3.56	0.00	0.26	0.06	1.18	5.06	
Total ouput per Region	***EJ***	2.49	0.00	0.26	0.09	0.90	3.74	
Total Co-product ouput per Region	*EJ*	0.00	0.00	0.00	0.00	0.00	0.00	
Citation								
Alternative or Detailed Inputs								
Capital Cost	*per unit*							*Alternative more detailed specification*
Capacity Per Unit	*joules (net)/s*							*Alternative more detailed specification*
Total O&M	*$/unit*							*Alternative more detailed specification*
Fixed O&M	*year/unit*							*Alternative more detailed specification*
fraction of O&M that is Labor	*$/unit*							*Alternative more detailed specification*
Variable O&M	*$/output*							*Alternative more detailed specification*
Input Detail -- Energy Good 1	*fuelname*							*Alternative more detailed specification*
Input Detail -- Energy Good 2	*fuelname*							*Alternative more detailed specification*
Input Detail -- Energy Good 3	*fuelname*							*Alternative more detailed specification*
Input Detail -- Energy Good 4	*fuelname*							*Alternative more detailed specification*
Input Detail -- Energy Good 5	*fuelname*							*Alternative more detailed specification*
Input Detail -- Energy Good 6	*fuelname*							*Alternative more detailed specification*
Land Requirement	*Ha/unit*							*Optional, but requested if available*
Maximum Efficiency	-							*Optional, but requested*
Notes - Additional Info								
Derived Values (for reference)	***Derived Values (for reference)***							
Non-Energy Cost per Unit of Output	*$/GJ*	$3.8	$16.9	$8.7	$12.8	$3.8		
Service Out	*EJ*	2.49	0.00	0.26	0.09	0.90	3.74	
Emissions	*otal per region*							
or	*or*							
Emissions Coefficients	*(per unit input)*							
CH4								
N2O								
SO2								
NOx								
CO								
VOC								
BC								
OC								
Regional Energy Input Data		*(if technology descriptions for other regions do not vary, regional energy input information can be added below)*						

DUMMY DATA

(Delete this box before completing)

Battelle

JGCRI Joint Global Change Research Institute

UNIVERSITY OF MARYLAND

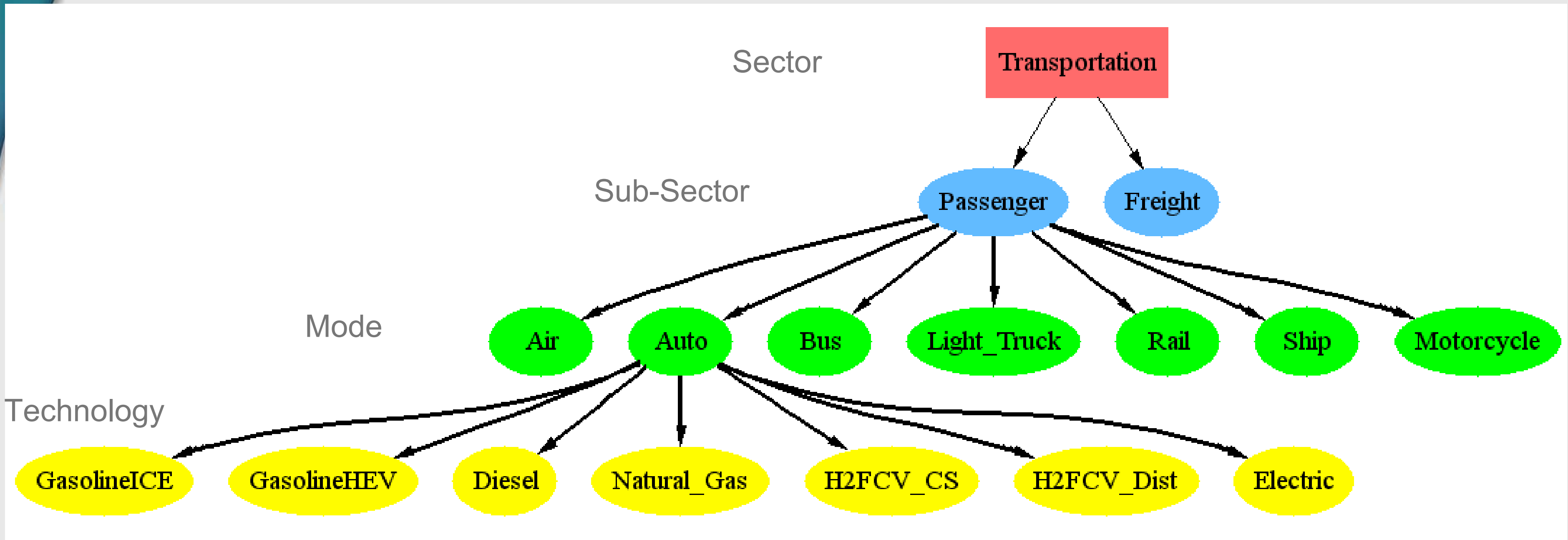
Pacific Northwest National Laboratory

Operated by Battelle for the U.S. Department of Energy

Industry and Transport Have Similar Data Needs as Buildings

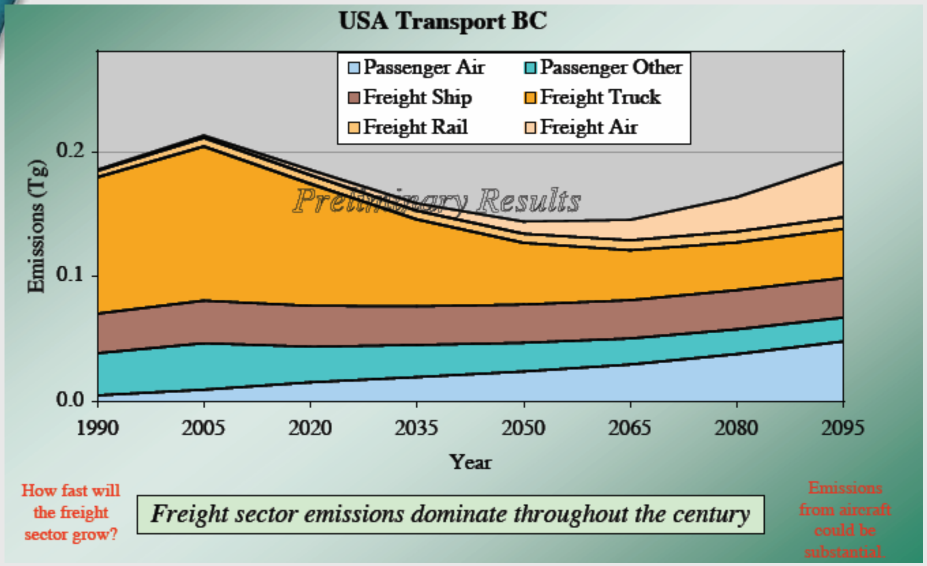
	Buildings	Industry	Transport
Activity	- population - # households (urban/rural) - m^2 residential - m^2 commercial	-GDP - Production - economic (VA/VOS) - physical (tonnes)	- personal -person-km - freight -ton-km
Structure	- By sub-sector -residential -commercial - By end-use - heating, cooling - refrigeration - appliances - equipment - lighting	- By sub-sector - iron & steel - non-ferrous - cement - pulp & paper - chemicals - etc… - Product mix	- By Mode - Road - Rail - Air - Water - By Vehicle Type - Passenger car - Truck -- etc…
Energy Intensity	- Technology - saturation - energy intensities - efficiency - usage - size/features	- Technology - saturation - energy intensities -Efficiency -Usage	-Technology - saturation - energy intensities - efficiency - usage

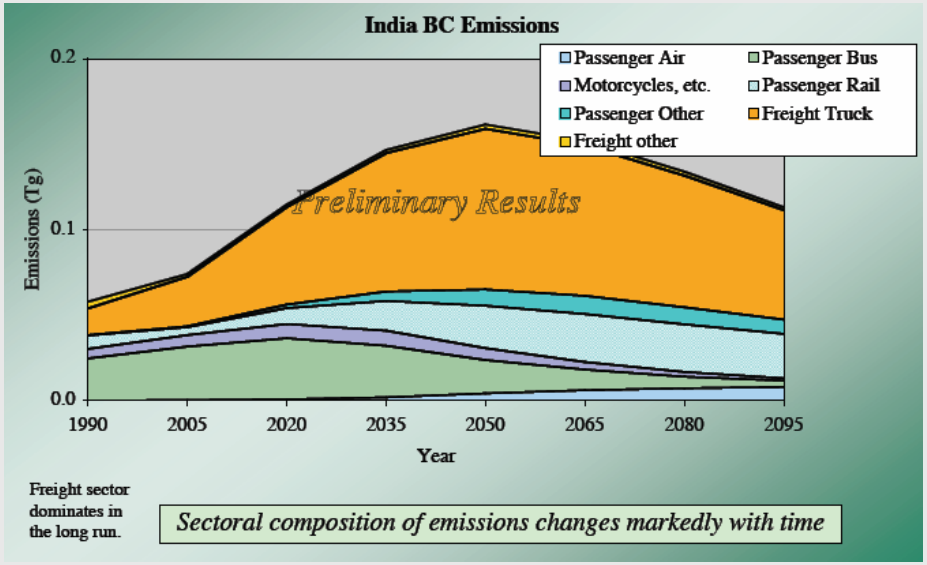
Objects.MiniCAM Passenger Transport



Non-CO_2 GHG's & Transport

Black Carbon Emissions: USA & India
1990 to 2095

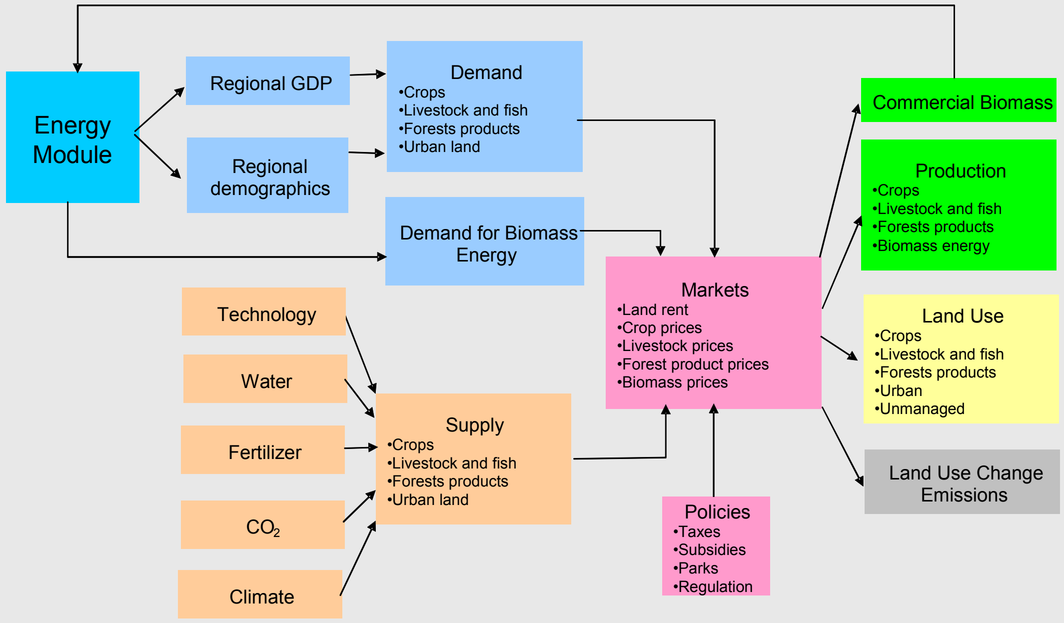




Emissions differ by region, but also by technology within a sector.

Objects.MiniCAM
Transport Fuels

- In transport it is useful to be able to discuss both the supply of and the demand for fuels.
- Particularly as we contemplate non-conventional fuels.



*The ag-land-use module of **Objects.MiniCAM** determines biomass production in the context of overall land use and land-use change.*

Flexibility

- *Objects.MiniCAM* is a flexible modeling framework
  - The general structure is set, but many elements are determined by the available data
    - E.g. the number of end-use energy services
    - Not every sector in every region need have the same set of technologies available.
  - The key ideas are
    - Global coverage
    - Long-term time horizon
    - **End-use energy detail**

END