The Use of Discrete Choice Research in Hybrid Energy-economy Models

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Goal for energy-economy models:

To be useful to policy-makers, an energy-economy model should be able to simulate real policies in a realistic manner

Traditional Energy-economy Models

Traditional top-down models

- Not able to explore policies that directly influence technologies (e.g. equipment standards)
- Not suitable for detailed modeling of technological change

Traditional bottom-up models

- Treat similar technologies as perfect substitutes (incandescent vs. compact fluorescent lightbulbs)
- Ignore risk, option value
- Ignore heterogeneity in the market

CIMS Model – a Hybrid

- Technologically explicit
  - Tracks technology purchases, retirements, retrofits
- Behaviourally realistic
  - Simulates the way in which people choose between technologies based on empirical studies
- Macroeconomic feedbacks
  - Realistic representation of import substitution, elasticities

Technology in CIMS

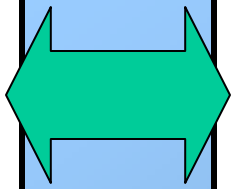
Demand

Industry
- Chemicals
- Industrial minerals
- Iron and Steel
- Metal smelting
- Mining
- Other Manufacturing
- Pulp and Paper

Transportation

Commercial

Residential



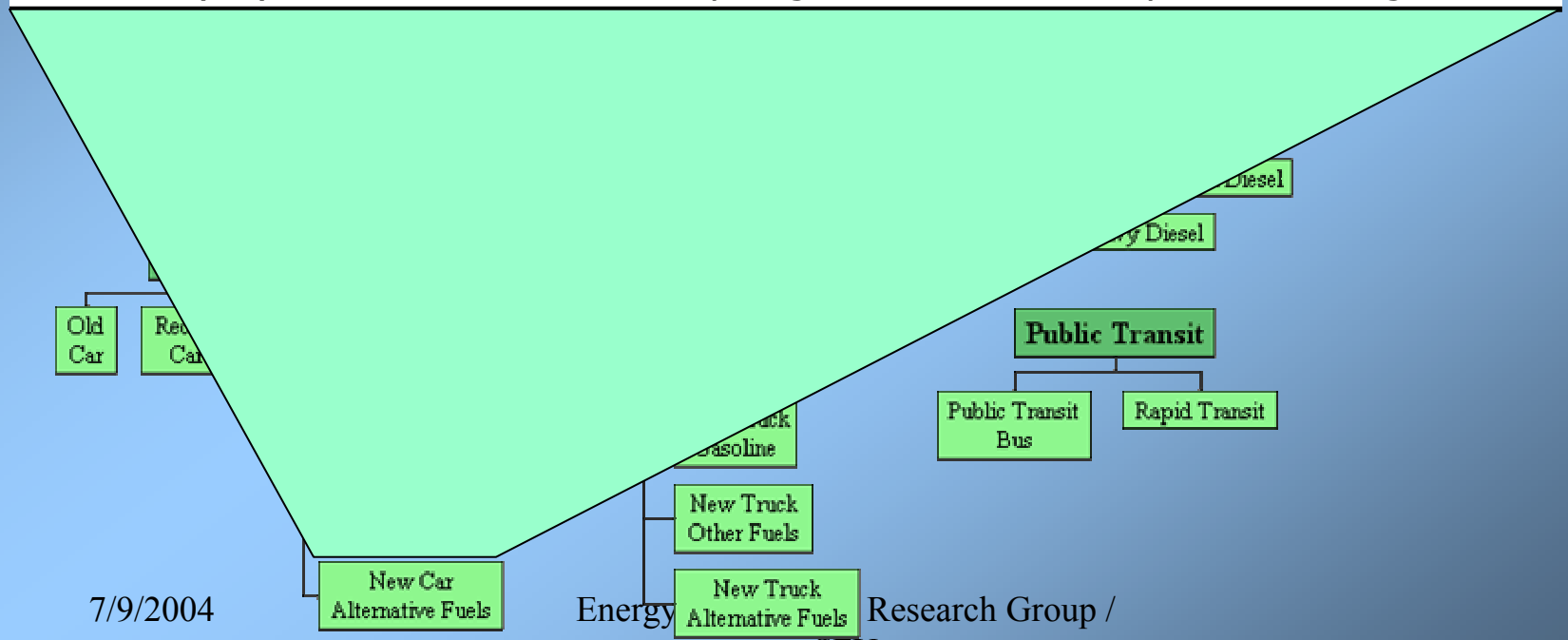
Supply

Upstream
- Coal Mining
- Natural Gas Extraction
- Petroleum Crude

Downstream
- Electricity Generation
- Petroleum Refining

Technology in CIMS

Technology	Capital Cost	Fuel Type	Fuel Cost	Direct CO2 Emissions
Ethanol	$25,511	85/15 Eth/Gas	$1,490/yr	0.049 kg/km
Methanol	$26,300	85/15 Meth/Gas	$1,975/yr	0.195 kg/km
Hybrid	$29,000	Gasoline	$496/yr	0.109 kg/km
Battery Electric	$48,500	Electricity	$262/yr	0 kg/km
Fuel Cell (H2)	$140,000	Hydrogen	$2,085/yr	0 kg/km



Behaviour in CIMS

- There is no "law" governing human decision-making:
  - People do not "optimize" – i.e., pick lowest financial cost technologies
  - Similar technologies are not perfect substitutes (compact fluorescent lights)
  - People are different from one another
- We must use real-world data to predict how people make choices and react to policies
  - Discrete choice modeling

Vehicle Choice Experiment

If these were the only four vehicles available to you, which would you choose?

choices

attributes

Vehicle Type	*Gasoline Vehicle*	*Alternative Fuel Vehicle*	*Hybrid-Electric Vehicle*	*Hydrogen Fuel Cell Vehicle*
Purchase Price	$21,000	$26,000	$29,000	$45,000
Fuel Cost	$25/week	$22/week	$16/week	$36/week
Stations with Proper Fuel	100%	25%	100%	5%
Express Lane Access	None	None	None	Yes
Emissions Compared to Current Vehicle	Equal	25% Less	40% Less	100% Less
Power Compared to Current Vehicle	Equal	Equal	25% Less	10% Less
	-	-	-	-

- Varied attribute levels
- Received over 3,000 responses

Results of Vehicle Choice Experiment

Attribute	ß - Value
Capital Cost	-9.01E-05
Fuel Cost	-4.60E-03
Fuel Availability	1.16
Express Lane Access	-0.16
Power	-0.22
ASC – Gasoline	-1.70
ASC – Alternative Fuel	-2.01
ASC – Hybrid Electric	-0.36

$$\text{Utility}_i = \beta_{CC} * (\text{Capital Cost}_i) + \beta_{FC} * (\text{Fuel Cost}_i) + \beta_{FA} * (\text{Fuel Availability}_i) + \beta_{EL} * (\text{Express Lane}_i) + \beta_P * (\text{Power}_i) + \beta_{ASC}$$

$$MS_i = \frac{e^{U_i}}{\sum_J e^{U_i}}$$

Simple Interpretation of Vehicle Choice Experiment

Attribute	Change Equal to $1000 Increase in Capital Cost
Fuel Cost	$-19.59 / month
Fuel Availability	+ 8%
Express Lane Access	+ 56%
Power*	+ 4%

Other Choice Experiments at EMRG

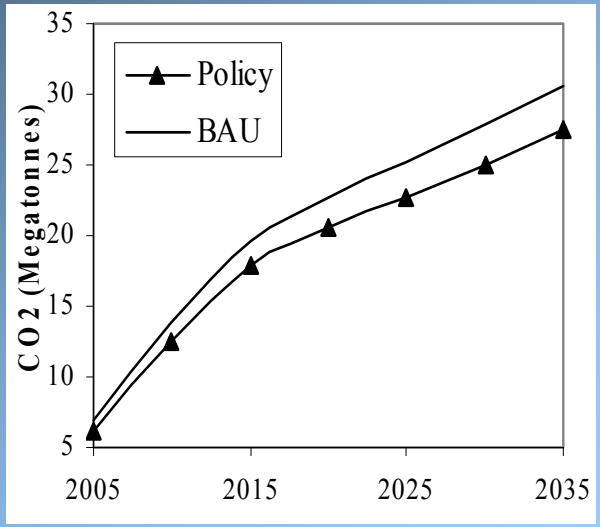
- Home energy retrofit choice (Canada)
  - Weather stripping, insulation, double/triple paned windows
- Home heating system choice (Canada)
  - Heat pump, electric baseboard, oil, etc.
- Industrial heating system choice (Canada)
  - Boiler, cogeneration system, boiler retrofits
- Mode choice and road and parking charges (Vancouver)
  - Carpooling, transit, single occupancy
- Mode choice (Canada)
  - Single occupancy, transit, walk/cycle, park & ride
- Vehicle choice (Canada)
  - Hybrid, fuel cell, gasoline

Integrate Behaviour into CIMS

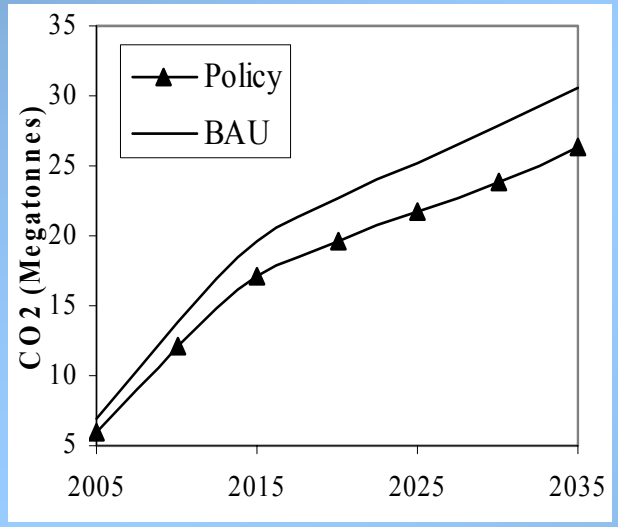
- Incorporate results of discrete choice models into CIMS
  - Account for feedbacks throughout the economy
- Realistic representation of behaviour
  - How people choose between technologies
  - How they change their choices in response to a policy

Some Sample Results (Transportation Policy)

New vehicle emissions in Ontario:

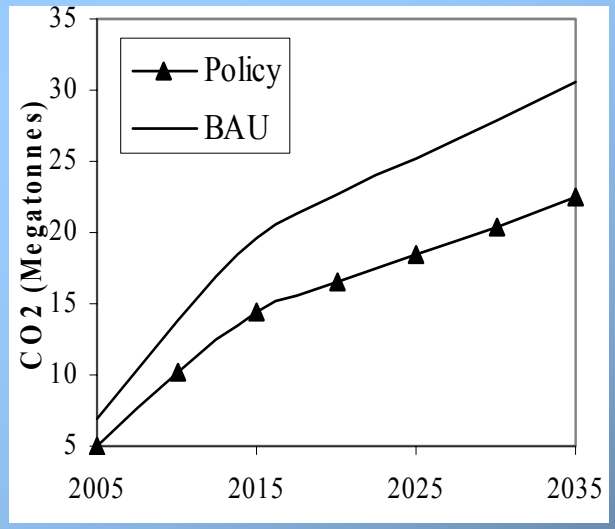


$50/t CO2 tax



Incentives for vehicle switching

- Increase other fuel availability
- Surcharge on gasoline vehicles
- Express lane access for hybrid and fuel cell

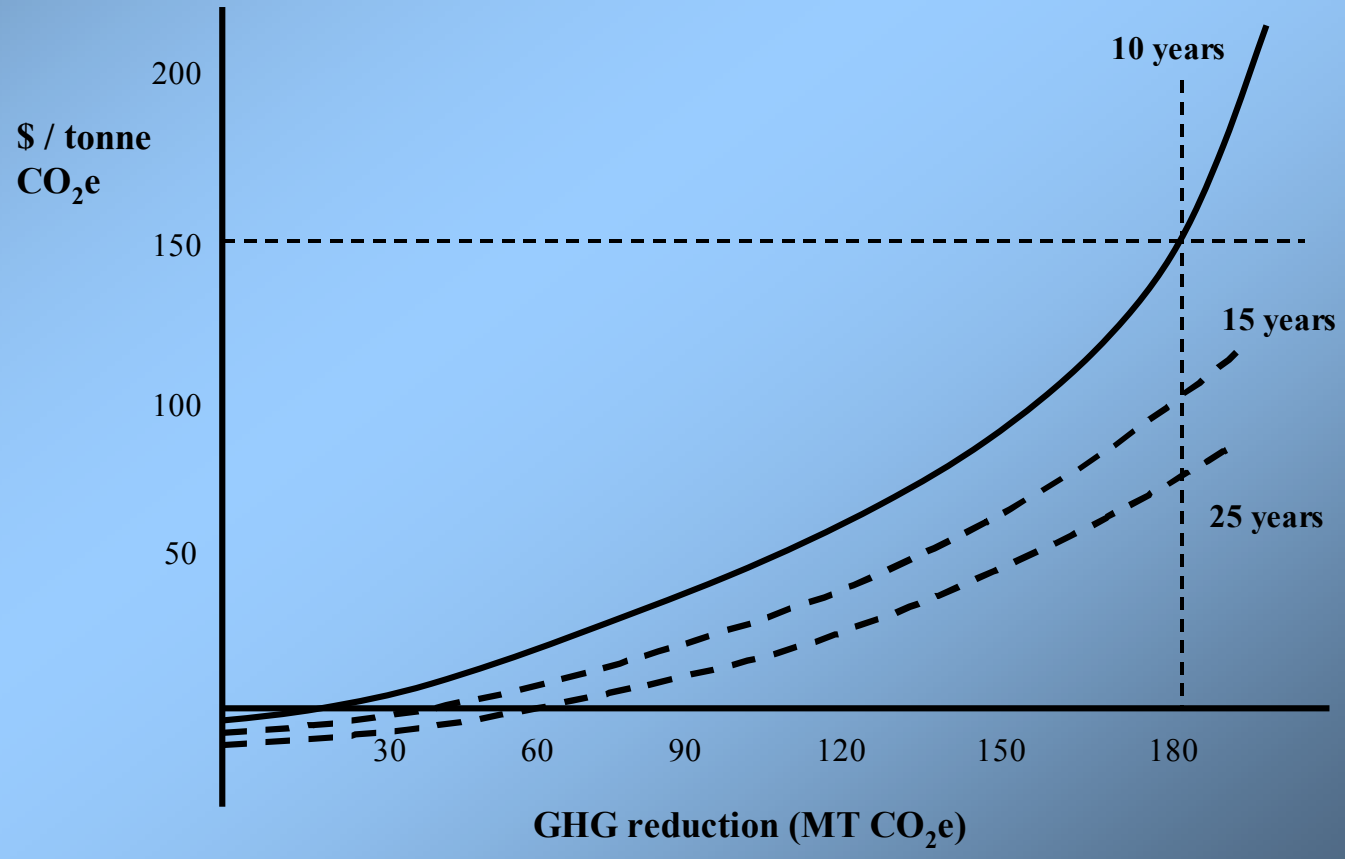


Incentives for mode switching

- Improving transit (reducing commuting time, waiting time, number of transfers)
- Reduce cost of transit 30%
- Increase cycling lane access

Sample National Results

- Integrate DCM results into a whole-economy model
- Simulate technology oriented or financial oriented policies



Conclusions

- Hybrid models have:
  - Explicit representation of technologies
  - Realistic representation of behaviour
  - Macroeconomic feedbacks
- Allows simulation of real policies with realistic results