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A hybrid top-down bottom-up model with macro-economic feedbacks

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Outline of presentation

- The energy policy context
- Current energy modelling practice
- Building the hybrid model “CIMS”
- Results from experiments with the hybrid – AEEI & ESUB estimates and cost curves of GHG abatement
- Future research & the potential for physical general equilibrium modelling

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Policy context

- The four main issues to which energy policy modelling speaks - forecasting and uncertainty in:
  - Climate change (< GHG emissions)
  - Energy efficiency (< energy use overall)
  - Local air quality (< emissions of criteria air contaminants)
  - Energy security (< use of insecure energy forms)
- The common thread – how does long run demand for energy services and technological development change in the face of policy?

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Recent practice in energy modelling

- Top down
  - Generally Macro-econometric or Computable General Equilibrium
  - Technological change depicted abstractly through input substitution (ESUB) and autonomous energy efficiency development parameters (AEEI)
  - Equilibrium (supply and demand) feedbacks inherent
- Bottom-up
  - Technologies depicted explicitly and are chosen via financial cost minimization, usually with perfect foresight
  - Equilibrium feedbacks partial or missing

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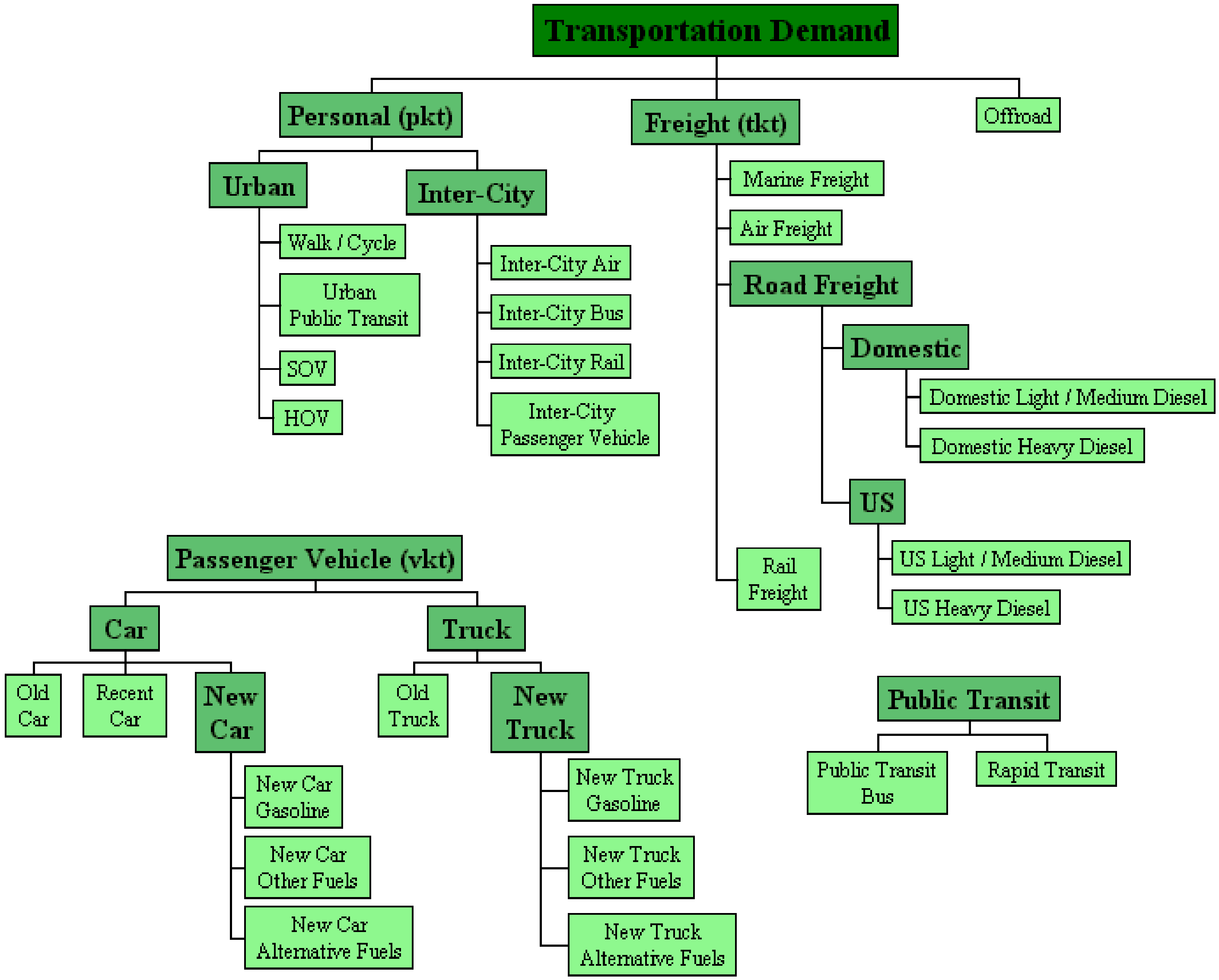
Overview of CIMS

- Technologically detailed, behaviourally realistic simulation model with equilibrium feedbacks.
- Starting from a base year, compares the evolution of the capital stock in a BAU and Policy world
- 3 step simulation process: sub-sector technology choice, energy supply/demand and goods and services supply/demand equilibrium

Sub-sector technology choice

- In each period, for each technology competition:
  - 1) retire old stock,
  - 2) assess demand,
  - 3) retrofit existing stock,
  - 4) compete new technologies using financial capital, fuel and emissions costs modified for intangible costs, agent intransigence, risk and option value


Transportation Demand
Personal (pkt)
Freight (tkt)
Offroad
Urban
Inter-City
Walk / Cycle
Urban Public Transit
SOV
HOV
Inter-City Air
Inter-City Bus
Inter-City Rail
Inter-City Passenger Vehicle
Marine Freight
Air Freight
Road Freight
Domestic
Domestic Light / Medium Diesel
Domestic Heavy Diesel
US
US Light / Medium Diesel
US Heavy Diesel
Rail Freight
Passenger Vehicle (vkt)
Car
Truck
Old Car
Recent Car
New Car
New Car Gasoline
New Car Other Fuels
New Car Alternative Fuels
Old Truck
New Truck
New Truck Gasoline
New Truck Other Fuels
New Truck Alternative Fuels
Public Transit
Public Transit Bus
Rapid Transit

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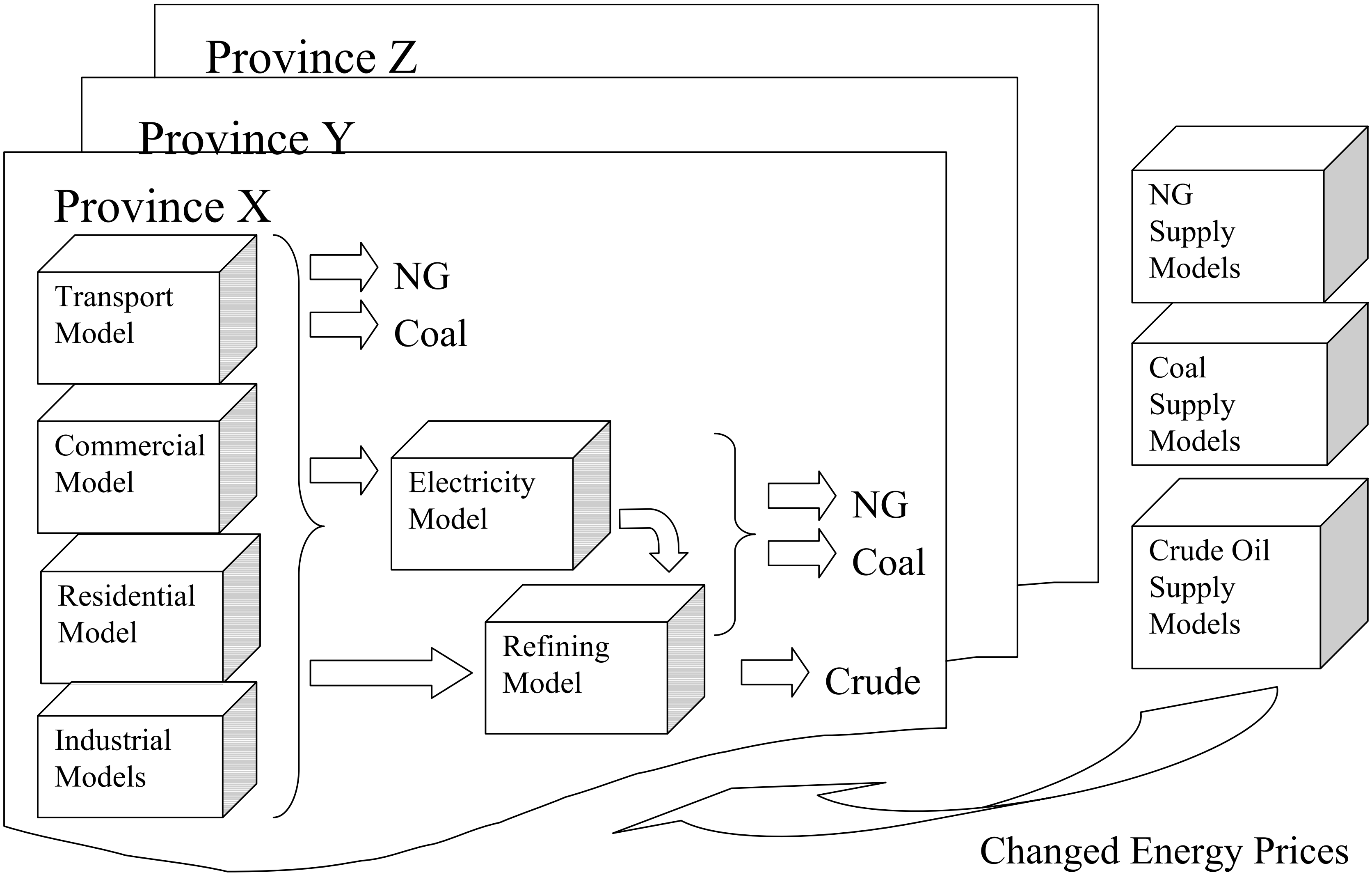
Energy supply/ demand equilibrium



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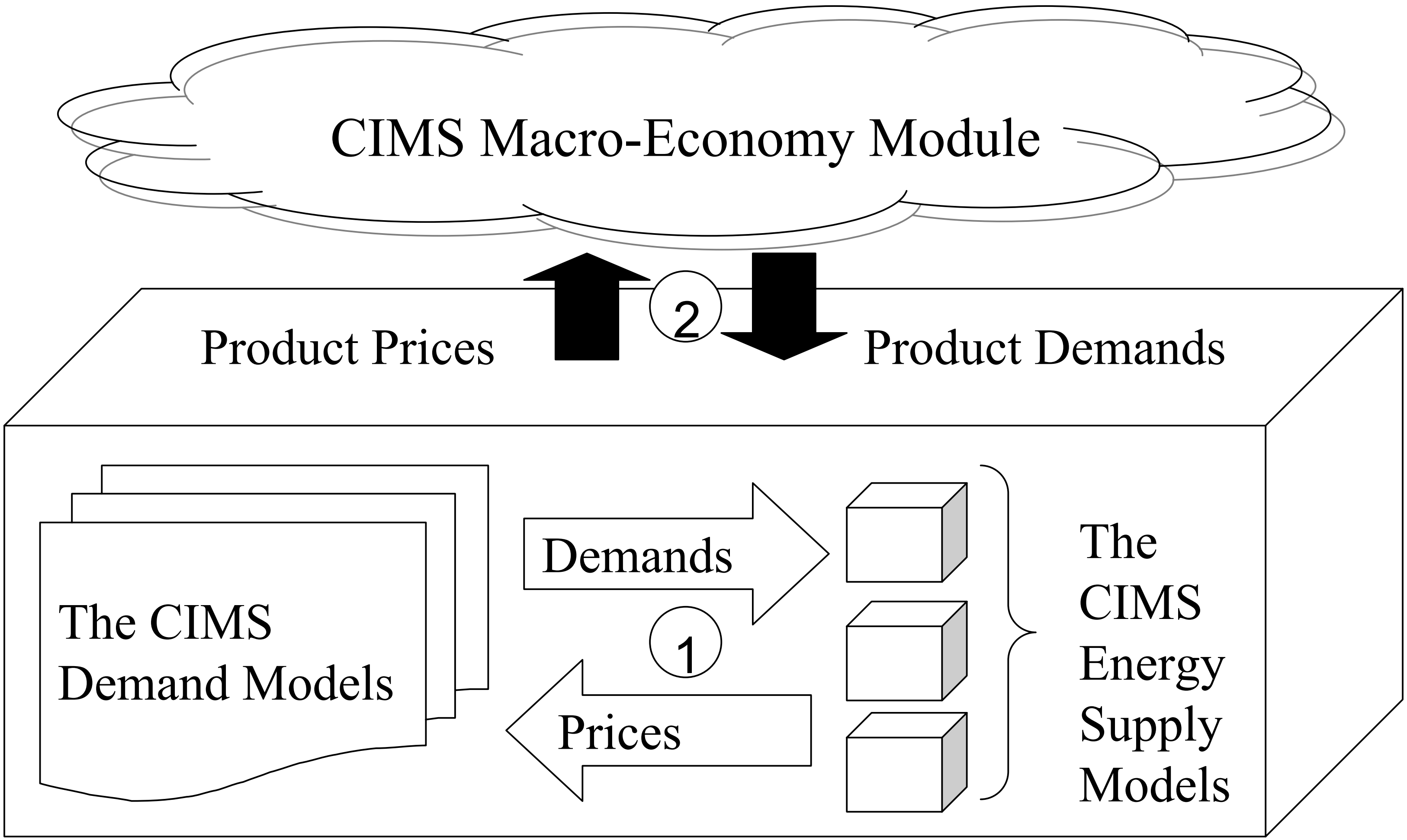
Goods and services supply and demand equilibrium



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The goods and services supply and demand loop

- Industry - Armington substitution elasticities used to provide a blended response of domestic and foreign demand for traded goods
- Residential, Commercial/Institutional and Freight Transportation – Driven by changes in manufacturing value-added using an econometrically estimated relationship
- Personal Transportation – Driven by personal kilometres travelled (pkt) elasticities

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Results from CIMS

- AEEI and ESUB parameter estimates that reflect possible future technological development
  - AEEI calculated by comparing a business as usual future with and with technological change
  - ESUB calculated by shocking CIMS with many price futures, and regressing the resulting data
- Cost curves of GHG abatement for Canada

Results – AEEI

Regions/Sectors	%/annum
Canada (w/ Transport)	0.41*
Canada (w/o Transport)	0.63*
Residences	0.46
Commercial & Institutional	1.70
Industry	0.22
Transportation	0.08

* Not including energy supply sector

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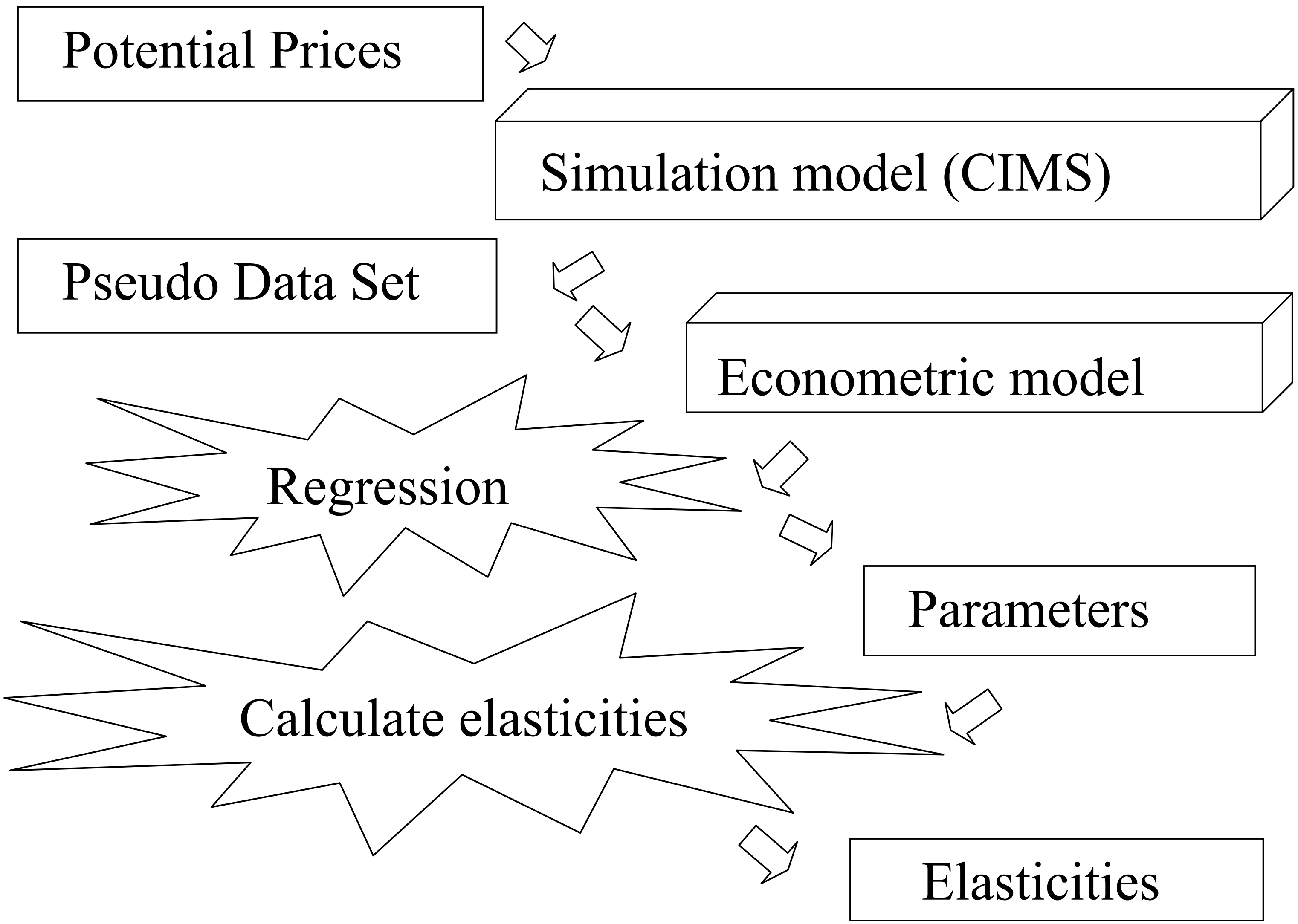
ESUB calculation procedure



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Results – Capital for Energy Substitution Elasticity (ESUB)

Regions/Sectors	
Canada (w/ Transport)	0.13
Canada (w/o Transport)	0.27
Residences	0.33
Commercial & Institutional	0.23
Industry	0.11
Transportation	0.08

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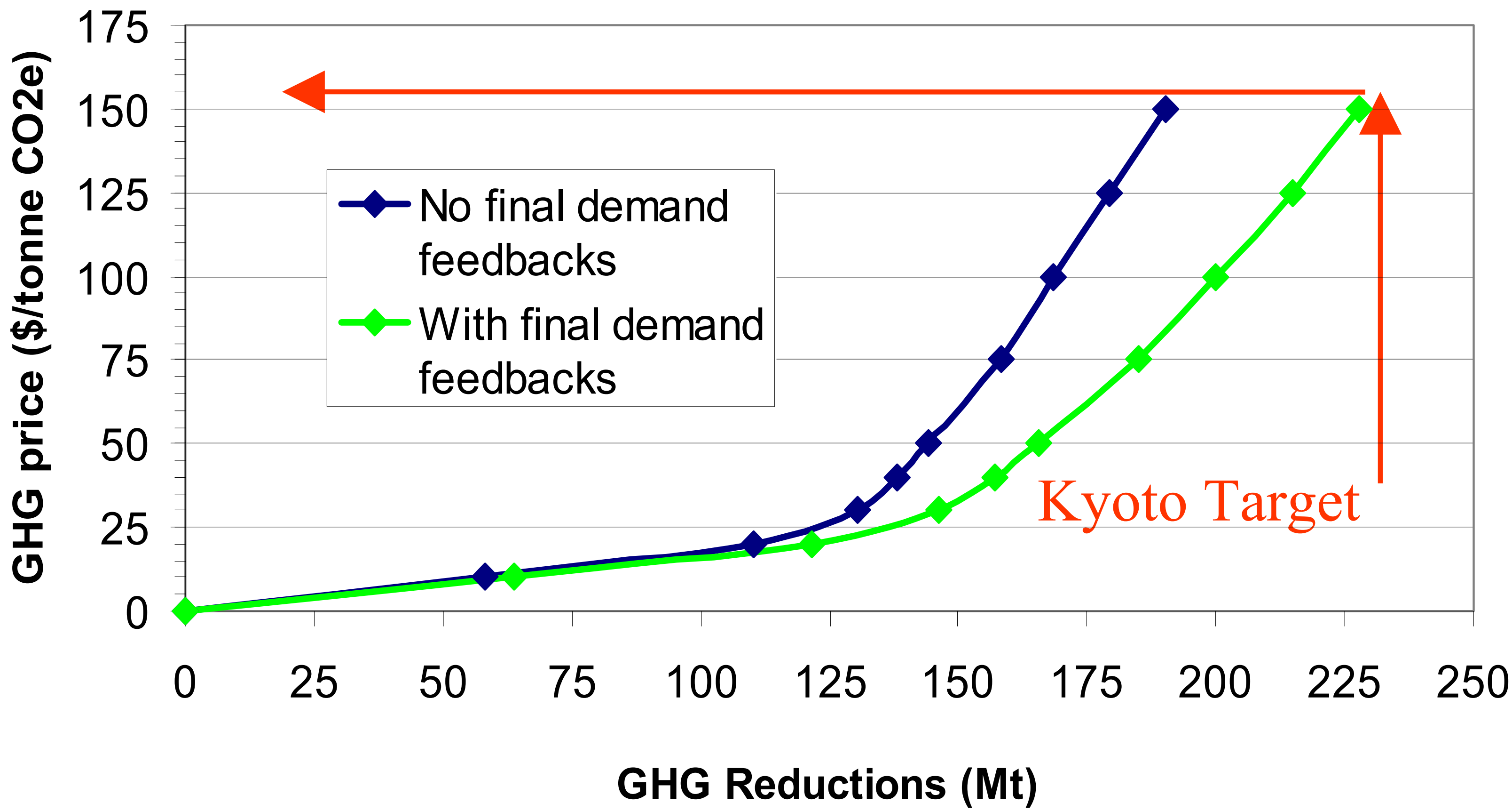
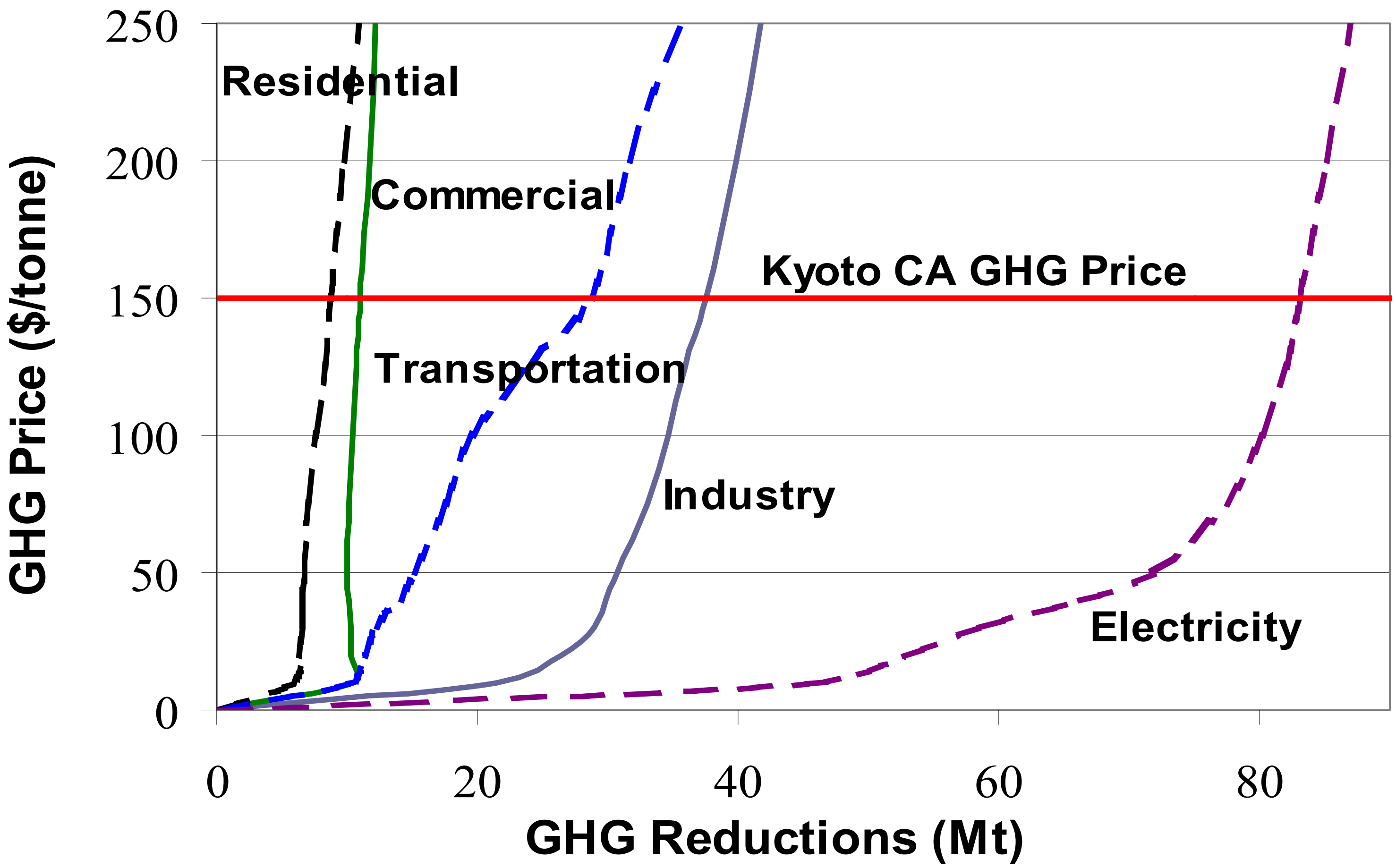
Results – Inter-input ESUBs

Capital for electricity	0.33
Capital for petroleum products	0.08
Capital for natural gas	-0.05
Capital for coal	-0.04
Electricity for petroleum products	1.69
Electricity for natural gas	1.83
Electricity for coal	0.01
Petroleum products for natural gas	1.26
Petroleum products for coal	1.29
Natural gas for coal	0.95

Results - Cost curves of GHG abatement for Canada



Sector Cost Curves



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Future research with CIMS & implications

- Modelling technology development:
  - Declining capital costs
  - Declining intangible costs
  - Empirical estimation of intangible parameters
- The future for general equilibrium modelling with technological explicitness

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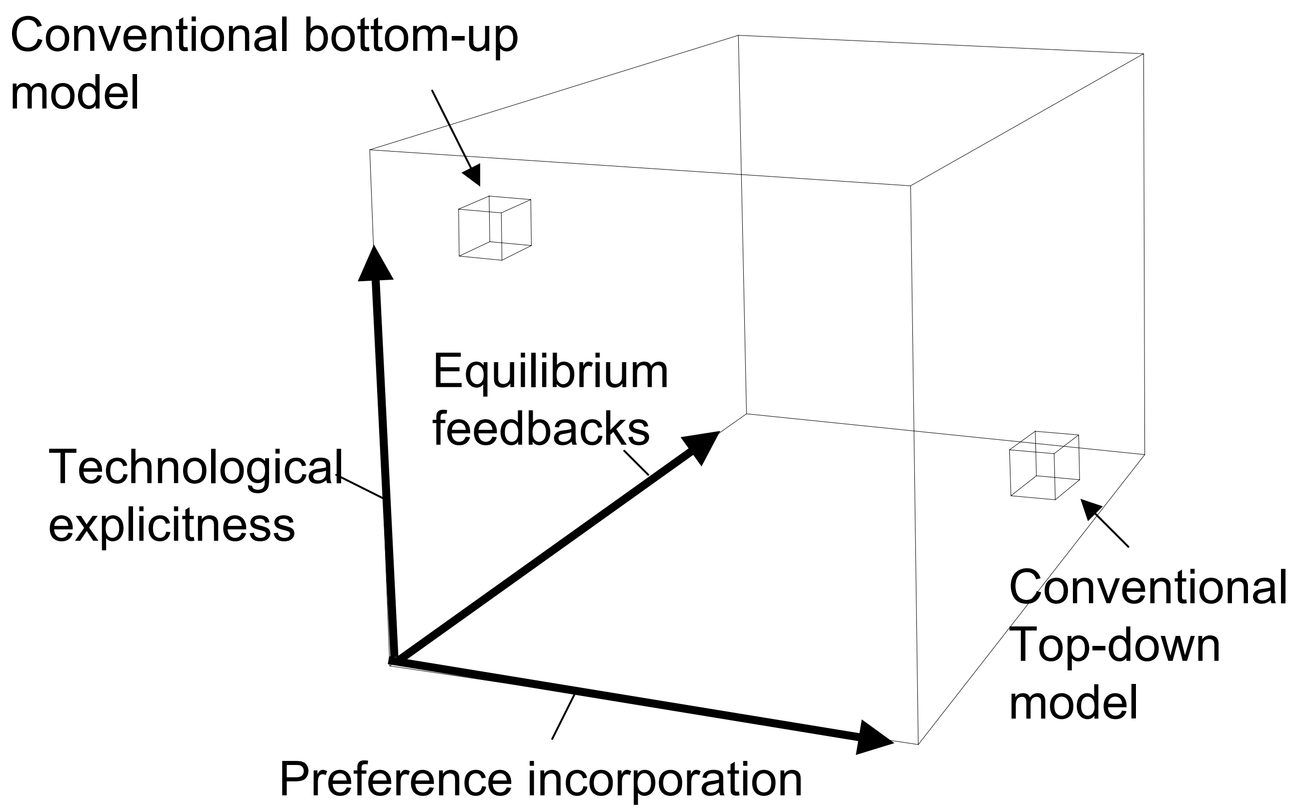
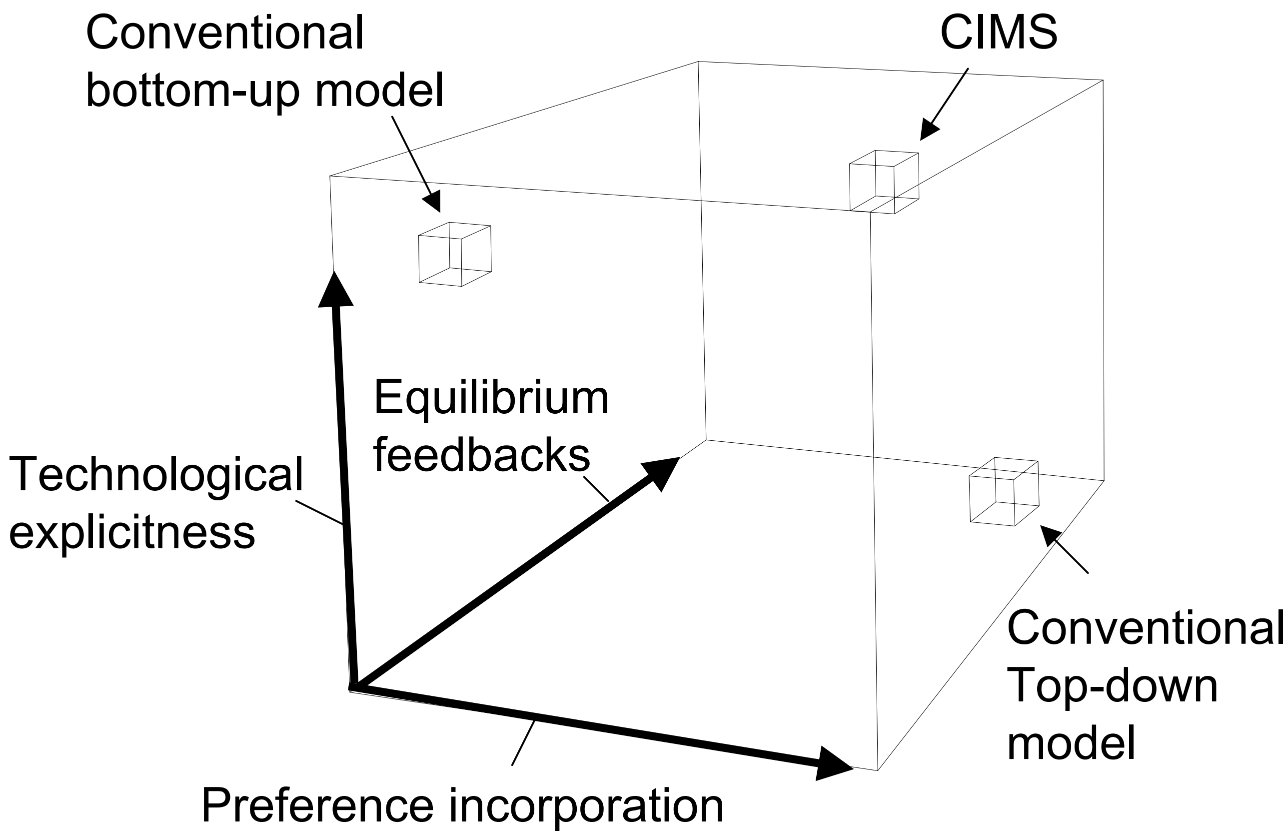
Energy supply & demand equilibrium

- Driven by changes in the average or marginal cost of production
- All volumes driven by domestic demand plus net exports
- Full endogenous pricing for electricity and RPP
- Supply curve pricing available for NG, coal and crude oil.
- Electricity, NG and crude oil trade adjusted by elasticities

The three dimensions model



Three dimensions model with the hybrid "CIMS"



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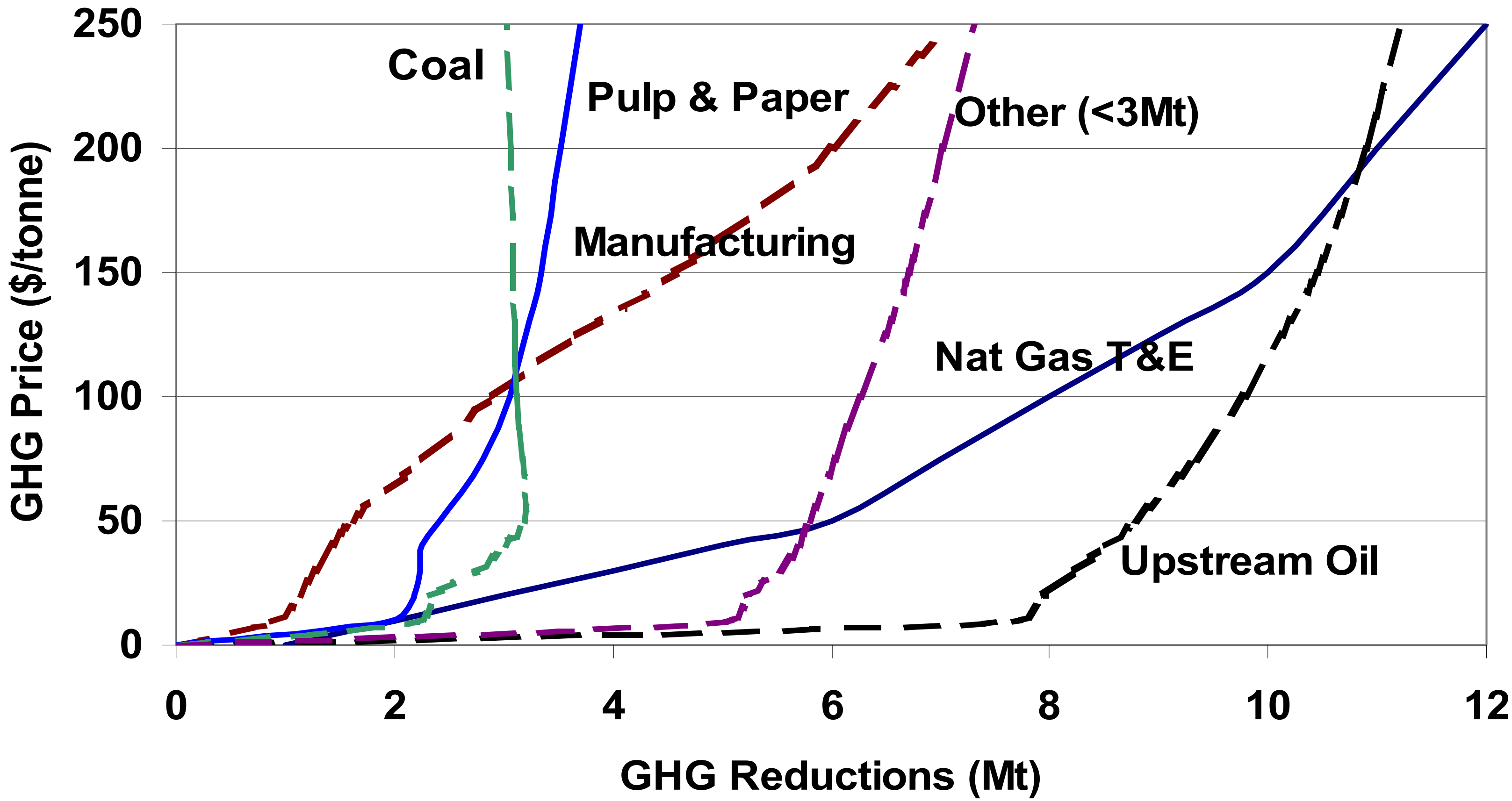
Industry – The major reductions



"Other" consists of Pet. Refining, Chemical Prod., Mining, Smelting, Iron and Steel and Industrial Minerals