Issues in Estimating the Cost and Effectiveness of Climate Policies

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Presentation overview

Estimating the cost of energy efficiency: revisiting old debates.

Hybrid models for simulating energy-environment policies and their implications for estimating energy efficiency potential.

Estimating the likely effectiveness and contribution of energy efficiency policies – some empirical case studies.

Calculating energy conservation cost curves

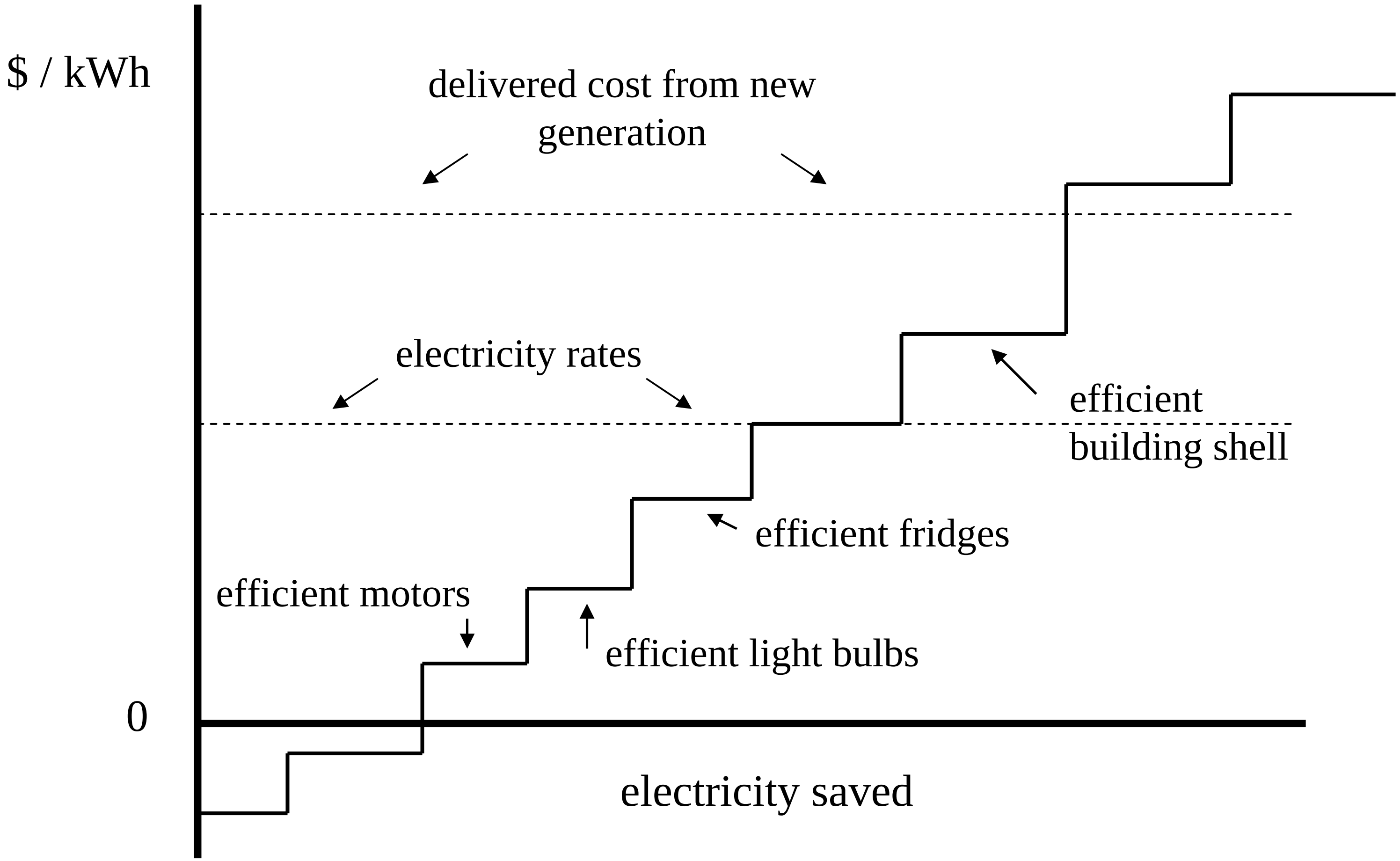
Compare a conventional technology with a higher efficiency alternative providing the same service.

Divide extra capital cost of efficient technology by its discounted energy savings = life-cycle-cost of conservation ($/kwh).

Graph estimated total energy savings (each service) in ascending order of cost to produce steps of conservation cost curve.

Initial steps could have negative costs; all steps costing less than utility rates are privately profitable; all steps costing less than new energy supply are socially profitable.

Energy conservation cost curve



Calculating GHG abatement cost curves

Compare a conventional technology with a lower emission alternative for the same service.

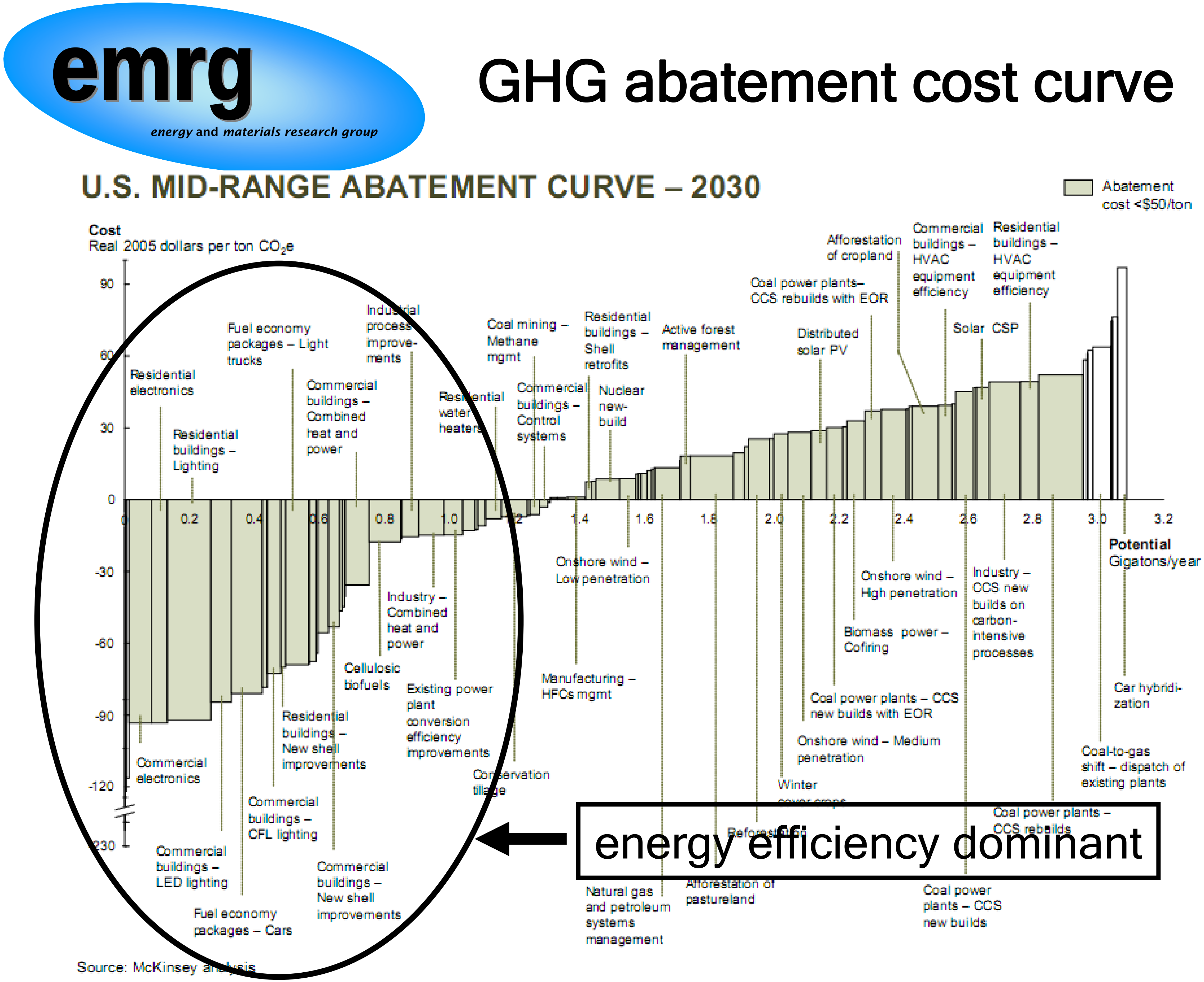
Calculate present value of capital and operating costs of both technologies.

Take the difference in these costs and divide by the difference between emissions = cost of abatement ($/tonne of CO_2).

Graph estimated total emissions reductions (each service) in ascending order of cost to produce abatement cost curve.

Initial steps could have negative costs, meaning profits + GHG abatement ("win-win", "no regrets")

GHG abatement cost curve



Source: McKinsey analysis

Issues with the use of cost curves

Conservation cost curves were popular 30 years ago and GHG abatement cost curves 20 years ago.

They fell out of favor with most energy-economy modelers, who argued these curves mislead about costs and are unhelpful with policy.

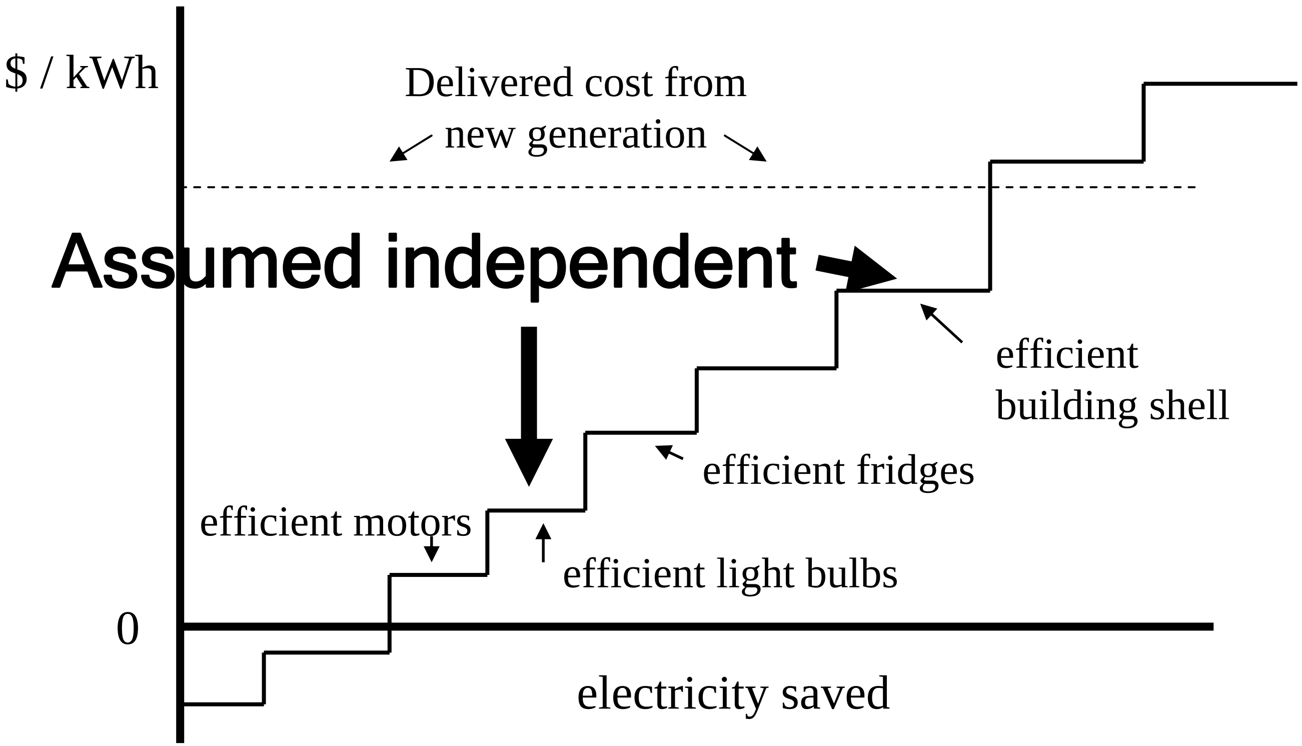
Yet these cost curves have recently re-emerged in GHG abatement policy discussions, rekindling old debates.

"Déjà vu all over again."

Issue #1
Actions assumed independent

Construction of cost curves implies that each action is completely independent of every other action. (extreme partial equilibrium analysis)

(1) demand-side, (2) supply-demand including price, (3) micro-macro rebounds



Issue #2
Market conditions assumed homogeneous

Market evidence shows that acquisition of a more efficient or lower emission technology will cost X for the first 20% of the market, X+Y for the next 20%, X+Y+Z for the next 20%, and so on.

Reasons include:

- different age of existing capital stock and hence cost of replacement at a particular time
- local differences in transaction costs – learning, acquisition, installation and operation

Issue #3
Technologies assumed perfect substitutes

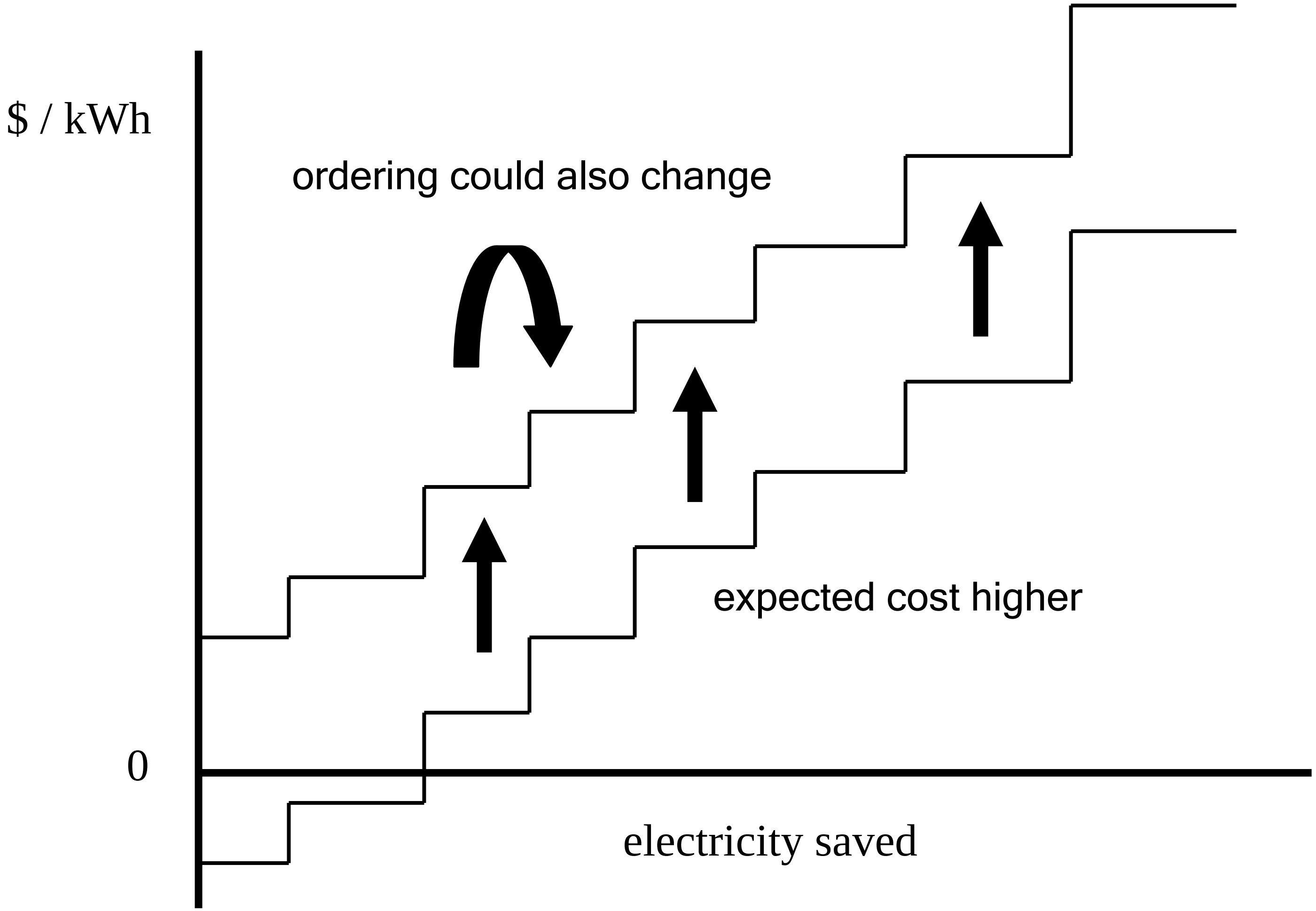
Quality of service assumed identical.

> But some technologies provide (or are perceived to provide) lower quality service – a frequent concern with new technologies (e.g., efficient light bulbs, transit vs personal vehicles)

Risk assumed identical.

> But (1) long payback investments usually higher cost risk, and (2) new technologies usually higher failure risk.
>
> Incorporating this risk usually causes higher “expected cost” for high efficiency / low emissions technologies.

Correction for expected cost



Modeler response to first three "issues" with cost curves

Construct integrated models:

- energy supply with energy demand
- energy system with rest of economy
- economy with natural system (integrated assessment models)

Track vintages of equipment stocks and portray heterogeneous character of market response

Estimate model behavioral parameters that explicitly or implicitly incorporate:

- non-financial values (preferences related to technology attributes)
- perceived and real differences in risk

(parameters could be "price elasticities" or specific "behavioral parameters" in a model that simulates technology choice)

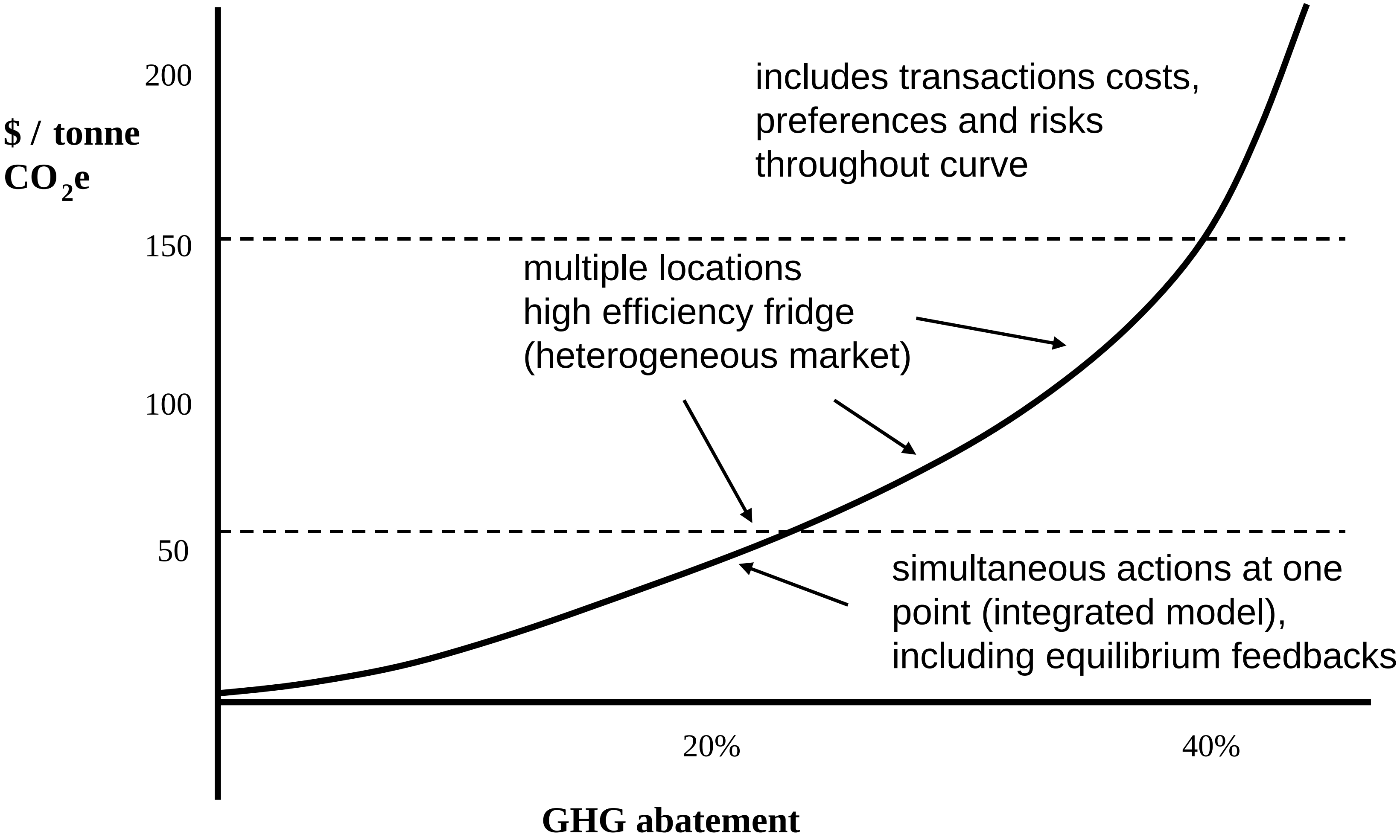
Energy-economy models: Estimating marginal abatement cost (MAC) curves

Using elasticities or other behavioral parameters, energy-economy models simulate responses of firms and households to changing energy prices due to market developments or emissions pricing policies.

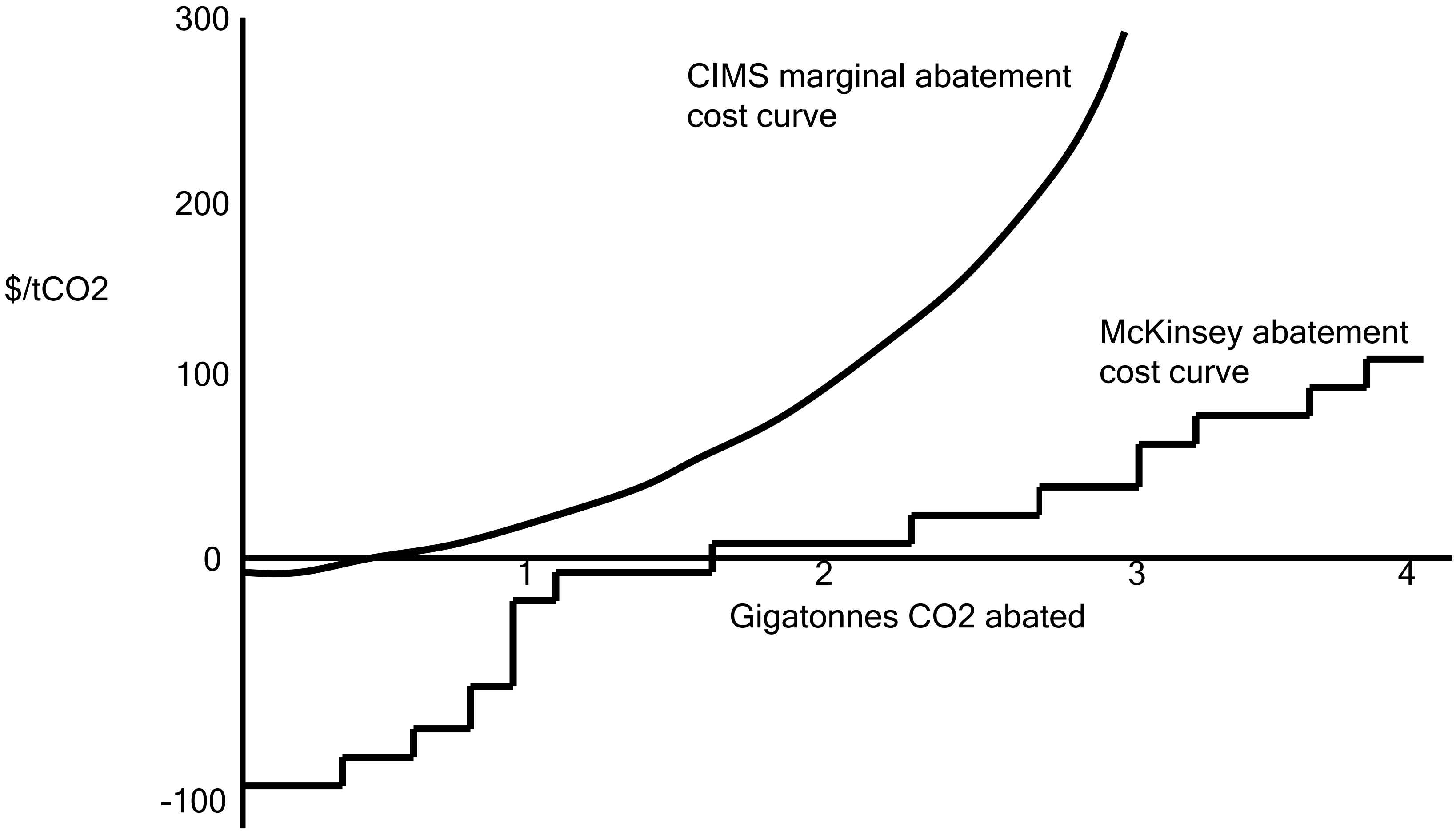
Graphing the results from raising the price of CO2 produces a marginal abatement cost (MAC) curve. This differs from conservation or abatement cost curves because:

- Each point on curve has simultaneous actions occurring (equilibrium effects)
- A particular action (more efficient fridges) occurs continuously along the curve, if model includes capital stock vintages and market heterogeneity.
- If model incorporates intangible costs and responsiveness to pricing policy (a simulation model), MAC curve likely to be much higher.

Energy-economy model: sample MAC curve



McKinsey study vs. CIMS hybrid model MAC: US - 2030



CIMS: A technology choice simulation model – “hybrid”

Model keeps explicit track of capital stocks of different types of technologies in terms of efficiency and emissions level.

Technology choices driven by three uncertain parameters – time preference, degree of market heterogeneity, technology specific intangible costs. Parameters estimated using revealed and stated preference research. (see next slide)

Model has other dynamics – learning curves, neighbor effect, rebound effect – which also require parameter estimation (published studies)

Technology simulation model provides elasticity of substitution values for a CGE model (global model, US model, Canada model). Price shocking of CIMS produces “pseudo data” for estimating ESUBs for the CGE.

CIMS: Technology choice algorithm

$$MS_j = \frac{\overbrace{\left(CC_j \cdot CRF_j + OC_j + EC_j + i_j\right)}^{\text{LCC}}{}^{-v}}{\sum\left(CC_k \cdot CRF_k + OC_k + EC_k + i_k\right)^{-v}}$$

$$CRF_j = \frac{r}{1-(1+r)^{-n_j}}$$

Three key behavioural parameters:

- **Discount rate (r)** – reflecting time preference with respect to technology acquisition decisions
- **Intangible cost (i)** – preferences associated with technology quality attributes, including differential risk
- **Market heterogeneity (v)** - different consumers and businesses face different costs, have different perceptions and preferences.

Discrete choice models to estimate r, i and v in CIMS

Survey / Observation → Empirical Model (DCM) → CIMS' *r*, *i* and *v*

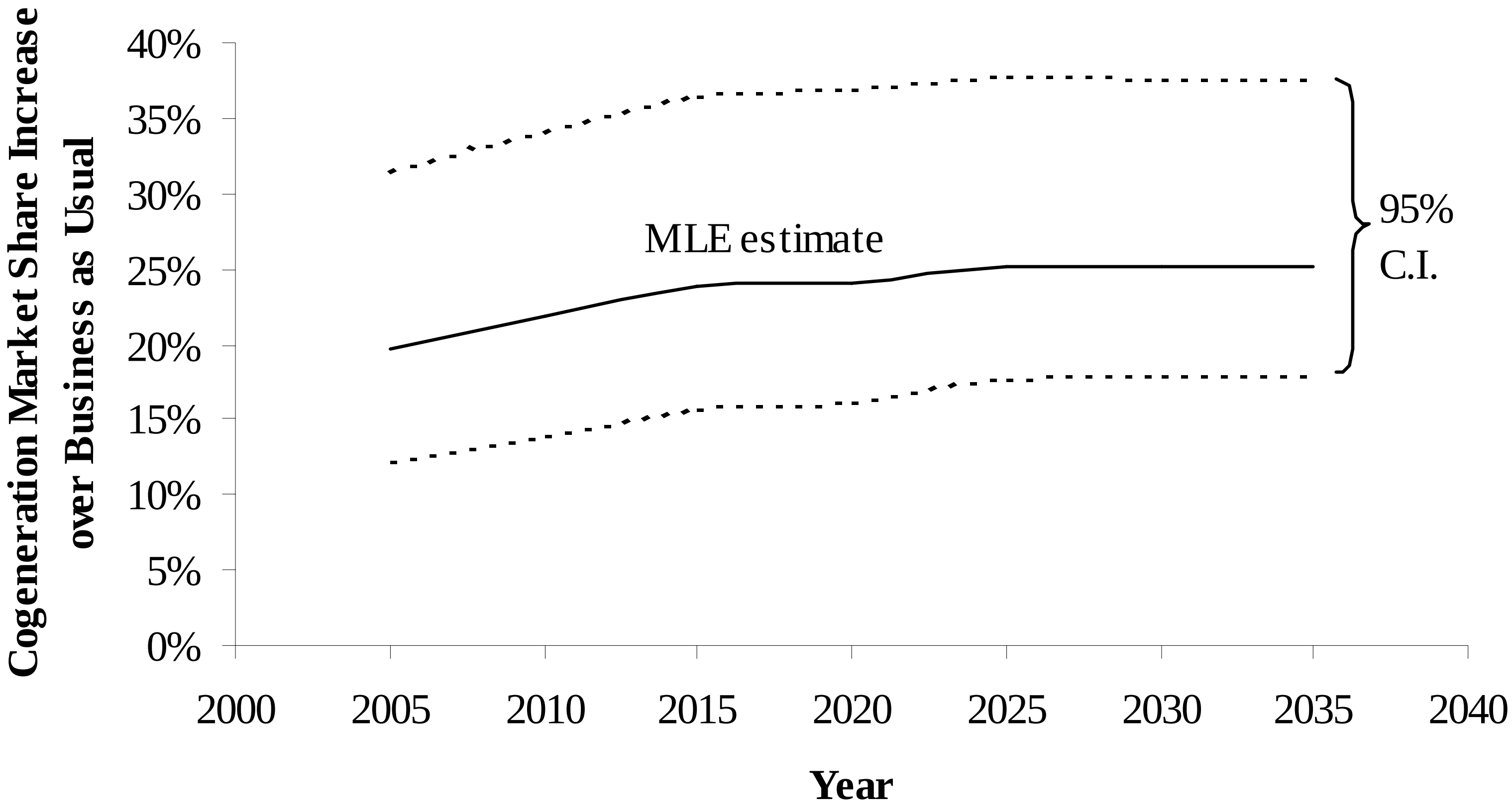
Standard discrete choice model for technology choice surveys

$$U_j = \beta_j + \beta_{CC}CC + \beta_{OC}OC + \beta_{EC}EC + e_j$$

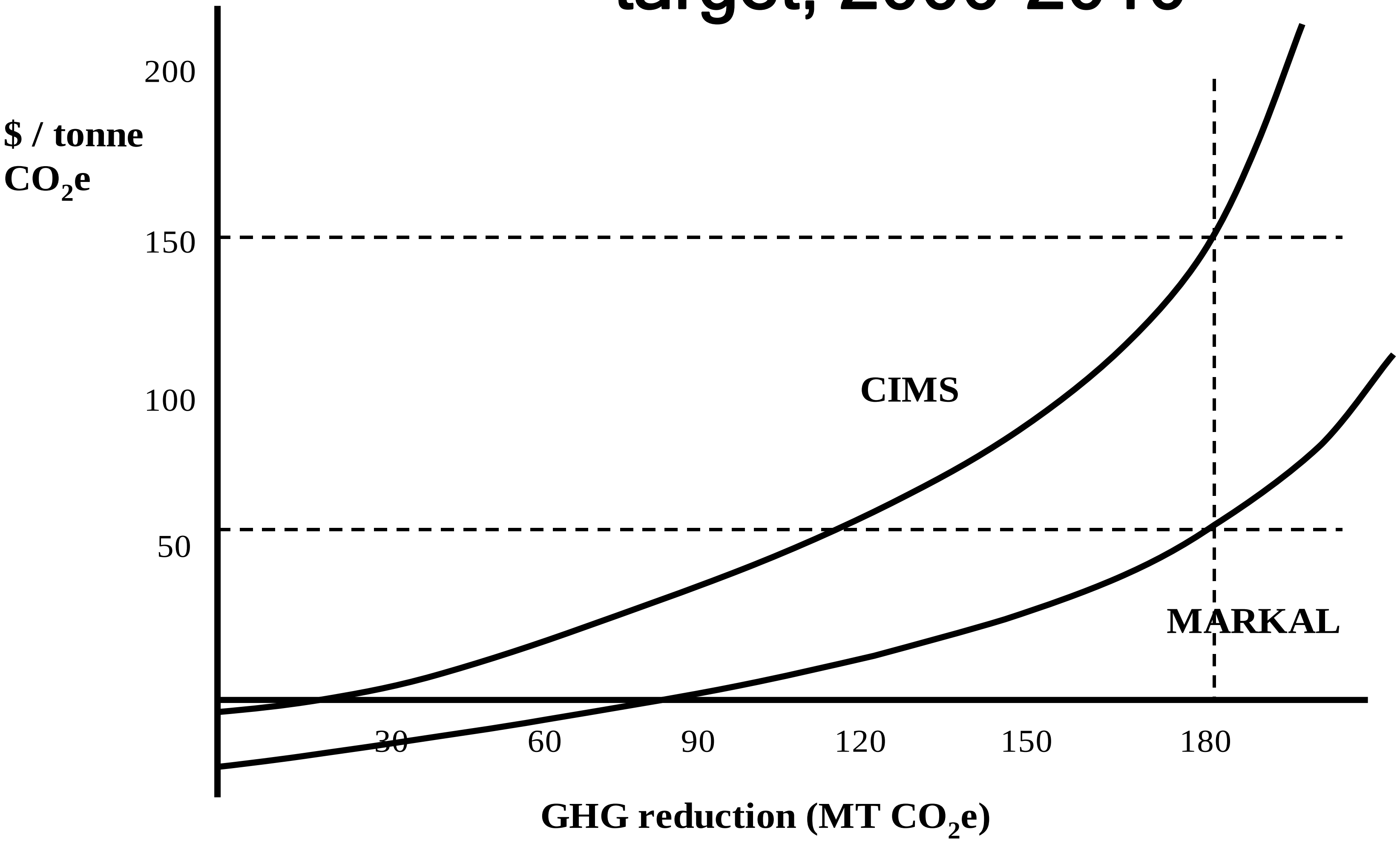
$$r = \frac{\beta_{CC}}{\beta_{AC}} \qquad i_j = \frac{\beta_j}{\beta_{AC}}$$

$v =$ ordinary least squares to estimate value for which predictions from CIMS are consistent with those from the DCM model. Depends on size of error terms relative to values of beta parameters.

Empirically estimated behavioral parameters - uncertainty propagated to model outputs



Simulation vs optimization, CIMS vs MARKAL: Canada-Kyoto target, 2000-2010



Issue #4
Cost curve policy implications

Studies producing conservation and abatement cost curves often silent on policy.

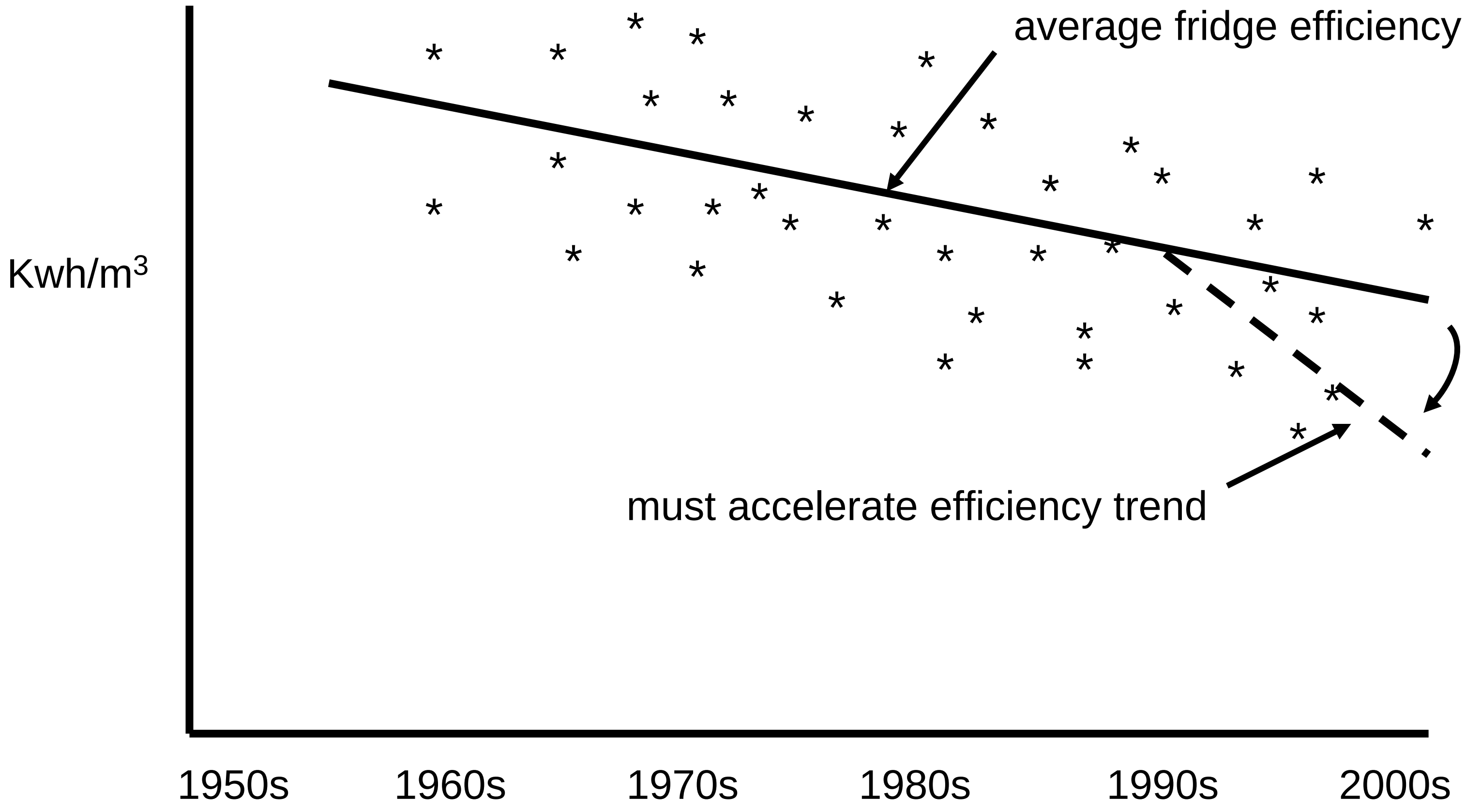
But, implicit cost message:

> “It is cheap to achieve substantial reductions of energy use and/or emissions.”

Implicit policy implication:

> “With conservation so cheap, little need for emissions pricing and regulations. Just focus on information and subsidies (including offsets) to drive energy conservation.”

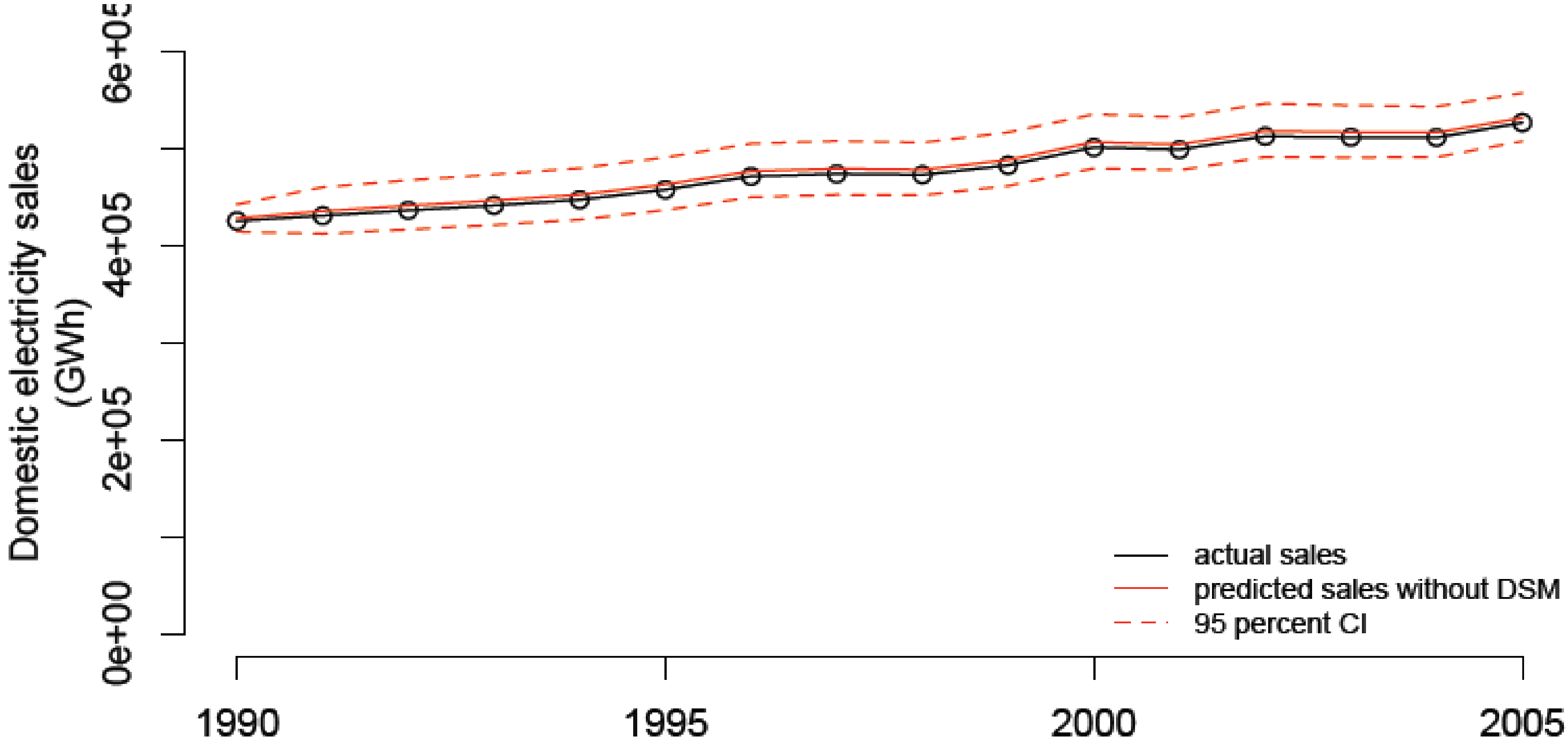
Policy challenges: efficiency subsidies and free-riders



Estimated free-ridership rates: quasi-experiments

Technology	Source	Free-ridership
Furnace	Malm (1996)	89%
Refrigerator	Train and Atherton (1995)	36%
Air conditioner	Train and Atherton (1995)	66%
Building shell retrofit	Grosche and Vance (2009)	50%
Electric utility DSM programs – various	Loughran and Kulick (2004)	50-90%
Hybrid vehicles	Chandra et al. (2009)	74%

Estimated effectiveness of efficiency subsidies in Canada



Rivers and Jaccard, 2009

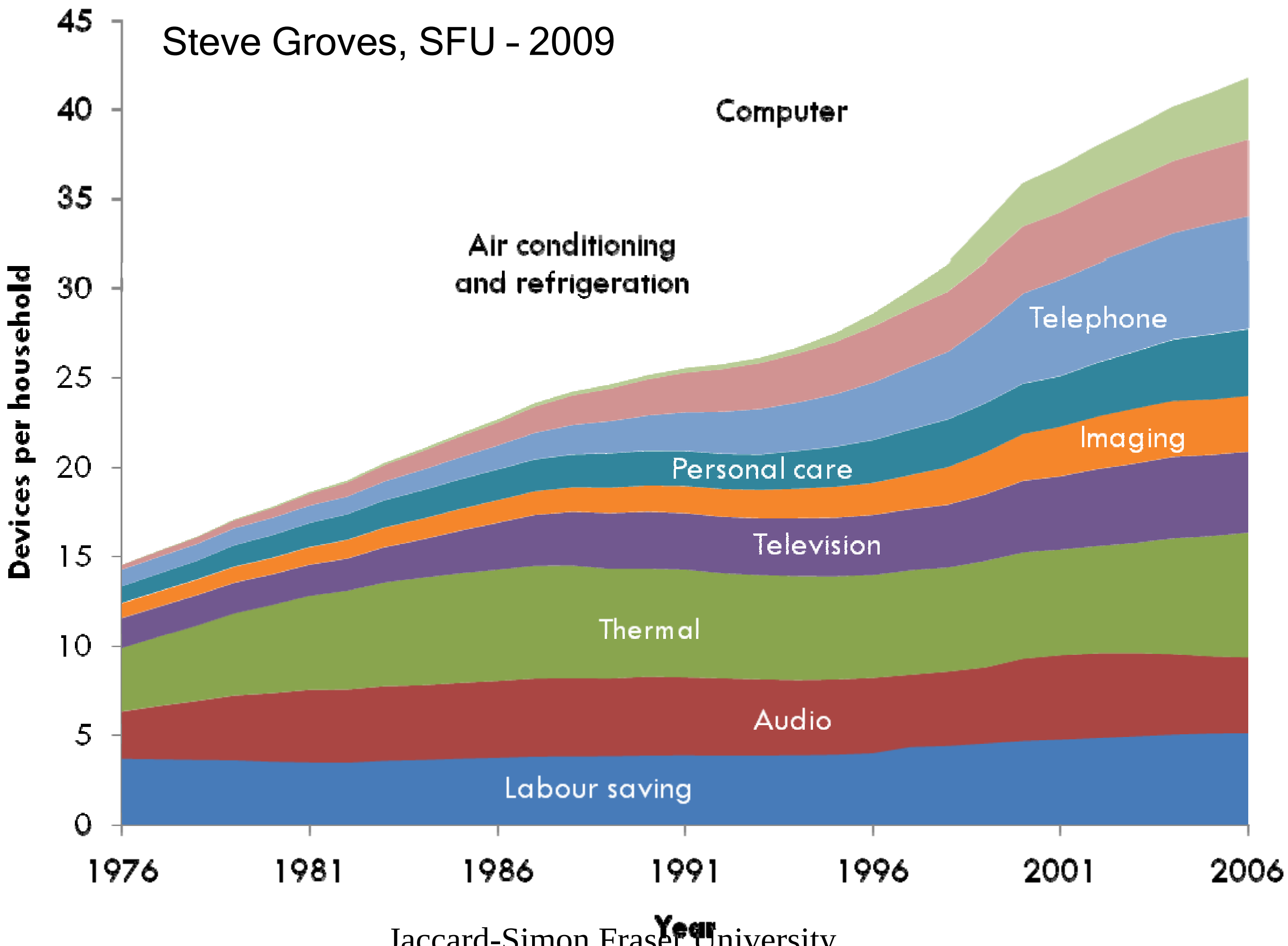
Net effect of subsidies on energy use

Free riders – evidence suggests 25-75%

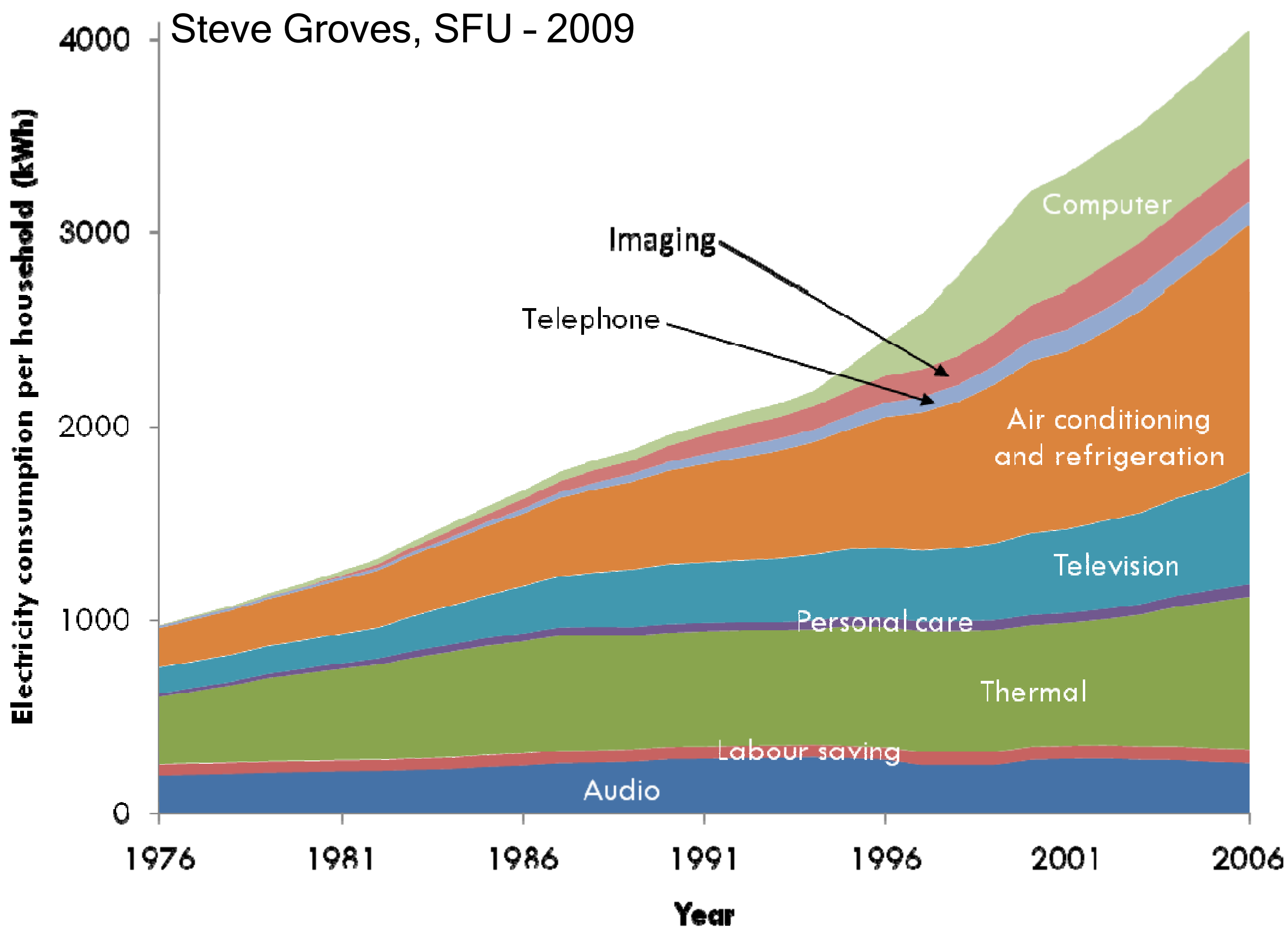
Direct rebound – evidence suggests 5-20%

Productivity rebound – uncertain, but initial evidence suggests high rebound potential when policy is efficiency subsidies (new devices, new energy services)

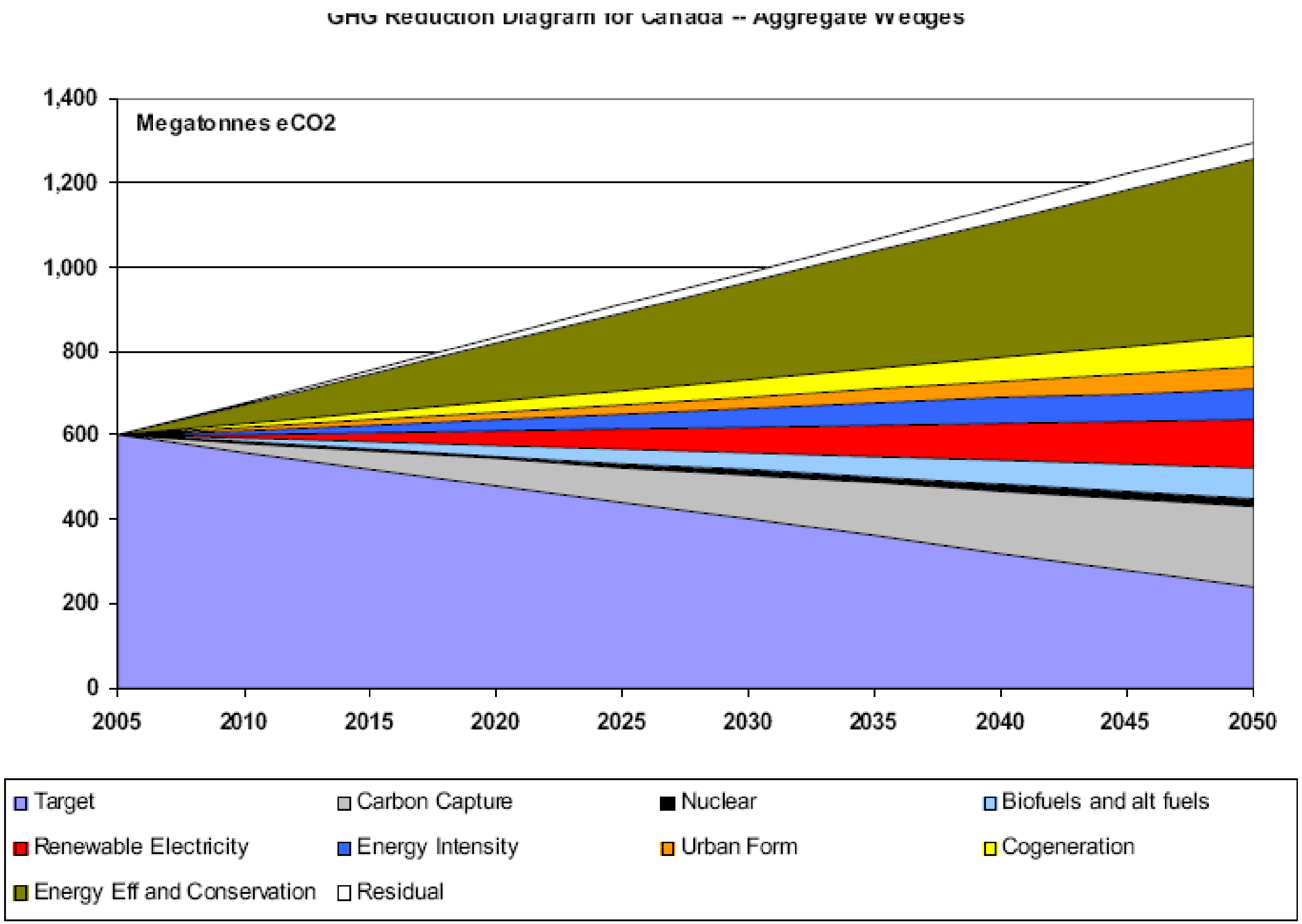
US data for “other” household devices - number



US data for “other” household devices – electricity consumption



Bottom-up estimate of efficiency's contribution: Canada in 2050



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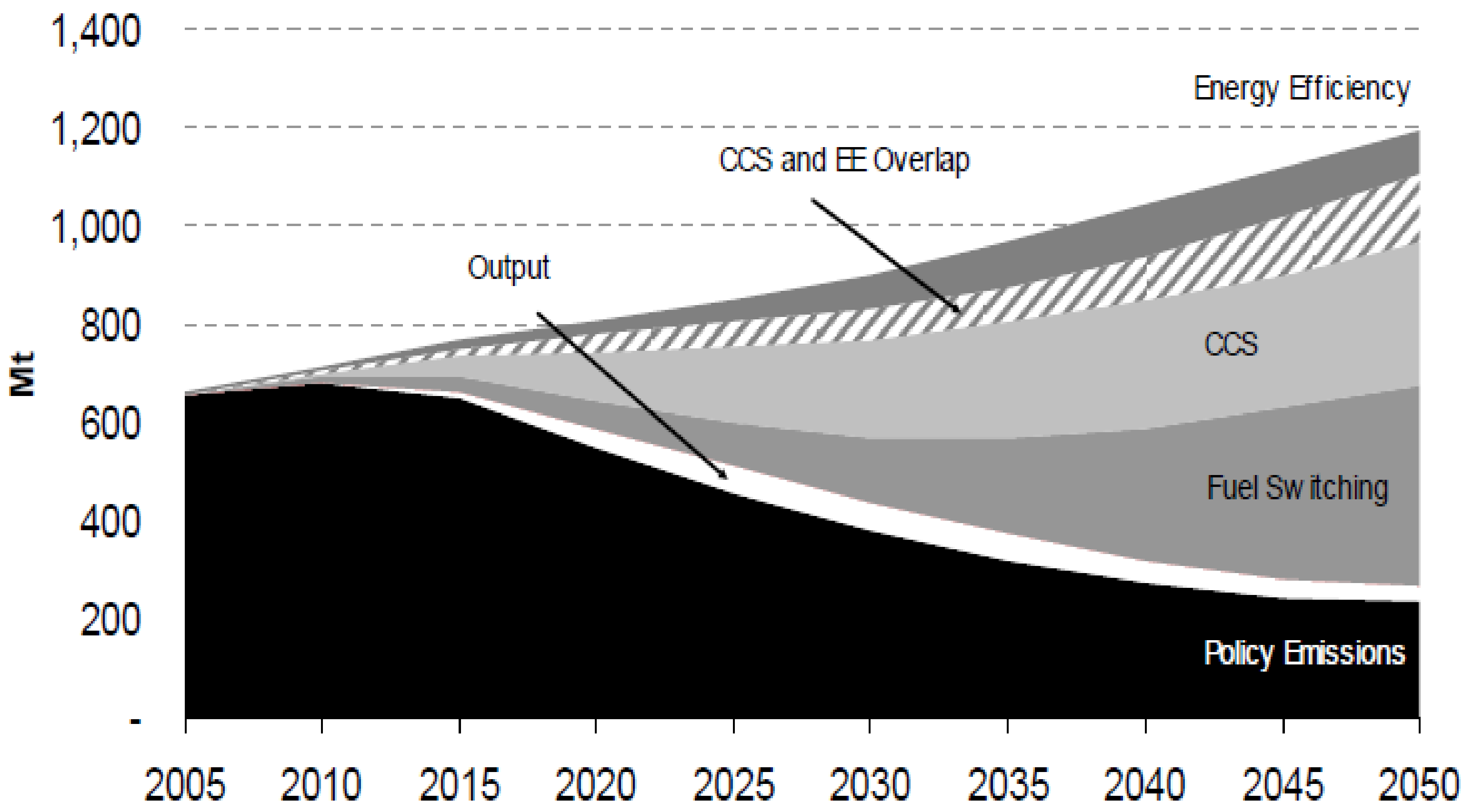
Hybrid estimate of efficiency's contribution: Canada in 2050



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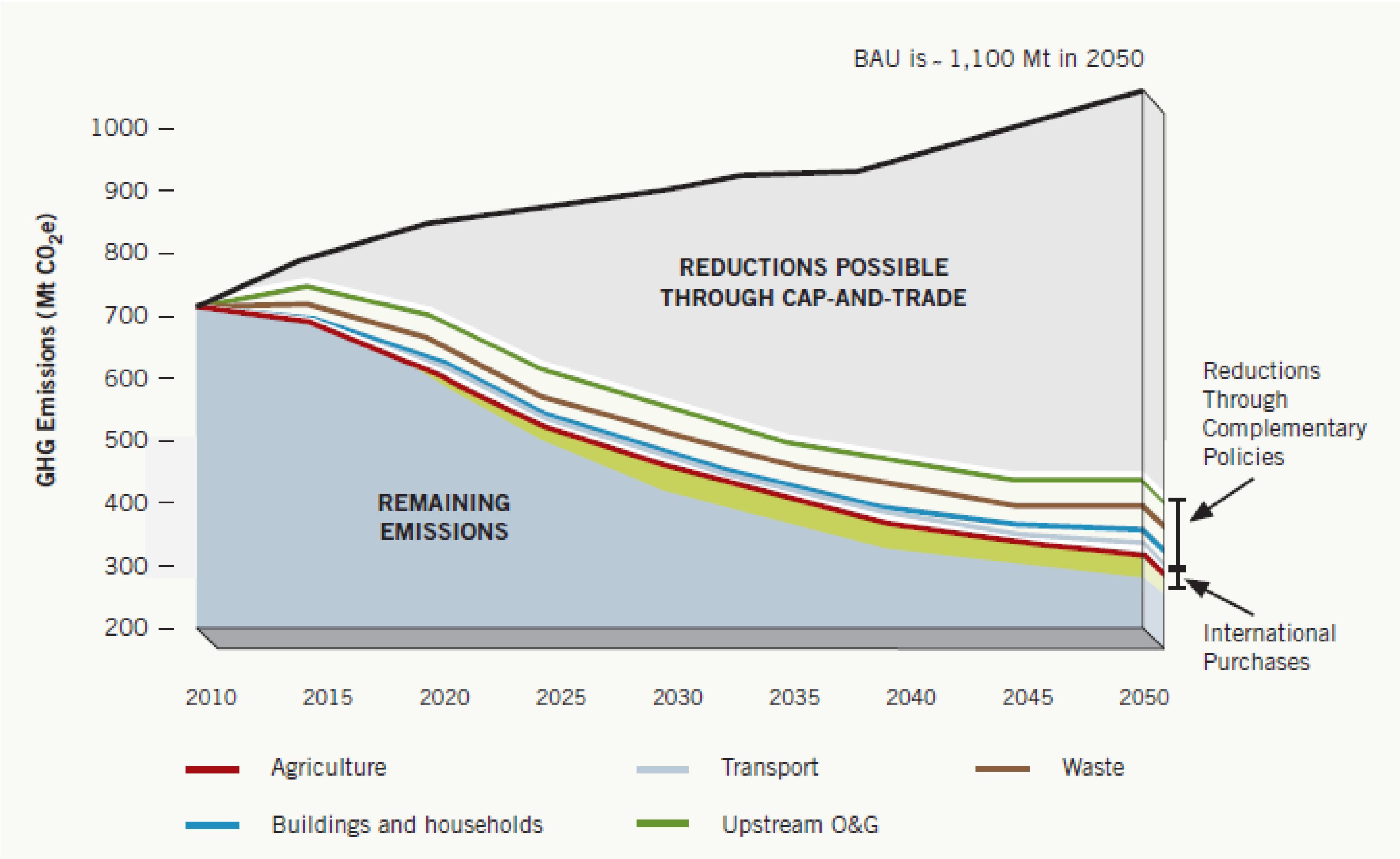
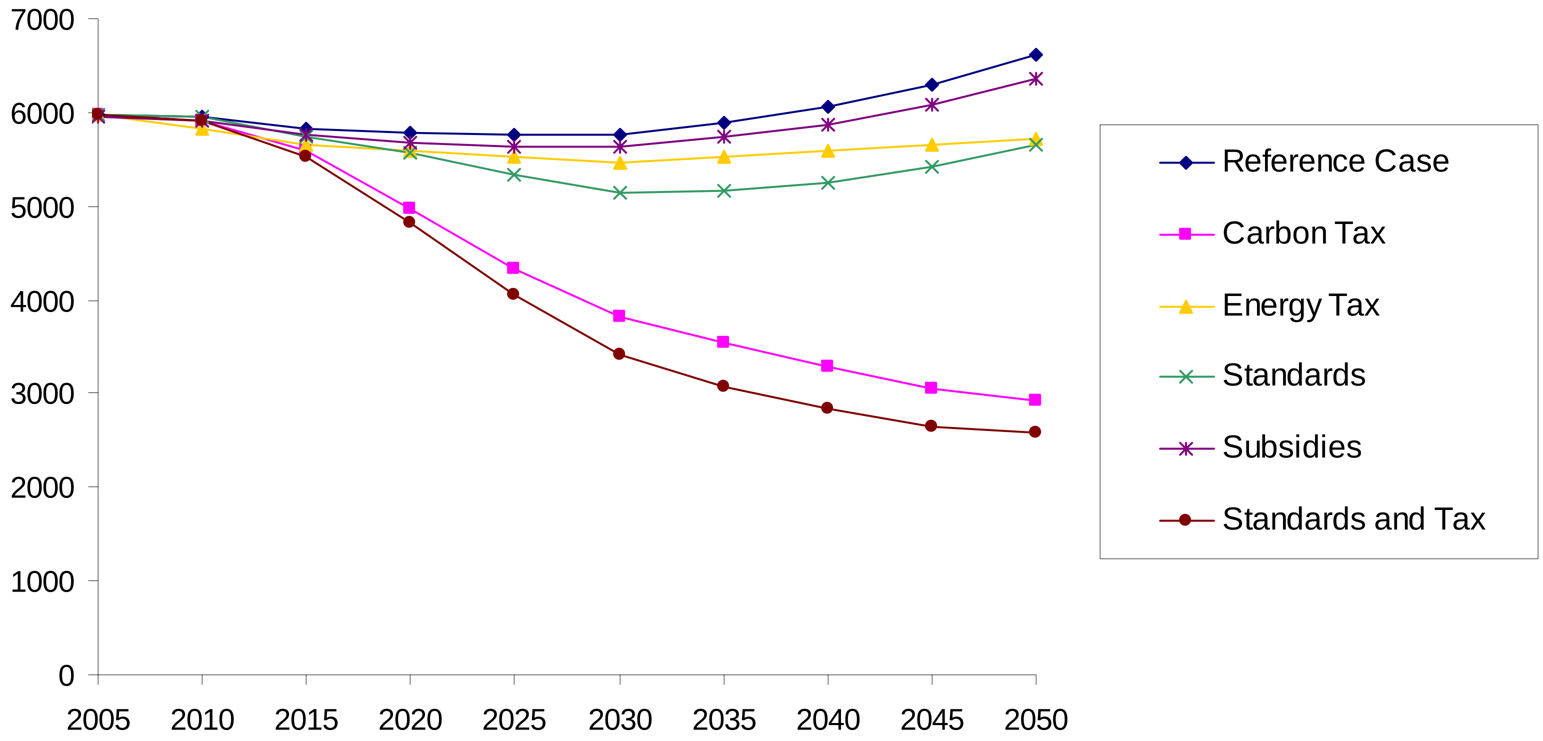
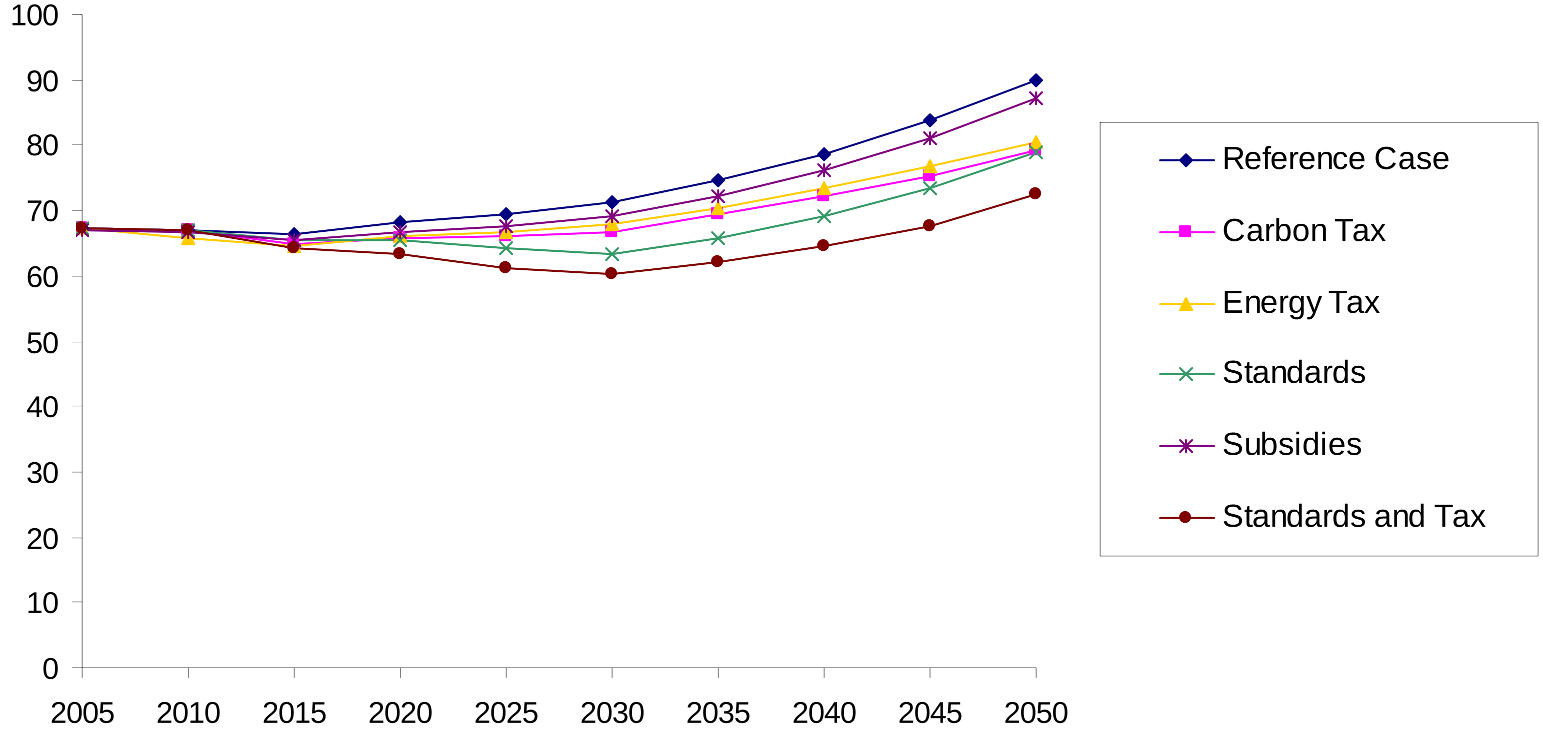
Incremental contribution of non-price policies: Canada 2050



CIMS EMF25: US CO_2e Emissions Incl. Elec. Gen. (Million Tons)

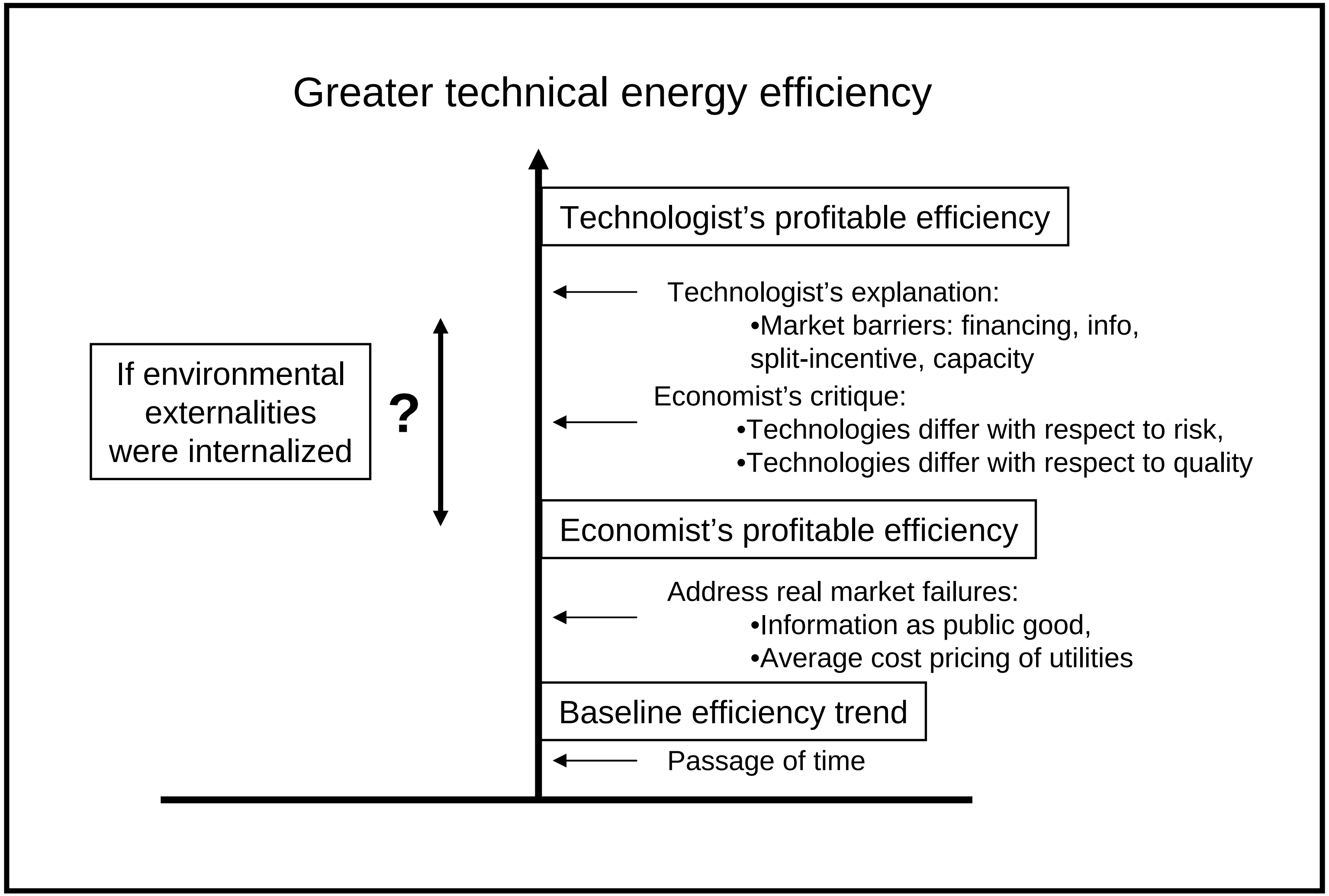


CIMS EMF25: US Energy Consumption Excl. Elec. Gen. (QBTU)

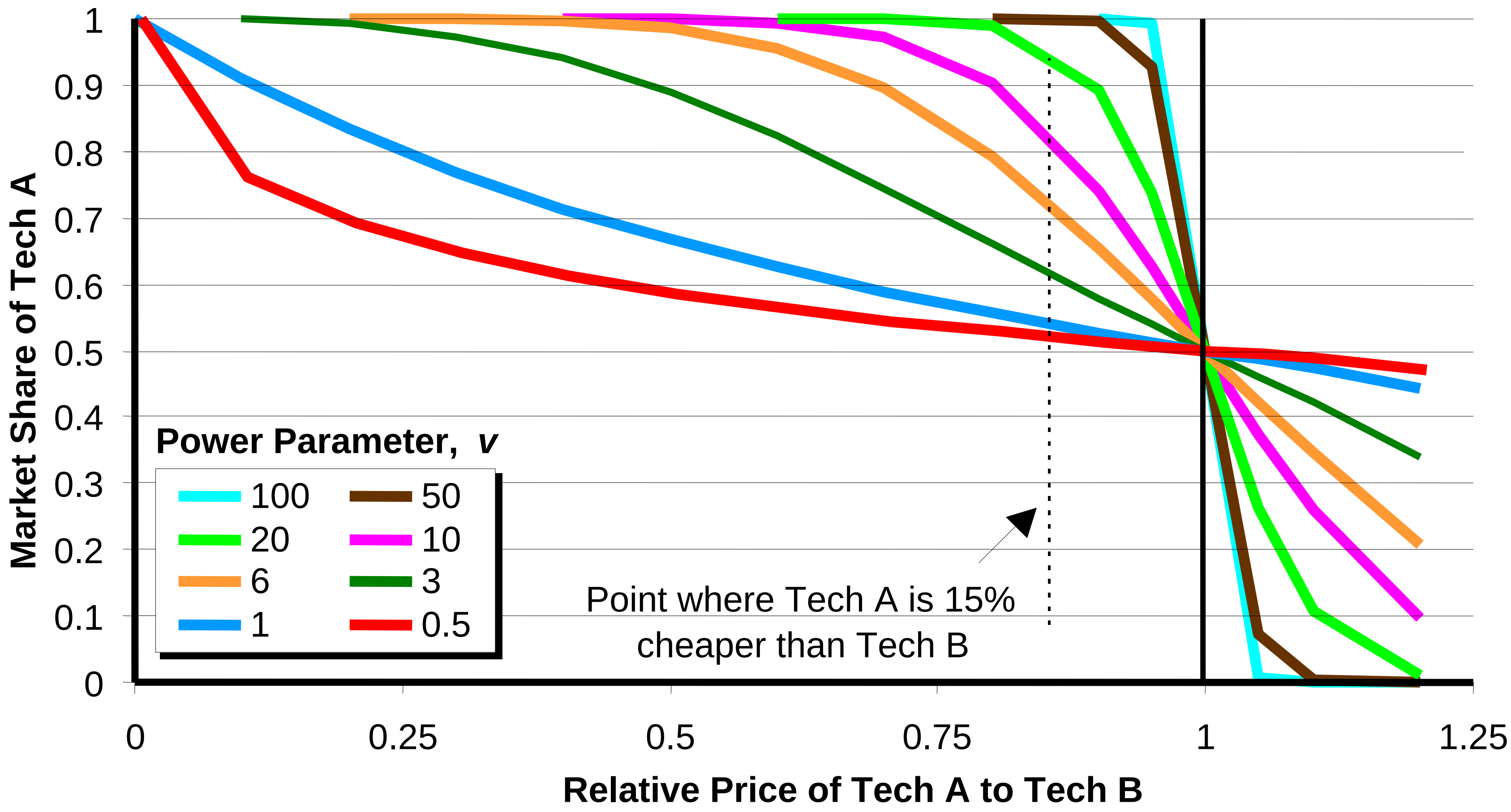


Extra slides

Views on profitable efficiency



Parameter Implications - Market Heterogeneity



Source: Nyboer, 1997

Carbon offsets: another form of subsidy

Definition of offset – a "subsidy," usually from one private entity to another, to help fund an action that reduces emissions from what they otherwise would be (business as usual)

Voluntary offset – individuals and corporations can voluntarily acquire offsets in order to reduce their net emissions

Regulated entity offset – a cap and trade system could allow a regulated entity to meet some or all of its emission reductions by acquiring offsets from unregulated entities (Alberta, Canada, CDM of the Kyoto Protocol)

Governments require, and offsetter companies promise, that offsets are "verified to be additional and permanent"

Range of carbon offsets

1. Improve energy efficiency so that less fossil fuels are combusted and less GHG emitted

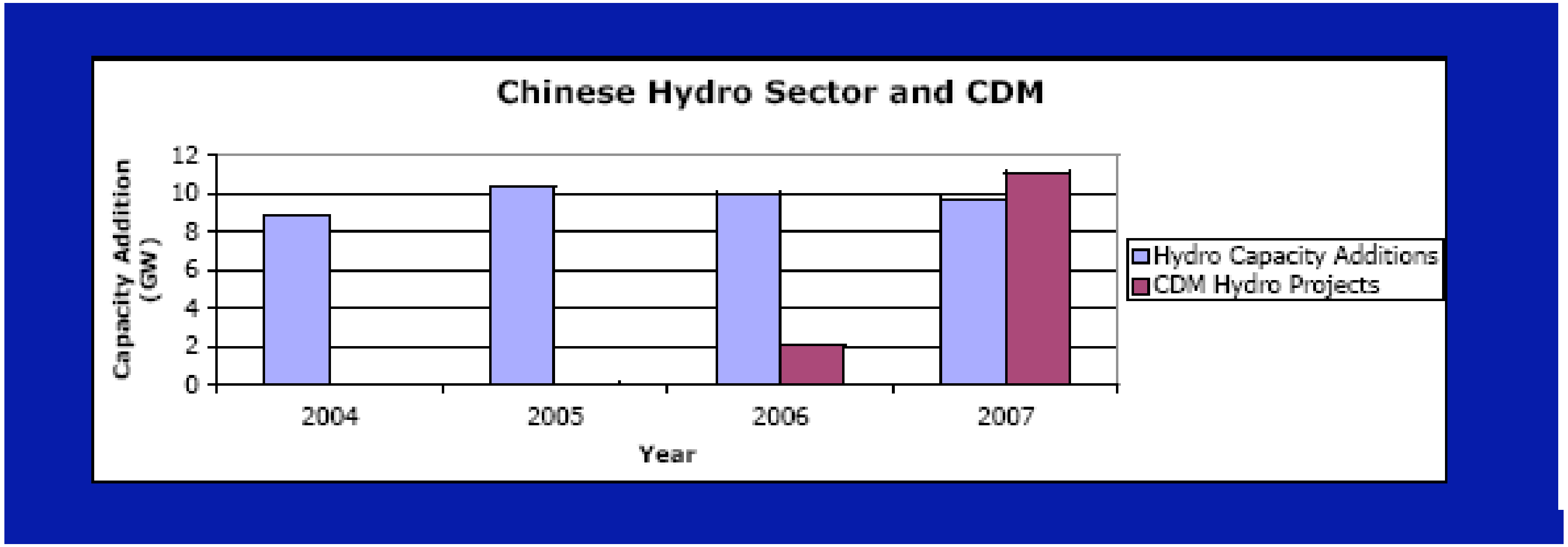
2. Subsidize renewable energy to reduce the carbon that otherwise would have been emitted

3. Changing agricultural practices, such as tillage, manure handling and livestock feed.

4. Planting trees to increase carbon in biomass on the earth's surface

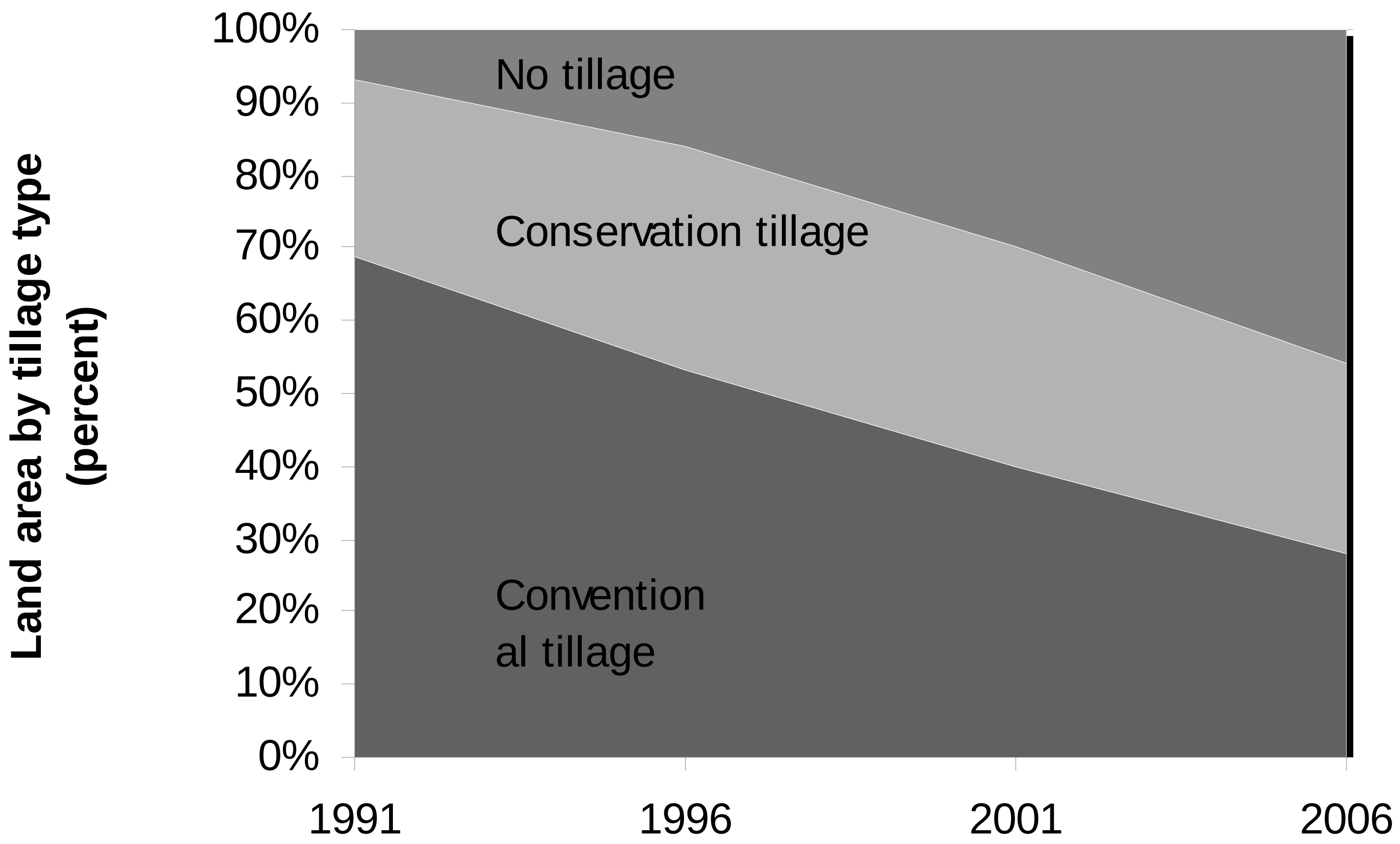
5. Capture or prevent a GHG emission (land fill gases, pipeline methane leaks, carbon capture and storage)

Offsets via the Clean Development Mechanism



Warr and Victor, 2008

Subsidies to changing tillage practices?



Afforestation offsets

Subsidize x percentage of landowners to plant trees on marginal agricultural land.

Offsetter companies verify that the trees are planted and the land remains forested.

Over time this policy should raise the value of agricultural land relative to forested land.

This would cause some forest owners with land of moderate agricultural value to convert it to agriculture.

This is leakage – economists call it a general equilibrium effect.