Electricity, Carbon and Competition

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This talk is based on a longer version downloadable from www.epoc.org.nz/ww2012.html

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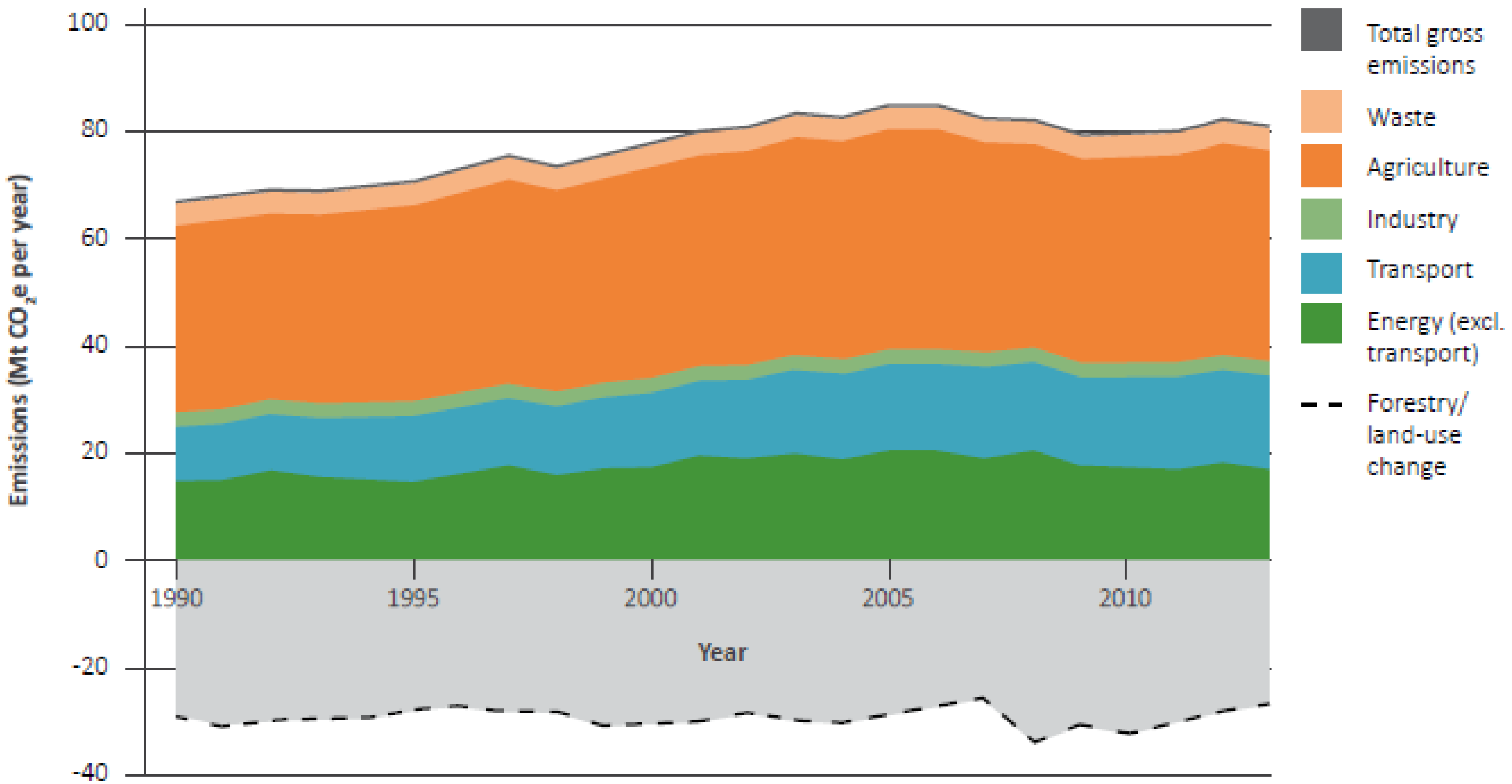
Overview

- **Background**
  - NZ GHG emissions and electricity
- **Emission trading and electricity prices: perfect competition**
  - Results
- **Emission trading and electricity prices: imperfect competition**
  - Why this is important
  - Modelling imperfect competition
- **Conclusion**
  - Competition in wholesale electricity market matters

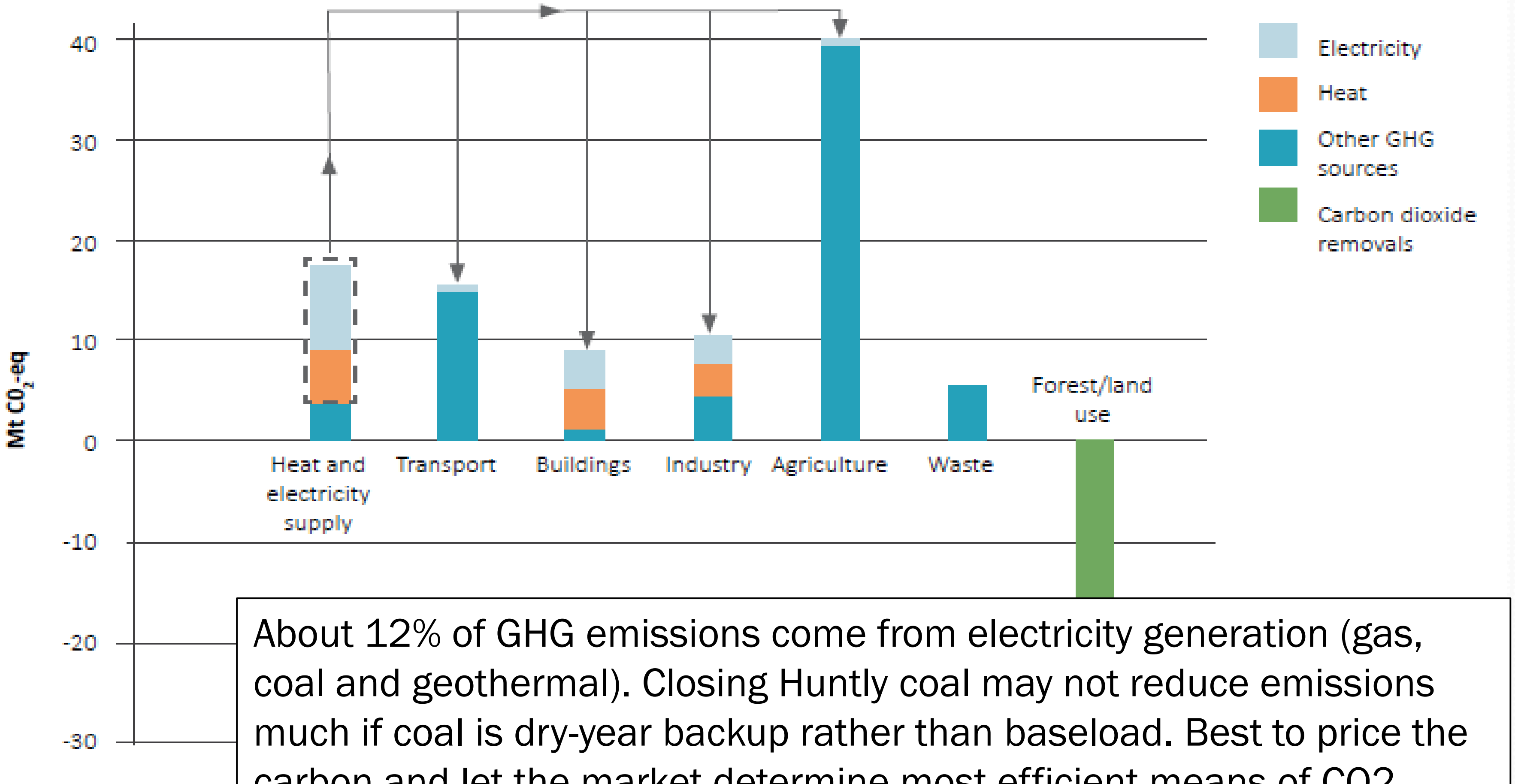
New Zealand GHG emissions

Figure 3.1 Gross GHG emissions in New Zealand from all sectors and removals by forests, 1990–2013.



Source: MfE (2015a).

Electricity GHG emissions 2013



Source: MfE (2015a).

About 12% of GHG emissions come from electricity generation (gas, coal and geothermal). Closing Huntly coal may not reduce emissions much if coal is dry-year backup rather than baseload. Best to price the carbon and let the market determine most efficient means of CO2 reduction.

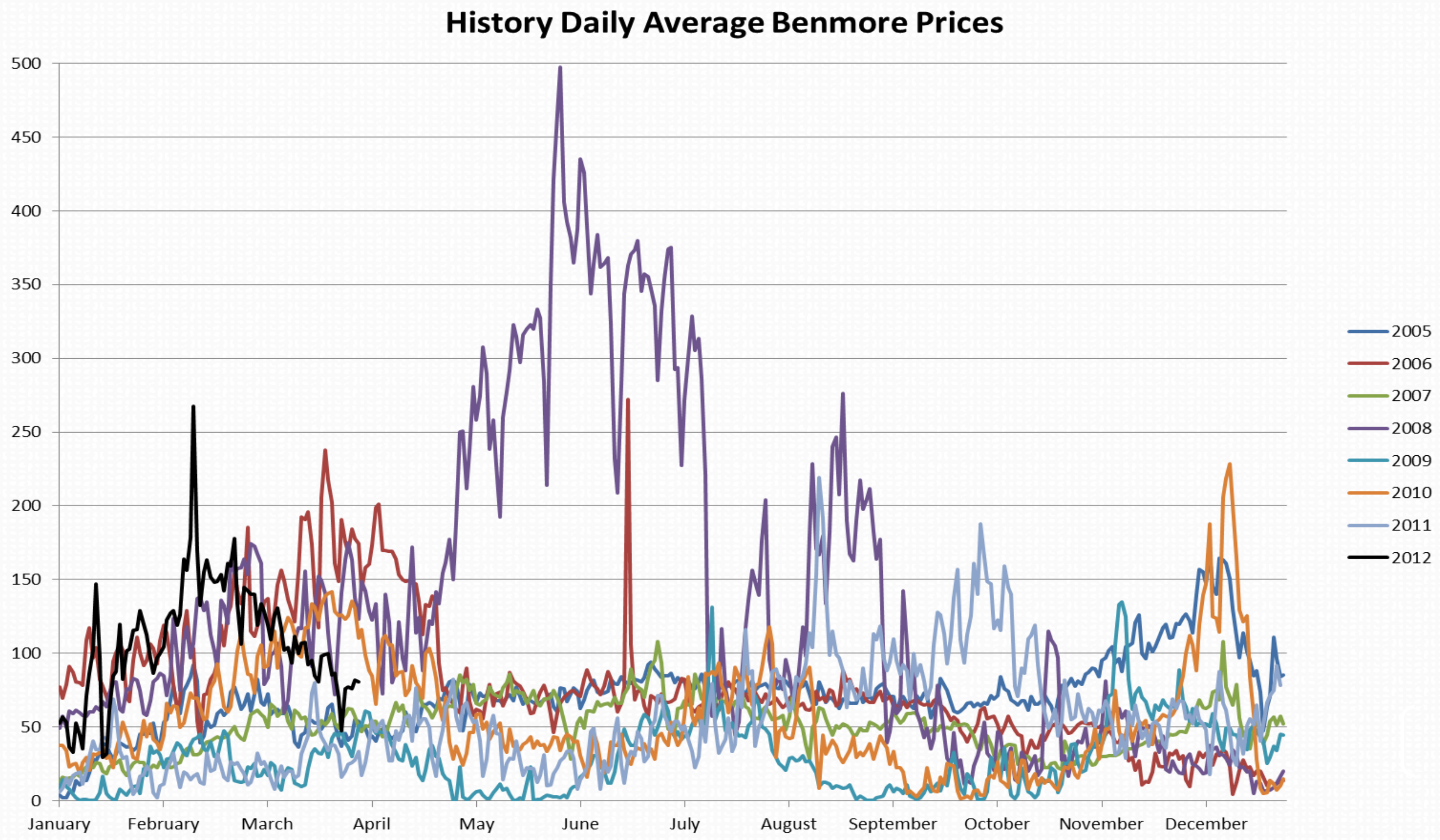
New Zealand Electricity Market Structure

- New Zealand operates a real-time nodal pool market with vertically-integrated gentailers.
- There are five main generation companies, three of which are 50% state owned.
- Generation dominated by hydro, however, the peak load must be met by thermal generation and there is always a risk of a drought.

Electricity Pricing

- Offers are submitted to the pool every half-hour and are cleared against demand.
- Offers do not have to reflect marginal cost.
- Electricity prices are computed at a nodal level, based on the marginal offer/bid for electricity.

Electricity prices depend on hydrology



The NZ Emissions Trading Scheme

- New Zealand's post 2020 target is to reduce greenhouse gas emissions to 30 per cent below 2005 levels by 2030.
- The New Zealand Emissions Trading Scheme is currently under review.
- Original scheme had a 1-for-2 exemption that effectively halved the carbon price for eligible consumers of electricity.
- 1-for-2 exemption to be removed from 2017..
- Submissions recently summarized and published at

http://www.mfe.govt.nz/climate-change/reducing-greenhouse-gas-emissions/new-zealand-emissions-trading-scheme/about-nz-ets

Modelling carbon and electricity prices

- Carbon prices increase short-run marginal cost (SRMC) of thermal plant

Fuel Type	Price ($ / GJ)	Tonnes CO_2 / GJ
Gas	6.0	0.0528
Coal	4.0	0.0912

- Fuel cost of **c** ($/GJ) becomes **c+αT**, where **α** is carbon price and T is Tonnes CO2/GJ
- SRMC ($/MWh) = (**c+αT)*Heat Rate** (approx 10 GJ/MWh)
- Higher fuel costs can be translated into higher electricity prices depending on the generation mix, and hydrology.
- Can forecast electricity prices by forecasting the generation mix (including investments). (done in 2012 for MFE by Energy Market Consultants)

Increase in SRMC of electricity = EF*CO2 Price

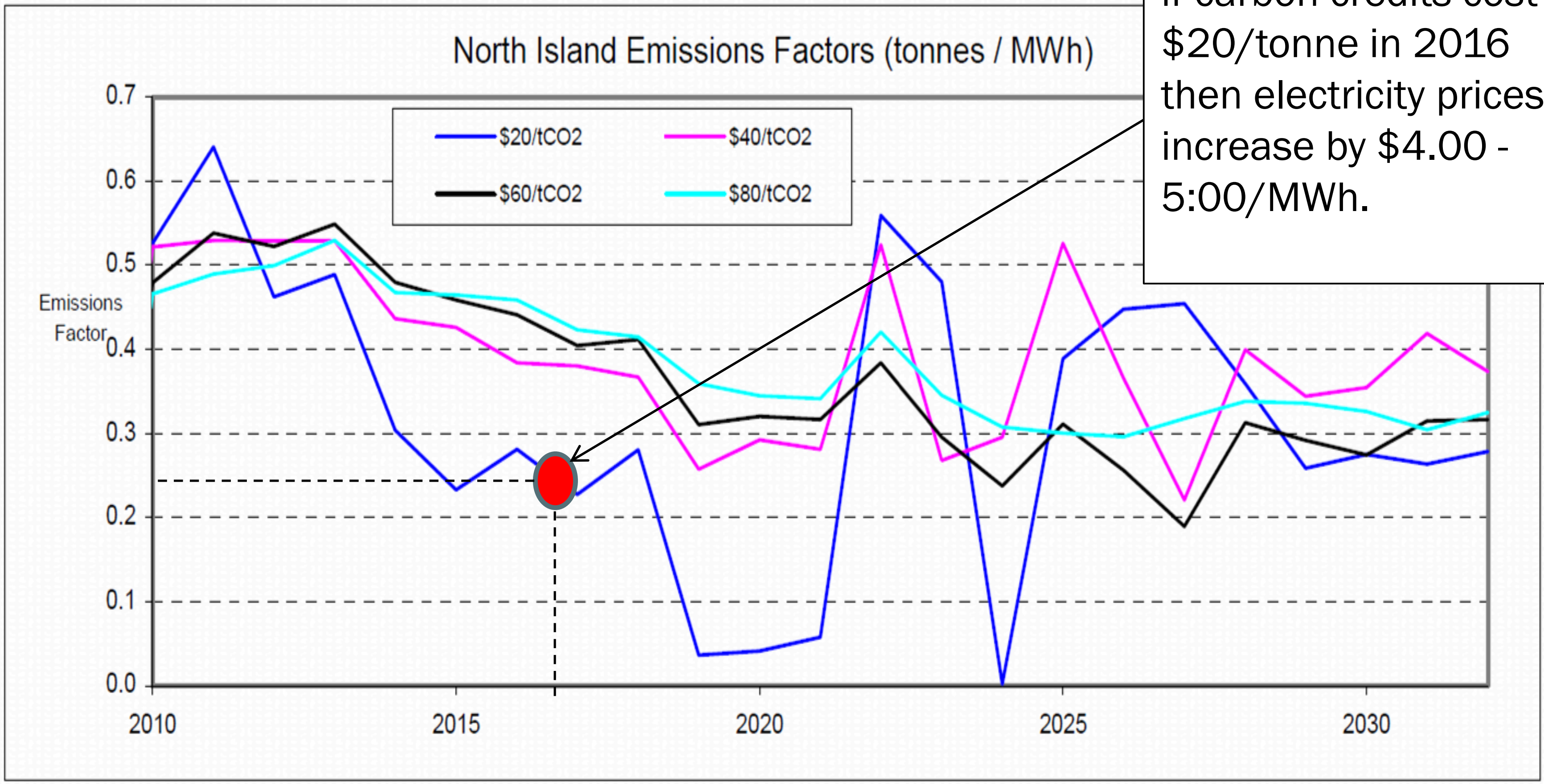


Figure 2: Annual Average Emissions Factor for each carbon cost, for North Island SRMC

if carbon credits cost $20/tonne in 2016 then electricity prices increase by $4.00 - 5:00/MWh.

Source: www.mfe.govt.nz

Perfectly competitive model

- "Increasing carbon costs to $25 per unit from $5 would increase wholesale prices by $4.50/MWh." (Genesis Energy, Energy News, October 6, 2016).
- Average percentage increase in SRMC comes out at about 0.52.

If market is not competitive…

If some generators can exercise market power to affect prices then CO_2 charges might lead to perverse outcomes.

1. If renewable electricity prices are artificially high then consumers make poor choices of technology based on price.
2. Increasing a carbon charge to reduce emissions might have unexpected consequences.

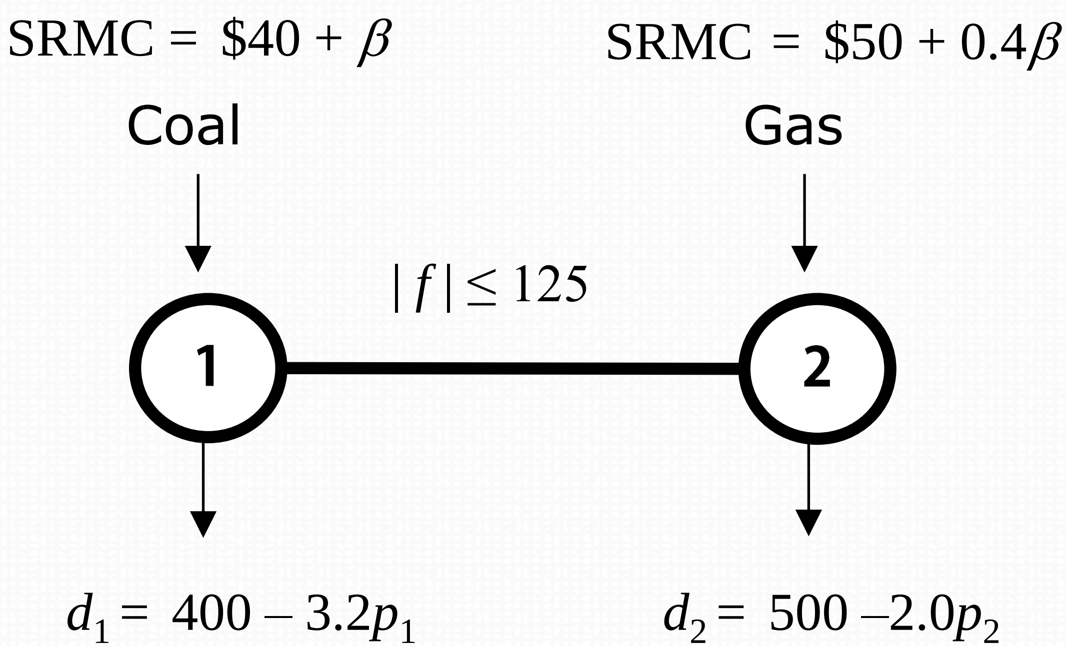
Example: rooftop solar panels

- Roof top solar installations growing very fast.
- At 18c/kWh retail prices it is a good investment: households can save over 25 year lifetime of panels.
- It is a marginal investment at 11c/kWh
- It is a poor investment at perfectly competitive energy prices of ~5c/kWh.
- Batteries do not make it more economic.
- Rooftop solar panels might be a poor substitute for other renewables.

CO2 prices and strategic behaviour

Consider a two-node transmission network with a line capacity of 125 MW. A coal plant is at one end of the line and a gas plant is at the other end. Carbon price = \$$\alpha$/tonne. SRMC of coal plant increases by

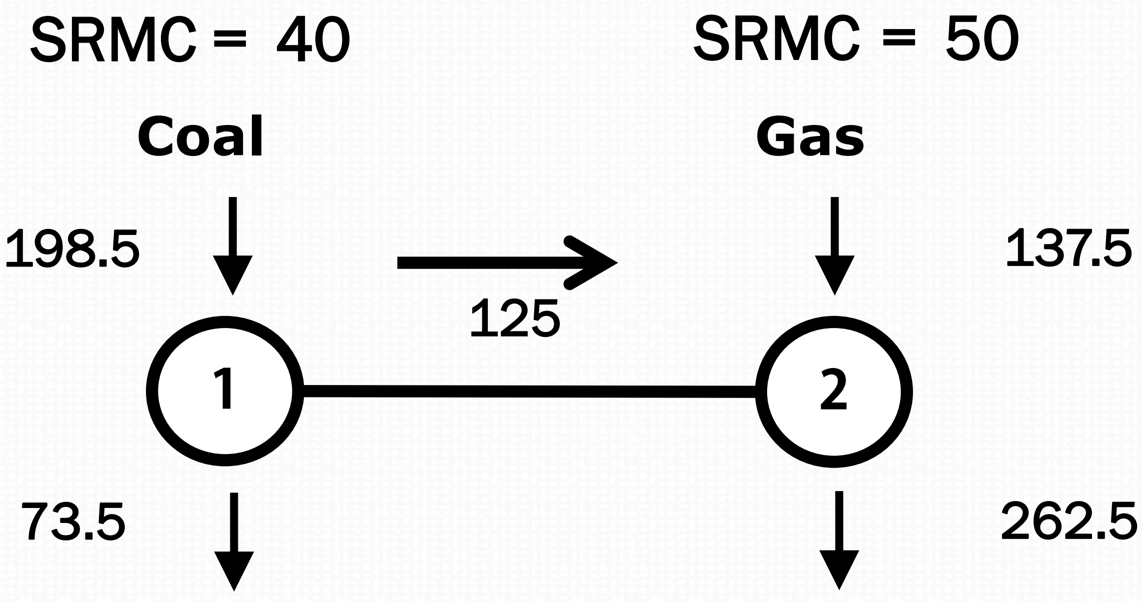
$$\beta = \alpha * T(\text{coal}) * \text{Heat Rate (coal)}$$



Downward A. The Energy Journal, 31(4):159–166 (2010)

CO2 prices and strategic behaviour

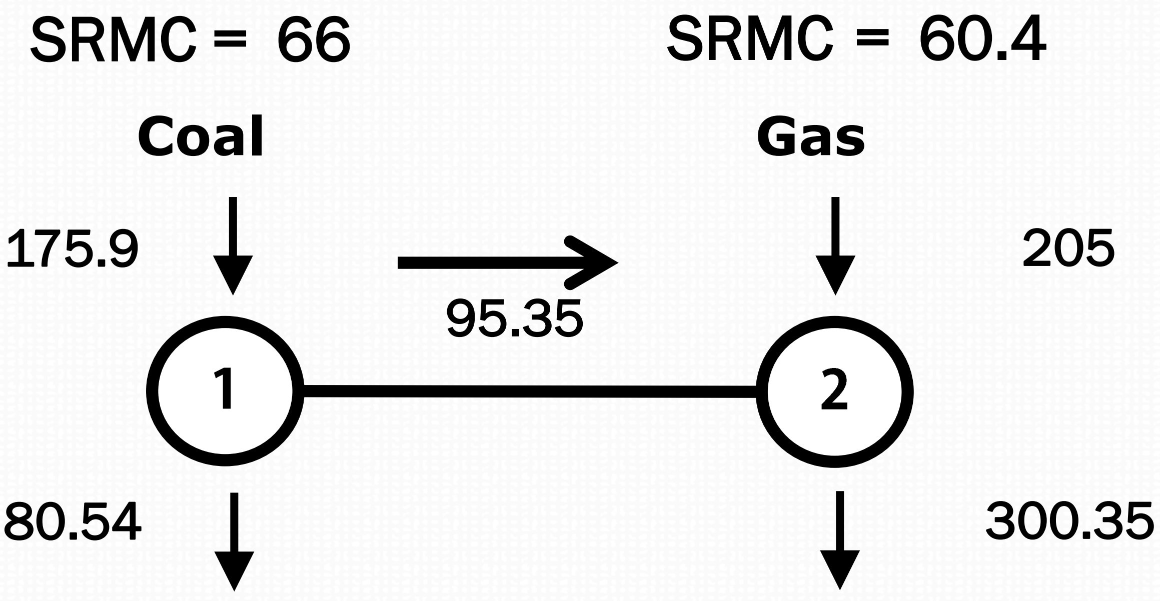
If β=0, the line is congested in equilibrium.



$d_1 = 400 - 3.2p_1$ $d_2 = 500 - 2.0p_2$

CO2 prices and strategic behaviour

If β=26, the line is uncongested in equilibrium. Less coal is produced, but much more gas.



$d_1 = 400 - 3.2p_1$ $\quad d_2 = 500 - 2.0p_2$

Carbon prices in strategic model

Nodal Prices	$\beta = 0$	$\beta = 26$
Node 1	\$102.03	\$99.83
Node 2	\$118.75	\$99.83

Generation	$\beta = 0$	$\beta = 26$
Coal	198.5	175.89
Gas	137.5	205.01

Welfare	$\beta = 0$	$\beta = 26$
Consumer	18,071	23,566
Producer	21,766	14,032

Carbon	$\beta = 0$	$\beta = 26$
Emissions	253.5 t	257.9 t
Revenue	\$0	\$6,705

Strategic behaviour affects outcomes

In example, prices **drop** as a result of the CO_2 charge..

Similar examples show the CO_2 charge causes congestion, leading to a price **increase** much larger than the increase in marginal costs from the charge.

Take-home message: incentives are much more effective when wholesale spot market is competitive.

Results using a Cournot model

- Average mark-ups due to carbon charge with no hydro mark up

	Off Peak	Shoulder	Peak
Wet	0.00	0.00	0.39
Normal	0.46	0.45	0.43
Uncertain	0.82	0.23	0.28
Dry	0.75	0.00	0.00

- Average mark-ups due to carbon charge with hydro mark up

	Off Peak	Shoulder	Peak
Wet	0.00	0.00	0.39
Normal	0.64	0.67	0.68
Uncertain	0.68	0.66	0.70
Dry	0.85	0.85	0.85

(joint work with Tony Downward in 2012)

Conclusions

- Emission trading schemes provide price incentives for firms to reduce GHG emissions.
- Incentives are effective when markets are competitive.
- Incentives from inflated prices lead to inefficient investments.
- Carbon charges in imperfect competition can give perverse outcomes.
- The impact on prices of adding carbon charges in imperfectly competitive markets is difficult to model: such models need to include hydro generators' anticipation of the thermal price increase. We can compute such a mark up under imperfect competition (with some pretty big assumptions).
- Regulators (EA in NZ) should push for more competitive wholesale electricity markets so that price signals drive socially optimal behaviour.