Economic impacts of permit allocation schemes

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Objectives of research

- Setting: GHG, NOX and SOX caps on industrial sector in Alberta
- Permit trading allowed across industries (and with external market in the case of GHG)
- Impact of various permit allocation schemes on:
  - Industrial outputs and energy production
  - Emissions and permit trading
  - Overall cost for Alberta
- The stand-alone Alberta-MARKAL model is used

Alberta-MARKAL model

- Detailed representation of energy production and consumption options by means of technologies.
- Driven by ~50 demands for energy services, elastic to their own prices
- Computes a partial inter-temporal dynamic equilibrium based on competitive markets and maximization of total surplus (taken as welfare function)
- Exports of oil and gas are price takers.

Environmental features

- Emissions of CO2, CH4, N2O, NOX, SOX) are modeled at technology level
- Many emission reduction actions for each pollutant
- CO2 capture and storage (geological) from oil and gas operations and from electricity generating plants
- Emission trading between industries, and with external market (GHG only; price of GHG permits = C$9, C$13, C$16/t CO2-e in 2010, 2015, 2020 resp.
- Banking of permits allowed, but limited in the case of SOX and NOX. “Borrowing” not allowed.

Industrial representation in MARKAL-Alberta

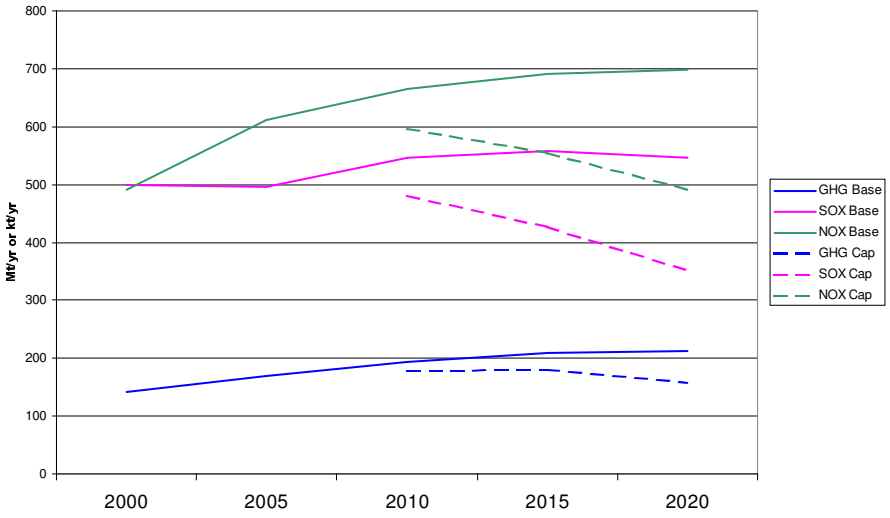
- End-use Industries: Chemicals, Pulp-and-Paper, Industrial Minerals, Mining, are modeled in detail
- Other Manufacturing (including Iron and Steel, Lumber, and other) is treated in less detail

- Conventional Oil, Oil sands, Gas, Oil refining:
  - Each is modeled separately using detailed processes (resource, reserves, extraction, processing plant, pipelines, upgraders, integrated oil refinery).
- Electric Power Generation
  - all existing and planned units are individually modeled.
  - all future (not yet planned) technologies are generic
  - Industrial Cogeneration is represented within each Industry

Price elasticities of industrial demands

- Price elasticities
  - P&P, Chemicals, Minerals, Mining: elasticity = -4
  - Other Manufacturing: elasticity = -1.5
  - Oil exports: price taker (infinite elasticity)
  - Gas exports: price taker (infinite elasticity)
  - Transportation: elasticity = - 0.2
- **Domestic demands** for electricity, gas and oil are endogenous modeled, Their elasticities are implicitly calculated by the model

Emission Caps



Allocations

- Case A: BASE case: no cap, no allocation
- Case B: Lump sum grandfathered gratis allocation at each time period t:

$$alloc_{s,p} = \alpha_p * emission_{2000,s,p}$$

(α_p chosen so that: $\Sigma_s alloc_{s,p} = cap_p$)

- Case C: Output-based gratis allocation at each time period t

$$alloc_{s,p} = \beta_p * intensity_{2000,s,p} * output_s$$

(β_p chosen so that: $\Sigma_s alloc_{s,p} = cap_p$)

Comments on allocations

- **Case B**: An allocation of a fixed amount of tonnes to an industry has no impact on the production decisions of that industry. It is treated as a 'lump sum compensation' that decreases the industry's overall financial burden, without affecting its production decisions (if we assume marginal cost pricing)
- **Case C**: an allocation that is proportional to output, is similar to a subsidy per unit produced. This has a direct influence on the marginal cost of production (and pricing) of that industry, and thus on its production decisions.

Results: Loss of total surplus (NPV_{2000} in M C$)

	BASE	CASE B	CASE C
Permit Cost (GHG)	0	157	752
Technology Cost	0	-3784	-1360
Demand Loss	0	3725	978
Surplus Loss	**0**	**98**	**370**

Output based allocations entails more technological cost because output loss is smaller than in lump sum allocation.
Loss of total surplus is higher as expected since output based allocation distorts the prices and leads to a less efficient equilibrium

RESULTS: Permit Trading

permit purchases		Case B 2010	2015	2020	Case C 2010	2015	2020
EPG coal	GHG	-12.3	-13.3	-9.5	6.3	8.3	13.7
EPG gas	Mt/y	2.1	3.0	5.4	0.5	0.6	1.6
GAS		-9.7	-11.3	-6.4	-1.4	-1.0	3.2
CHEMICALS		-3.8	-3.8	-0.8	0.5	1.0	3.1
CEMENT		-1.3	-1.5	-1.1	0.1	0.2	0.4
MINING		0.0	0.1	0.2	0.0	0.1	0.2
P&P		0.0	0.0	0.2	0.3	0.3	0.5
OTH INDUSTRY		-1.1	-1.0	-0.3	-1.2	-1.2	-0.6
CONV OIL		-5.5	-6.1	-5.3	0.3	0.4	1.2
OIL REFINING		-2.6	-1.3	-0.5	0.4	0.8	1.2
OIL SANDS		31.6	38.3	36.5	3.3	8.0	10.4
Total covered		**-2.6**	**3.2**	**18.5**	**8.8**	**17.5**	**34.9**
CHEMICALS	NOX	-4.6	-3.1	0.0	-0.4	0.9	3.1
CEMENT	kt/yr	-2.2	-2.4	-1.8	0.6	0.9	1.4
P&P		-0.8	-0.7	0.1	0.5	0.8	1.2
EPG coal		-32.5	-26.7	-22.8	-10.6	-4.1	1.0
EPG gas		-3.3	-2.3	-0.2	-4.6	-5.0	-4.8
GAS_ALL		-22.0	-77.5	-45.7	-18.6	-43.8	-7.4
CONV OIL		-24.1	-23.0	-22.4	0.4	2.3	4.2
OIL REFINING		-1.4	0.1	0.8	0.5	1.1	1.6
OIL SANDS		91.1	109.2	116.3	9.5	25.8	41.8
WOOD PROD		-0.3	0.5	1.6	-0.3	0.5	1.6
Total covered		**0.00**	**-25.94**	**25.93**	**-23.1**	**-20.4**	**43.7**
CEMENT	SOX	-0.6	-0.9	-0.5	1.1	0.9	1.2
P&P	kt/yr	0.1	0.2	0.6	0.9	1.0	1.3
EPG coal		-6.6	5.0	14.4	27.5	41.1	56.8
EPG gas		0.0	0.0	0.0	0.0	0.0	0.0
GAS_ALL		-75.5	-69.3	-107.3	-27.7	-60.4	-74.4
CONV OIL		-12.7	-9.8	-6.4	0.0	2.5	4.7
OIL REFINING		-0.5	-1.4	0.9	4.5	1.7	0.4
OIL SANDS		78.5	93.3	98.2	-12.7	-4.7	24.7
Total covered		**-17.22**	**17.21**	**0.00**	**-6.5**	**-8.5**	**14.7**

RESULTS: Emission Reductions

GHG reductions relative to BASE		CASE B 2010	2015	2020	CASE C 2000	2005	2010	2015	2020
EPG coal	GHG	0%	-3%	-23%	-28%	-32%	0%	3%	-3%	-8%	-8%
EPG gas		-2%	-5%	30%	44%	48%	-3%	-16%	-11%	9%	13%
GAS		0%	0%	-12%	-16%	-17%	0%	0%	-12%	-16%	-17%
CHEMICALS		0%	0%	-22%	-32%	-34%	0%	0%	0%	-5%	-9%
CEMENT		0%	-24%	-39%	-47%	-50%	0%	0%	-11%	-15%	-21%
MINING		0%	0%	-7%	-6%	-4%	0%	0%	-7%	-6%	-4%
P&P		0%	-6%	-16%	-25%	-23%	-7%	-6%	-5%	-14%	-13%
OTH INDUSTRY		-2%	-3%	-8%	-11%	-11%	-2%	-3%	-9%	-14%	-18%
CONV OIL		0%	0%	-2%	-2%	-2%	0%	0%	-2%	-2%	-2%
OIL REFINING		-1%	-8%	-10%	-8%	-14%	0%	-8%	-9%	-8%	-13%
OIL SANDS		0%	0%	0%	0%	-8%	0%	0%	0%	0%	-8%
Total covered		**0%**	**-2%**	**-10%**	**-13%**	**-17%**	0%	0%	-4%	-7%	-9%
CHEMICALS	NOX	0%	0%	-32%	-41%	-44%	0%	0%	-13%	-20%	-22%
CEMENT		0%	-21%	-37%	-46%	-50%	0%	0%	-10%	-15%	-20%
P&P		0%	0%	-10%	-20%	-20%	0%	0%	0%	-10%	-10%
EPG coal		0%	-2%	-28%	-32%	-39%	0%	2%	-16%	-20%	-25%
EPG gas		-1%	-11%	-7%	46%	55%	-1%	-29%	-46%	6%	14%
GAS_ALL		0%	0%	-11%	-37%	-39%	0%	0%	-23%	-40%	-39%
CONV OIL		0%	0%	4%	5%	4%	0%	0%	-1%	-1%	-1%
OIL REFINING		-1%	-1%	-3%	-3%	-3%	0%	-1%	-2%	-2%	-2%
OIL SANDS		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WOOD PROD		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total covered		**0%**	**-1%**	**-10%**	**-24%**	**-26%**	0%	0%	-14%	-23%	-23%
CEMENT	SOX	0%	-21%	-37%	-54%	-57%	0%	0%	-10%	-27%	-31%
P&P		0%	0%	-10%	-20%	-20%	0%	0%	0%	-10%	-10%
EPG coal		0%	-2%	-10%	-15%	-23%	0%	2%	-3%	-6%	-6%
EPG gas		-1%	1%	18%	63%	66%	-2%	-3%	-38%	9%	14%
GAS_ALL		0%	0%	-32%	-41%	-75%	0%	0%	-32%	-59%	-78%
CONV OIL		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
OIL REFINING		-1%	-1%	-3%	-36%	-36%	0%	-1%	-2%	-36%	-54%
OIL SANDS		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total covered		**0%**	**-1%**	**-15%**	**-20%**	**-36%**	0%	0%	-13%	-25%	-33%

Results: Output Losses

		Average Growths				Average growth
		2000-2005	2005-2010	2010-2015	2015-2020	2000-2020
BASE	Electricity	2.94%	1.35%	1.51%	0.79%	1.65%
	Chemicals	3.00%	2.72%	3.38%	2.76%	2.96%
	Gas	4.09%	-0.51%	-0.03%	-0.13%	0.84%
	Cement	2.16%	1.29%	-0.29%	1.30%	1.11%
	Oil Conv	-1.04%	-0.89%	-0.64%	-1.92%	-1.13%
	Oilsands	14.92%	8.87%	1.62%	0.00%	6.19%
	Pulp & Paper	1.25%	1.24%	1.12%	1.15%	1.19%
	Oil refining	-1.35%	0.35%	4.31%	0.62%	0.96%
CASE B	Electricity	2.77%	0.37%	1.02%	0.79%	1.23%
	Chemicals	3.00%	-2.24%	0.39%	2.23%	0.83%
	Gas	4.09%	-0.51%	-0.03%	-0.13%	0.84%
	Cement	-2.61%	-3.00%	-3.53%	0.00%	-2.30%
	Oil Conv	-1.04%	-0.89%	-0.64%	-1.92%	-1.13%
	Oilsands	15.03%	8.87%	1.62%	0.00%	6.21%
	Pulp & Paper	1.25%	-0.87%	-1.23%	1.15%	0.07%
	Oil refining	-1.50%	0.06%	4.34%	0.61%	0.85%
CASE C	Electricity	3.00%	1.05%	1.48%	1.04%	1.64%
	Chemicals	3.00%	2.72%	2.23%	2.07%	2.50%
	Gas	4.09%	-0.51%	-0.03%	-0.13%	0.84%
	Cement	2.16%	-0.83%	-1.38%	0.04%	-0.01%
	Oil Conv	-1.04%	-0.89%	-0.64%	-1.92%	-1.13%
	Oilsands	14.99%	8.87%	1.62%	0.00%	6.20%
	Pulp & Paper	1.25%	1.24%	-0.99%	1.16%	0.66%
	Oil refining	-1.50%	0.10%	4.35%	0.65%	0.88%

Results: Permit prices

emission prices $/t		2010	2015	2020
CASE B	GHG	9	12	15
	NOX	61	61	98
	SOX	136	218	218
CASE C	GHG	9	12	15
	NOX	61	98	158
	SOX	136	218	352

In Case C, emission prices tend to be higher since equilibrium is less efficient than in Case B

Results: Electricity mix

Scenario	Type	2005	2010	2015	2020
BASE	Coal	4.1	15.1	19	19
	Gas	5.4	4.3	7.1	10.3
	Total	**9.5**	**19.4**	**26.1**	**29.3**
CASE B	Coal	2.9	2.9	2.9	2.9
	Gas	6.7	12.7	16.6	22.2
	Total	**9.6**	**15.6**	**19.5**	**25.1**
CASE C	Coal	5.3	13.3	14.5	14.5
	Gas	6	6.1	10.9	15.4
	Total	**11.3**	**19.4**	**25.4**	**29.9**

In Case C, thanks to the "subsidy" of the output based allocation:
, a) total electricity is back to that of BASE and
b) coal fired production is less affected than in case B ,

Results: Electricity prices

cents/kWh	2005	2010	2015	2020
BASE	3.90	3.55	3.66	3.42
CASE B	3.90	3.91	3.77	3.91
CASE C	3.89	3.44	3.41	3.53
% change wrt base	**2005**	**2010**	**2015**	**2020**
BASE	0%	0%	0%	0%
CASE B	0%	10%	3%	14%
CASE C	0%	-3%	-7%	3%

In Case B electricity prices are moderately higher than in BASE, due to cost of abatement actions
In Case C, electricity prices are subsidized and are back to similar levels as in BASE

Conclusions

- Output based allocation is a subsidy that proves effective at reducing negative impacts on industrial output (and hence on labor, etc.)
- Overall additional loss of total surplus is moderate, but not negligible
- More differentiated allocation schemes may be devised and tested
- Issue of international (WTO) acceptability?