Development and Analysis of Alternative GHG Emission Allocations

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Ministry of Water, Land and Air Protection

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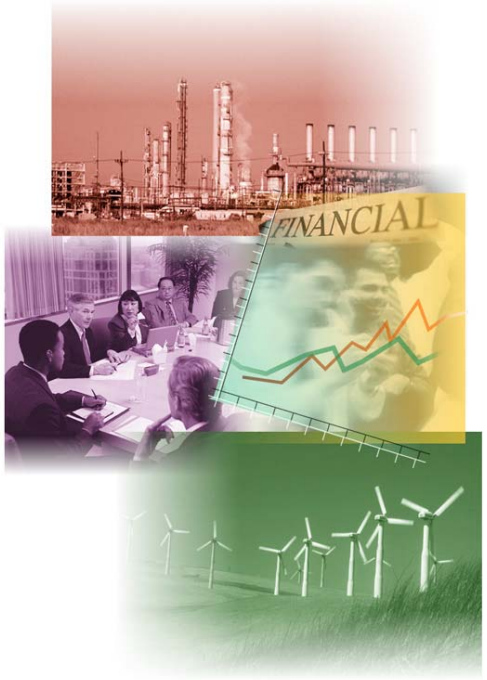

Global Change Strategies International
150 Isabella Street, Suite 305
Ottawa ON K1S 1V7 Canada
Tel: (613) 232-7979 Fax: (613) 232-3993 Email: info@gcsi.ca

www.gcsi.ca

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Global Change Strategies International
150 Isabella Street, Suite 305 Ottawa ON K1S 1V7 Canada
Tel: (613) 232-7979 Fax: (613) 232-3993 Email: info@gcsi.ca Website: www.gcsi.ca

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1. EXECUTIVE SUMMARY

The federal government has proposed a Domestic Emission Trading (DET) as an important part of its plan to reduce greenhouse gas emissions. The implementation of a DET requires that emitters receive allocations of emission permits at the outset. The federal government is only now broaching the topic of allocation. Allocation is a question of equity or fairness and is a zero-sum game because the total number of permits issued is fixed.

Allocation of permits will likely arise from negotiations. Negotiations generally start with principles, or "fairness concepts", such as higher allocations to industries that are growing rapidly, or are by nature emission-intense, or are exposed to competition from non-Kyoto countries. To get from a fairness concept to a number of permits for each emitter, it may be helpful to use a mathematical formula that codifies the concept. For any emitter or collection thereof, it may therefore be possible to gain strategic advantage in the negotiation by advocating fairness concepts whose formulas result in the highest number of permits.

This report calculates the total number of permits allocated to BC under 15 different fairness concepts. The input data is based on the same datasets used by the federal government in current work on DET design, supplemented by standard economic statistics where necessary. The allocation process is assumed to start by dividing the "pie" by sector, nationally (as is assumed in the current federal design exercise). Five fairness concepts are applied at the national sector level. They are: 1990 Emission Intensity, 2000 Emission Intensity, Current Emissions, Export Intensity and Emissions and Export Intensity.

An additional three concepts (share by output, by emissions and by exports) are used to split national sector allocations by province. The splits by province are based only on the relevant activities of the companies located in each province and are what would occur under a sectoral permit allocation negotiation assuming there is no federal-provincial negotiation on permit allocation.

The mathematics of the formulas in this analysis are straightforward, but assembling and spreadsheeting the data is a substantial task. In some cases, the large volume of published data must be supplemented by additional assumptions needed to synthesize data that fits in the formulas.

Table ES-1 shows the basic results for BC. These allocations may be compared to the assumed 2010 BAU emissions for BC of 18.1 MT CO_2e for the industries that the federal government proposes to be covered by the DET. The allocation is 70% higher than BAU emissions for the combination of the 1990 Emission Intensity and Export share formulas at the high end and 12% lower for the combination of the Current Emissions and Emissions Share formulas at the low end.

Table ES1: Total BC Emissions for Covered Industries by National and Provincial Share Formulas (MT of CO_2e)

National Formula	Provincial Share Formula		
	Emissions Share	Output Share	Export Share
1. 1990 Emission Intensity	16.8	17.3	31.0
2. 2000 Emission Intensity	16.6	17.6	30.0
3. Current Emissions	16.0	17.1	24.2
4. Export Intensity	16.3	18.3	21.1
5. Emissions and Export Intensities	16.4	18.5	21.8

The most noticeable result in Table ES-1 is the high allocation provided to BC under the provincial export share formula. It springs largely from the very high value of electricity exports from BC in 2000, which is the year (arbitrarily) chosen for export share allocation. Some part of the high allocation also relates to the arithmetic of the chosen formula, which is based (as is the federal analysis) on the concept of "fossil fuel-fired electricity" as a covered sector as opposed to "all electricity". The effect is to leave out the "cushion" that GHG-free hydro provides against reduced exports under Canadian emission pricing and therefore to give BC's "fossil-fuel-fired" electricity sector a higher allocation than would be the case if all electricity generation power sources were taken into account. This mathematical artifact is not significant in itself. However it shows the large effect that choice of formula, including detailed definitions and choice of base year, can have on the calculations. The result is therefore valuable because it illustrates the strategic advantage available to negotiators who have control of the numbers.

2. PURPOSE

The objectives of this analysis are three-fold.

- To identify fairness concepts for allocation and coverage of GHG emission allowances under a Canadian implementation of the Kyoto Protocol, which maximize BC's share of allowances under the Federal Government's proposed Domestic Emission Trading (DET) system.
- To determine emission reduction vulnerabilities and strengths of different industries in BC, relative to the rest of Canada that are not reflected in the allocation arithmetic. .
- To develop arguments that can be used to support allocation concepts that are advantageous to BC and to reject disadvantageous ones.

3. BACKGROUND

The Federal Government has proposed that a DET system be included in a Canadian implementation of the Kyoto Protocol. A Large Final Emitter (LFE) system is one of two options that have been much discussed in Canada and recent departmental work indicates that the Federal Government favours it.

Allocation formulas have been "tested" by the federal government but there have been few hints about favoured ones. All formulas tested so far assume that GHG emission allowance allocation will be undertaken by sector on a national basis, and then allocated by firm within each sector. Under these assumptions, the economic burden of compliance under the LFE DET for British Columbia will depend upon both sectoral, firm (and possibly entity) allocations, varying with factors such as emission intensities and production levels of its industries, relative to those in other provinces. Different formulas for allocation and coverage will result in different total allocations for BC and for each of its industry sectors.

4. DET SYSTEM

The definition and the details of the DET system used in this analysis are based upon recent unpublished Federal Government analytical work[2].

4.1. Criterion for whether a sector has some coverage

Federal Government analysis assumes that whether or not a sector has some coverage under the DET system is based on sector emissions rather than emitting establishment. The emissions level of the typical establishment in a sector, rather than a threshold for individual establishments independent of the sector to which they belong, would be the basis for inclusion. Under this approach, sectors would be included based on the "average of GHG emissions from stationary sources per establishment".

4.2. Minimum size for inclusion

The Federal Government analysis assumes the DET will cover sectors having establishments that average eight or more kt per annum of GHG emissions. The primary reason for the establishment emission minimum is to lessen administrative costs of a DET system.

4.3. Inclusion of methane and nitrous oxide

The Federal Government analysis assumes that methane (CH_4) and nitrous oxide (N_2O) from stationary combustion are not covered in a DET system because accurate estimation of these emissions would be substantially more difficult than estimation of combustion CO_2 emissions.

Fugitive emissions of methane (CH_4) would be included only when they are measurable at the entity level (e.g., pipelines but not at well-heads).

[2] Unpublished papers. August and September 2002. Climate Change Secretariat.

4.4. Industrial process emissions

The Federal Government analysis assumes that GHG emissions from industrial processes other than CO_2 from fossil fuel combustion would be covered[3].

4.5. Mobile emissions

GHG emissions from mobile sources, such as air, truck and rail transport carriers and personal use vehicles, would be excluded from a Canadian DET system. Targeted measures would be adopted to help reduce some transportation emissions.

4.6. Allowances

Under the Federal Government proposed DET system, legal entities responsible for covered GHG emissions would have to surrender "allowances", which are equivalent to the tonnage of their covered emissions, to the Federal Government. The Federal Government also plans to issue gratis allowances based on the allocation scheme to covered emitters. Currently, it is expected that the Federal Government will issue gratis allowances equal to the total amount of target emissions for the Canadian industry sector. The allocation formulas will help determine the distribution of gratis allowances within the Canadian industry sector.

4.7. Industry Sector Target

It is anticipated that the Federal Government will set a target or cap of 279,000,000 tonnes of CO_2e for the covered industry sectors in 2010, which is approximately 16% below the expected BAU total for covered emissions of approximately 330 MT[4]. Appendix II is an explanation of the calculation of this target.

4.8. Industry and Emission Coverage

The following table shows coverage for the proposed DET system by percentage of industry coverage and covered industry emissions for 1990, 2000 and 2010[5].

[3] Emissions such as CO_2 from cement production, N_2O from ammonia, nitric and adipic acid plants, SF_6 from magnesium smelters, PFCs from aluminium smelters are included. However, HFCs are not included.

[4] The 330 Mt figure comes from emissions data that was available when the federal government's May 2002 discussion paper was produced. Since its release, each of Natural Resources Canada (NRCan) and Environment Canada (EC) have produced new emission data sets at the national level. Based on unpublished information, it is our understanding that the federal government's Climate Change Secretariat is using a figure of 359 Mt for covered emissions. It has not altered the 279 Mt cap. In this analysis, the most up-to-date data for covered emissions is used, a total of 359 Mt, along with a cap target of 279 Mt.

[5] The data in the table was prepared utilizing an estimation methodology that is largely based on the approaches that the federal government's Climate Change Secretariat has used to develop data for its recent DET estimation work. Data sources and estimation methodologies are presented in Appendix I.

Table 1 - DET System Industry Coverage

Sector	BAU 2010 Emissions Coverage	Covered Emissions (MtCO2e)			% change 1990 - 2010
		1990	2000	BAU 2010	
Thermal Electricity					
Coal/Oil	100%	91	93	112	23%
Gas	100%	4	18	28	607%
Oil and Gas					
Oil Sands	100%	14	21	56	310%
Upstream Conventional	47%	21	29	32	53%
Pipelines	100%	14	22	25	77%
Petroleum Refining	71%	15	15	17	9%
Mining	100%	5	7	8	60%
Manufacturing					
Pulp and Paper	90%	3	11	3	20%
Iron and Steel	100%	10	16	12	24%
Chemicals	100%	1	20	1	4%
Smelting & Refining	100%	14	13	16	15%
Other manufacturing[6]	Approx'ly 15%	14	10	13	-11%
Total	**90%**	**244**	**279**	**359**	**47%**
Total Canadian Emissions		**607**		**809**	
Share		**40%**		**44%**	

5. ALLOCATION FORMULA ALTERNATIVES

The industry sector target of 279 Mt sets an upper limit for its GHG emissions but the Federal Government could allocate allowances to covered enterprises within the sector in several ways. The choice of allocation method will create winners and losers between covered enterprises, industries and provincial economies as the target makes for a zero sum game. Some allocation formula alternatives are discussed below,

5.1. Percentage Cap

The simplest formula distributes allowances according to a uniform percentage reduction that achieves the 279 Mt target. Using this approach, covered entities would receive allowances equal to about 83.5% of their 2010 BAU emissions.[7] By using other formulas and variables different considerations can be taken account. For example, growth, either physical or financial, can be taken into account.

[6] Included in this category are Motor Vehicle, Lime and Glass manufacturing.

[7] Based on 334 Mt of covered emissions. If covered emissions are assumed to be 359Mt and the target remains at 279 Mt then the percentage cap falls to 77.7%. This qualification telegraphs the importance and variability of emissions data and coverage assumptions in estimating allocations. The federal government continues to refine its emissions estimates and has yet to produce provincial data sets based on its most recent national data sets. As well, there are ongoing discussions about covered emissions within certain industries. The estimates of this analysis are based on the most recent federal government data and coverage boundaries. However the estimates should be interpreted as indicative rather than definitive because of the changing data and policy environments.

5.2. Production Output Change

One fairness concept provides higher allocations to industries and companies that are expecting to grow in the future. Within the Kyoto Protocol framework, the First Commitment Period is 2008-2010 so 2010 is most often employed as the future comparison year for these purposes. The choice of starting year is important because it re-distributes allowances among covered industries and entities. Illustratively, if annual growth varies among industries, but each industry has the property that annual growth does not vary by year, then high growth industries will favour an earlier starting year such as 1990, and slower growth industries will prefer a later starting year, such as 2000.

The earlier Kyoto impact debates focused on lowering emissions 6% below 1990 levels but the focus shifted to 2010 BAU emission levels in the federal government's May 2002 Discussion Paper. If the focus had stayed on a 1990 target year, strikes and other economic slowdowns in 1990 would have been an important factor in redistributing allowances.

5.3. Export Intensity

An allocation formula can also attempt to take into account international competitiveness implications of GHG emission regulation. Using export intensity of entities and industries as a proxy is a simple way to attempt to include potential competitiveness exposure in an allocation system. The premise is that the economic burden of a Kyoto implementation will fall on entities and industries that export a large proportion of their production to "non-Kyoto" countries. On a first pass, complex formulations are not necessary to distinguish between trade with Kyoto- versus non-Kyoto countries because the overall share of exports to Kyoto countries is relatively small in most Canadian industries.

Reinforcing the competitive disadvantage of Kyoto to Canadian exporters to non-Kyoto markets is the advantage that non-Kyoto exporters to Canada would have over Canadian suppliers to Canadian markets. In this analysis, only gross exports to all countries are considered. This assumption can be refined in a future analysis.

5.4. Export and Emission Intensity

It is feasible to account for production growth and competitiveness exposure in a single formula by using emission and export intensity factors in the same formula.

5.5. Other Variables

Data availability limits the ease of integrating other relevant variables into allocation formulas.

5.5.1. Physical Output Change

Growth in physical output may be more relevant than financial output in terms of driving GHG emissions but comprehensive physical output data for covered industries is lacking at this juncture. As a result, financial output data, which is influenced by price differences between provinces and regions, is incorporated into allocation formulas.

5.5.2. Fossil Fuel Input Change

Another example is a fossil fuel energy input intensity variable. However, different fossil fuels have different GHG intensities, so these allocation coefficients would probably end up being disaggregated by fuel type in a negotiation – at which point allocation by reference year GHG emissions would likely emerge as preferred.

5.5.3. Best Available Technology Benchmark

In Appendix III of the May 2002 Federal Discussion Paper an emissions intensity benchmark, based on "best available technology" (BAT), is applied against physical output and a scale back factor. The scale back factor in the Discussion Paper is 85%. While some models incorporate BAT factors there is considerable controversy about choice of technology and its emissions. BAT factors are valuable analysis tools but suffer as regulatory parameters. Incorporating controversial data into the allocation formulas would likely hinder negotiations.

5.5.4. Marginal Cost of Abatement

Another possibility is to account for marginal cost of abatement relative to traded permit prices. This relationship will be another impact differentiator between covered entities and industries. One federal analysis sets the allocation on the basis of the proportion of the gap that can be closed only at more than \$10/tonne CO_2. This method requires the use of economic modeling results on emission reduction costs, which may be more controversial than BAU emissions or output.

6. NATIONAL ALLOCATION FORMULAS

Specific allocation formulas have yet to be announced by either the Federal Government or provincial governments. The May 2002 Federal Government Discussion Paper suggested broad outlines for allocation formulas but did not set out specific formulas.

The Federal Government will use mathematical formulas to evaluate allocations by Canadian and provincial industry. Formula structure and variables will dictate distribution of allowances among provinces and industries (and therefore economic impacts). Considerable variation in allocation of allowances is possible through the choice of formulas and variables.

In the absence of firm proposals about allocation formulas and their variables, this report assumes five national allocation formulas[8]. The formulas incorporated variables for GHG emission volume, production output value and export value. They calculate an allocation in tonnes of CO_2e for each sector, using an overall emissions ceiling of 279 MT of CO_2e for covered industries. The scale factor in each case adjusts sector allocations in equal proportions so that the overall emissions ceiling cap of 279 MT is met. The number of permits allocated to a sector is the product of the last two columns of Table 2 below.

[8] More formulas are possible but these formulas are reasonable candidates.

Table 2 - National Allocation Formulas

Name	Formula	Scale factor
1990 Emissions Intensity	[(1990 GHG emissions / 1990 output) x 2010 output] x scale factor	279,000t divided by sum of [(1990 GHG emissions / 1990 output) x 2010 output] for all covered industries
2000 Emissions Intensity	[(2000 GHG emissions / 2000 output) x 2010 output] x scale factor	279,000t divided by sum of [(2000 GHG emissions / 2000 output) x 2010 output] for all covered industries
Current Emissions	2000 GHG emissions x scale factor	279,000t divided by sum of 2000 GHG emissions for all covered industries
Export Intensity	[(2000 exports / 2000 output) x 2010 BAU emissions] x scale factor	279,000t divided by sum of [(2000 exports / 2000 output) x 2010 BAU emissions] for all covered industries
Emissions and Export Intensity	[(2000 exports / 2000 output) [2000 GHG emissions / 2000 output] x 2010 output] x scale factor	279,000t divided by sum of [(2000 exports / 2000 output) [2000 GHG emissions / 2000 output] x 2010 output] for all covered industries

6.1. Formula Driving Factors

The driving factors behind each formula are as follows.

- 1990 Emissions Intensity formula: industries with more output growth over the 1990-2010 period receive a higher allocation; industries that were more emission intensive in 1990 get a higher allocation.
- 2000 Emissions Intensity formula – same as above, except base year = 2000.
- Current Emissions formula –industries with more emission growth over the 2000-2010 period receive a higher allocation.
- Export Intensity formula –more export intensive industries receive a higher allocation; the fairness concept is based on the assumption that the majority of trade is with non-Kyoto ratifying countries.
- Emissions and Export Intensity formula – a combination of 2000 Emission Intensity and Export Intensity. High-growth industries, emission intensive industries and industries with high emissions growth all receive a higher allocation.

7. PROVINCIAL ALLOCATION FORMULAS

For this project, provincial shares of each of year 2000 emissions, output and exports were selected to arrive at provincial allocations by industry. This approach yielded three provincial allocation formulas as follows.

Table 3 - Provincial Allocation Formulas

Name	Formula
Current Emissions Share	(2000 emissions for province (i.e. BC) / 2000 emissions for Canada) x (national formula x national scale factor)
Current Output Share	(2000 output for province (i.e. BC) / 2000 output for Canada) x (national formula x national scale factor)
Current Export Share	(2000 exports for province / 2000 exports for Canada) x (national formula x national scale factor)

The Current Export Share coefficients are somewhat difficult to define, for two reasons. First, pipelines are providing a service, unlike other sectors that are extraction or manufacturing based, and their export values are reported by border crossing so the export service within a province is difficult to define. For example, in 2000, about 22.5 m^3 of natural gas was produced in BC but 33 m^3 of natural gas was exported from the province, 9 m^3 from BC gas fields, the remainder from Alberta. About 4.5 m^3 of BC gas was transported into Alberta. The Alberta transmission situation is more complex as this province's gas is transported across Canada, exiting into the US at Alberta, Saskatchewan, Manitoba, Ontario and Quebec border crossings. As a consequence some simplifying assumptions were made in this analysis to arrive at pipeline export GDP value. Second, energy sector exports are not reported by Statistics Canada by the same categories as used in the federal government's emissions estimates, such as the CEOU document. This applies to sub-types of oil, and of course to electricity, where the generation source of exports is generally unknowable. In both these cases the share of exports by sub-industry (e.g., oil sands, gas-fired electricity) is assumed to be same as the share by sub-industry in production.

The driving factors in each of these formulas are the relative provincial shares of each variable. .

8. ALLOCATION FORMULA CALCULATION RESULTS

Combining the national and provincial allocations yields 15 combinations, i.e. 15 possible allocations.

The BC share of the covered emissions cap of 279 MT ranges from 31.0 MT, to 16.0 MT, about 11% and 6%, respectively of the anticipated cap. The total emission amounts for each combination of formulas is displayed in the following Table 4.

Table 4 - Total BC Emissions for Covered Industries for different National and Provincial Share Formulas (MT of CO2e)

National Formula	Provincial Share Formula		
	Emissions Share	Output Share	Export Share
1. 1990 Emission Intensity	16.8	17.3	31.0
2. 2000 Emission Intensity	16.6	17.6	30.0
3. Current Emissions	16.0	17.1	24.2
4, Export Intensity	16.3.	18.3	21.1
5. Emissions and Export Intensities	16.4	18.5	21.8

A combination of the 1990 Emission Intensity (national sector) and Export Share (provincial share) formulas is most favourable towards BC because it provides the largest total number of permits to firms in BC. That combination is followed closely by the combination of the 2000 Emission Intensity and Export Share formulas.

For comparison, 2010 BAU covered emissions for DET industries in BC total 18.1 MT, which is 5% of the national covered BAU total of 358.6 MT for DET industries. (The BC total is relatively low because of the province's low reliance on fossil fuels compared to Alberta, Saskatchewan and Ontario and its smaller manufacturing base, especially compared to Ontario.)

The combination of 1990 Emission Intensity and Export Share Formulas gives a BC allocation that is approximately 70% greater than the projected 2010 BAU total. At the low end, the combination of the Current Emissions (national sector) and Emissions Share (provincial share) fFormulas shows a BC allocation that is 12% lower than 2010 BAU emissions.

The percentage difference between total emission amounts for each combination of formulas and 2010 BAU emissions for BC is presented in the following table.

Table 5 - 2010 Allocation compared to 2010 BAU Emissions (% difference)

National Formula	Provincial Share Formula		
	Emissions Share	Output Share	Export Share
1. 1990 Emission Intensity	- 7.2	- 4.4	71.3
2. 2000 Emission Intensity	- 8.3	- 2.8	65.7
3. Current Emissions	- 11.6	- .5	33.7
4, Export Intensity	- 9.9	1.1	16.6
5. Emissions and Export Intensities	- 9.4	- 2.2	20.4

The result that jumps out of Tables 4 and 5 is the high allocations provided to BC under the provincial export share formula. Table 6 below shows that majority of this effect comes from gas-fired electricity. For example, the allocation to BC gas-fired electricity is over 5 MT in the 1990 Emission Intensity (national sector) & Export Formula (provincial share) version.

One reason for high allocations under the provincial export share formula is the very high value of electricity exports from BC in 2000, relative to the rest of Canada. due in turn to the California crisis. However, the provincial allocations for electricity also rely (and must rely) on a formula that splits the value of electricity exports into portions from gas versus coal/oil. In the model used here, the share of exports attributed to gas-fired electricity is the share of provincial gas-fired generation within fossil-fuel-fired electricity, as opposed to within all electricity (including

hydro). This follows from the formal logic: national data pertains to the aggregate of coal/oil-fired electricity and gas –fired electricity and the sum of the shares must be 1. However this formula does not reflect BC's GHG-free hydro base and could be adjusted[10]. The result would be a lower allocation for BC. The following tables present BC industry allocation results by allocation formula.

Table 6 - BC Industry Results by Allocation Formula (MT of CO2e)

Sector/Allocation Formula	1990 Emission Intensity - National	1990 Emission Intensity & Emission Share	1990 Emission Intensity & Output Share	1990 Emission Intensity & Export Version	2000 Emission Intensity – National	2000 Emission Intensity & Emission Share	2000 Emission Intensity & Output Share	2000 Emission Intensity & Export Share
Thermal electricity								
▪ Coal / oil	62.4	-	-	-	69.2	-	-	-
▪ Gas	28.4	5.4	5.0	20.7	26.9	5.1	4.8	19.6
Oil and Gas								
▪ Oil sands and bitumen	47.4	-	-	-	47.4	-	-	-
▪ Conventional upstream	24.0	2.7	1.9	1.7	27.8	3.1	2.3	2.0
▪ Pipelines	15.0	1.9	1.9	-	18.2	2.3	2.3	-
▪ Petroleum refining	12.5	1.9	1.0	0.3	12.8	1.2	1.1	0.3
Mining	5.5	0.5	0.5	1.1	6.1	0.6	0.5	1.2
Manufacturing								
▪ Pulp and paper	10.4	0.6	3.0	2.8	10.3	0.6	3.0	2.7
▪ Iron and steel	15.1	0.2	-	0.3	13.7	0.2	-	0.2
▪ Chemical	26.8	0.5	1.1	1.1	20.6	0.4	0.8	0.8
▪ Smelting and refining	17.0	1.5	1.5	1.7	12.7	1.1	1.1	1.3
▪ Cement	6.4	0.9	1.1	1.3	9.0	1.3	1.6	1.9
▪ Other manu-facturing	8.1	1.5	0.1	0.1	4.2	0.8	0.1	0.1
Industry total	279.0	16.8	17.3	31.0	279.0	16.6	17.6	30.1
Rest of Canada (ROC) Total		262.8	261.7	248.0		263.1	261.4	248.9

[10] The formula used for the gas-fired electricity allocation in province X is [the dollar value of X's electricity exports in 2000/ the dollar value of Canada's electricity exports in 2000] x [gas-fired Mwh in X/the sum of gas-fired and coal/oil-fired Mwh in X] x national allocation to gas-fired electricity (tonnes). It could be is [the dollar value of X's electricity exports/ the dollar value of Canada's electricity exports] x [gas-fired Mwh in X/the sum of all Mwh in X] x national allocation to gas-fired electricity x a scale- factor to ensure that the sum of shares is one. In BC's case the first formula gives a bigger allocation because the second factor is 1. In the second case, the second factor is much smaller for BC, Quebec and Manitoba than it is for the other provinces, so the hydro provinces would get a smaller allocation., even after scaling.

Table 6 (continued)

Sector	Current Emissions-National	Current Emissions & Emissions Share	Current Emissions & Output Share	Current Emissions & Export Share	Export Intensity-(Canada)	Export Intensity & Emission Share	Export Intensity & Output Share	Export Intensity & Export Share
Thermal electricity								
▪ Coal / oil	93,044,170	-	-	-	24,043,055	-	-	-
▪ Gas	18,023,962	3,427,320	3,233,267	13,128,506	6,098,458	1,159,643	1,093,985	4,442,067
Oil and Gas								
▪ Oil sands and bitumen	20,782,250	-	-	-	63,725,244	-	-	-
▪ Conventional upstream	28,698,821	3,181,641	2,326,229	2,020,503	36,674,091	4,065,804	2,972,678	2,581,992
▪ Pipelines	22,018,276	2,747,280	2,748,416	-	28,624,406	3,571,545	3,573,022	3,573,022
▪ Petroleum refining	15,021,468	1,426,184	1,238,184	384,739	9,308,769	883,803	767,300	238,422
Mining	6,907,667	665,634	618,936	1,342,016	1,773,326	170,881	158892	344,520
Manufacturing								
▪ Pulp and paper	10,866,496	602,606	3,119,502	2,889,833	13,810,937	765,891	3,964,778	3,672,877
▪ Iron and steel	16,009,861	217,276	6,093	267,706	6,976,700	94,683	2,655	116,660
▪ Chemical	20,252,820	388,500	838,006	814,236	49,366,754	946,978	2,042,661	1,984,722
▪ Smelting and refining	12,772,060	1,088,272	1,130,041	1,264,955	20,559,171	1,751,789	1,819,025	2,036,196
▪ Cement	10,029,353	1,427,367	1,801,519	2,062,177	9,648,638	1,373,185	1,733,133	1,983,897
▪ Other manufacturing	4,572,796	844,701	68,747	63,007	8,390,451	1,549,910	126,142	115,609
Industry total	279,000,000	16,016,781	17,128,941	24,237,680	279,000,000	16,334,113	18,254,271	21,089,984
All sources		263,743,768	261,871,059	254,762,320		263,137,198	260,745,729	257,910,016

Table 6 (continued)

Sector	Emissions and Export Intensities – national version	Emissions and Export Intensities & emission share	Emissions and Export Intensities & output share	Emissions and Export Intensities & export share
Thermal electricity				
▪ Coal / oil	17,886,621	-	-	-
▪ Gas	6,973,493	1,326,034	1,250,955	5,079,435
Oil and Gas				
▪ Oil sands and bitumen	65,141,586	-	-	-
▪ Conventional upstream	37,982,496	4,210,858	3,078,732	2,674,109
▪ Pipelines	24,772,437	3,090,925	3,092,203	3,092,203
▪ Petroleum refining	8,655,599	821,789	713,461	221,692
Mining	1,688,034	162662	151,250	327,950
Manufacturing				
▪ Pulp and paper	14,261,326	790,867	4,094,073	3,792,653
▪ Iron and steel	7,064,573	95,876	2,689	118,129
▪ Chemical	52,813,648	1,013,098	2,185,284	2,123,299
▪ Smelting and refining	24,917,072	2,123,114	2,204,601	2,476,806
▪ Cement	8,700,482	1,238,244	1,562,821	1,788,943
▪ Other manufacturing	8,142,634	1,504,133	122,416	112,195
Industry total	279,000,000	16,377,600	18,458,485	21,798,414
All sources		264,899,588	260,541,515	257,201,586

The following Table 7 presents the percentage difference between the different Provincial Share Allocation Formulas[11]. The results demonstrate the favourable impact of using export share to allocate provincial emissions by industry.

Table 7 - Percentage Difference between Provincial Share Allocation Formulas (%)

Sector	Emission Allocation Comparison		Output Allocation Comparison		Export Allocation Comparison	
	VS Output	VS Exports	VS Emission	VS Exports	VS Emission	VS Output
Thermal Electricity						
▪ Coal/Oil	-	-	-	-	-	-
▪ Gas	6.0%	-73.9%	-5.7%	-75.4%	283.1%	306.0%
Oil, Gas & Mining						
▪ Oil Sands & Bitumen	-	-	-	-	-	-
▪ Conventional Upstream	36.8%	57.5%	-26.9%	15.1%	-36.5%	-13.1%
▪ Pipelines[12]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
▪ Petroleum Refining	15.2%	270.7%	-13.2%	221.8%	-73.0%	-68.9%
Mining	7.5%	-50.4%	-7.0%	-53.9%	101.6%	116.8%
Manufacturing						
▪ Pulp & Paper	-80.7%	-79.1%	417.7%	7.9%	379.6%	-7.4%
▪ Iron & Steel	3465.9%	-18.8%	-97.2%	-97.7%	23.2%	4293.5%
▪ Chemical	-53.6%	-52.3%	115.7%	2.9%	109.6%	-2.8%
▪ Smelting & Refining	-3.7%	-14.0%	3.8%	-10.7%	16.2%	11.9%
▪ Cement	-20.8%	-30.8%	26.2%	-12.6%	44.5%	14.5%
▪ Other Manufacturing	1128.7%	1240.6%	-91.9%	9.1%	-92.5%	-8.3%

[11] The percentage differences are the same for each National Allocation Formula because the data for the Provincial Share Formulas remains the same when used in combination with the National Allocation Formulas.

[12] There are no differences between the provincial allocation share formulas for pipelines because emission share by province was used as a proxy to allocate output and exports by province. See Appendix I for further information.

9. BIBLIOGRAPHY

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10. APPENDIX I – DATA SOURCES[13]

10.1. Electricity Generation – Coal/Oil

	Source	Comments/Computation
Coverage		• 100% coverage of combustion CO_2 emissions and 0% coverage of all other GHG emissions
1990 and 2000 Emissions	CEOU (1999)	• CEOU emissions for 1990 includes all GHGs (CO_2 emissions from combustion > 98% of total GHGs)

2010 BAU Emissions	CEOU (1999)
	
	Environment Canada (2002)
		• CEOU emissions estimate for BAU 2010 includes all GHGs (CO_2 emissions from combustion > 98% of total GHGs)
		• Adjustments to CEOU are provided by Environment Canada data:
		  ○ Without adjustment, CEOU estimates are 89 Mt for coal/oil and 30 Mt for gas
		  ○ With adjustment, CEOU estimates are 112 Mt for coal/oil and 28 Mt for gas
		• Attributed increase of 16 Mt in coal fired emissions to Alberta
		• Attributed increase of 7 Mt in oil fired emissions (switch to orimulsion) to New Brunswick

Output	CEOU (1999)
	
	Econnections (StatsCan, 2001)
	
	Industry Price Indices 1990-2001 (Statscan 62-011-XPB)
		• CEOU provides production data in physical units, but not in value
		• Production 'price' per unit output was estimated in order to calculate output value:
		  ○ In 1995, total electricity intensity is 3.79 t/ 1992$1000 (Econnections); this converts to 2.97 t/ 2000$1000, based on the general manufacturing price index: 3.79 / (139.3/109.1) = 2.97
		  ○ Total electricity production (543 TWh) and emissions (100 Mt) in 1995 from CEOU, electricity 'price' in 2000$ is: 100 Mt /(2.97t/$1000 x 543 TWh) = $0.062/kWh
		  ○ 2000$0.062/kWh is multiplied by coal/oil electricity physical production in 1990 to get output value in 2000$

Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 electricity export data by NAICS code (2211) by Canada and province • gross electricity export data re-allocated by energy source to obtain exports attributable to thermal electricity

10.2. Electricity Generation – Gas

	Source	Comments/Computation
Coverage		• 100% coverage for combustion CO2 emissions, 0% coverage for all other direct GHG emissions associated with gas electricity generation
1990 and 2000 Emissions	CEOU (1999)	• CEOU emissions for 1990 includes all GHGs (CO_2 emissions from combustion > 98% of total GHGs)

[13] The industry and emissions coverage methodology used in this project largely follows a methodology outlined in an unpublished federal government paper.

	Source	Comments/Computation
2010 BAU Emissions	CEOU (1999) Environment Canada (2002)	• CEOU emissions estimate for BAU 2010 includes all GHGs (CO_2 emissions from combustion > 98% of total GHGs) • Adjustments to CEOU are provided by Environment Canada data: Without adjustment, CEOU estimates are 89 Mt for coal/oil and 30 Mt for gas With adjustment, CEOU estimates are 112 Mt for coal/oil and 28 Mt for gas • Gas electricity generation estimate: 28 Mt • Split reduction of 2Mt between BC and Alberta
Output	CEOU (1999) Econnections (StatsCan, 2001) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• CEOU provides production in physical units, but not in output value • Production 'price' per unit output estimated in order to calculate output value: ○ In 1995, total electricity intensity is 3.79 t/ 1992$1000 (Econnections); this converts to 2.97 t/ 2000$1000, based on the general manufacturing price index: 3.79 / (139.3/109.1) = 2.97 ○ Total electricity production (543 TWh) and emissions (100 Mt) in 1995 from CEOU, electricity 'price' in 2000$ is: 100 Mt /(2.97t/$1000 x 543 TWh) = $0.062/kWh ○ 2000$0.062/kWh is multiplied by coal/oil electricity physical production in 1990 to get output
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 electricity export data by NAICS code (2211) by Canada and province • gross electricity export data re-allocated by energy source to obtain exports attributable to thermal electricity

10.3. Oil Sands

	Source	Comments/Computation
Coverage		• 100% coverage for combustion CO_2 emissions in the production of oil sands; 0% coverage of fugitive emissions
1990 and 2000 Emissions	CEOU (1999)	• Oil sands 1990 sub-sector emissions: ○ Bitumen production ○ Oil sands production ○ Upgrader emissions
2010 BAU Emissions	CEOU (1999) Environment Canada (2002)	• On national basis, oil sands BAU 2010 sub-sector emissions estimates: ○ Bitumen production: 12.4 Mt ○ Oil sands production: 25.1 Mt ○ Upgrader emissions: 0.4 Mt • Total 'oil sands' emissions estimate: 37.9 Mt • Update from EC: 55.8 Mt, incremental increase allocated to Alberta
Output	CEOU (1999)	• CEOU provides physical production: • Production value obtained by multiplying physical output by nominal price per oil barrel in year 2000 (CEOU): ○ Light oil: Edmonton crude oil priced at C$28.26 (assume CEOU price is nominal) ○ Heavy oil: assume ½ of Edmonton price

	Source	Comments/Computation
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 oil and gas extraction export data by NAICS code (211110) by Canada and province • gross oil and gas export data re-allocated into oil sands and conventional source exports on the basis of production shares reported in COEU

10.4. Fossil Fuel Industries

	Source	Comments/Computation
Coverage	TPWG Options Report CEOU (1999) CEOU Adjustment (2002)	• Coverage of GHG emissions from the Fossil Fuels Industries is comprised of fossil fuel industry source emissions not covered by the Petroleum Refining, Oil Sands, and Pipelines sectors • Coverage of 47% to total GHG emissions from sector • Coverage is based on the following assumptions concerning coverage of source and type of the sector's GHG emissions: o 0% coverage of fugitive CH_4 emissions from oil & gas production o 0% coverage of flaring CO_2 emissions o 100% coverage of CO_2 emissions from fuel combustion, except for 0% of those emissions from drilling and service activities o 75% coverage of CO_2 emissions from stripping of natural gas • 47% coverage is calculated using BAU 2010 emission summing intensities for CO_2 and CH_4 emissions as provided by CEOU for the following sectors: o conventional oil + flaring o heavy crude oil + flaring o frontiers: same as conventional oil (as per Table 9 of oil & gas competitiveness report to AMG) o natural gas: production + processing • Covered intensities (100% of CO_2): o conventional oil: 23.2 kg/bbl + 13.6 kg/bbl (flaring) o heavy crude oil: 9.7 kg/bbl + 13.6 kg/bbl (flaring) o frontiers: 23.2 kg/bbl + 13.6 kg/bbl (flaring) o natural gas: 3.2 kg/mcf (production (2.1 kg/mcf) + natural gas processing (1.1 kg/mcf)) • The covered emissions intensities are then multiplied by estimated BAU 2010 production levels, taken from CEOU with AMG adjustments: o conventional oil: 746 bbl/day (CEOU) o heavy crude oil: 496.1 bbl/day (CEOU) o frontiers: 249.8 bbl/day (CEOU) +275 bbl/day (AMG adjustment- Newfoundland) o natural gas: 7998 bcf (CEOU) +
1990 and 2000 Emissions	CEOU (1999) Environment Canada (2002)	
2010 BAU Emissions	CEOU (1999) Environment Canada (2002)	• Estimated CEOU emissions not covered: 58.6 Mt (121.2 Mt total for 'upstream oil & gas industry', minus emissions from oil sands, bitumen production, upgrader emissions, and mining diesel fuel) • Updated EC estimate for 2010: 68.5 Mt

	Source	Comments/Computation

Output	CEOU (1999)	• CEOU provides physical production for crude oil production:
		  ○ Took total (1667.9 TBPD (Thousand Barrels Per Day)) and subtracted production from oil sands: Sum of 'light oil – synthetic' plus 'heavy crude oil-in-situ & bitumen' minus ' upgrader input-bitumen')
		  ○ Estimate: 1330 TBPD
		• CEOU provides physical production for 1990 natural gas production: 3494 billion cubic feet/year
		• Production value obtained by multiplying physical output by nominal prices in year 2000 (CEOU):
		  ○ Crude oil: Edmonton crude oil priced at C$28.26 (assume CEOU price is nominal)
		  ○ Natural gas: domestic price at Alberta border 2000$ 2.1 per thousand cubic feet (mcf)
		• Total production value for BAU 2010: 2000$ 21.1 billion

Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 oil and gas extraction export data by NAICS code (211110) by Canada and province • gross oil and gas export data re-allocated into oil sands and conventional source exports on the basis of production shares reported in COEU

10.5. Pipelines

	Source	Comments/Computation
Coverage		• 100% coverage to all GHG emissions resulting from pipeline transmission and gas distribution (i.e. combustion and fugitive emissions)

1990 and 2000 Emissions	CEOU 1999	• Pipeline 1990 sub-sector emissions:
		  ○ Gas distribution
		  ○ Pipeline transmission

2010 BAU Emissions	CEOU 1999	• No adjustment update made by AMG or Environment Canada
Output	EconBase (NRCan) Industry Price Indices 1990-2001 (Statscan 62-011-XPB) CEOU (1999)	• EconBase provides 1990-1999 data on 'GDP at factor cost' for Canadian pipeline transport and gas distribution http://www.nrcan.gc.ca/es/ener2000/eng.htm • Note that all other output data is reported as gross revenues; pipeline transport is a service so GDP value is most appropriate for this analysis • Converted into 2000$ using general manufacturing price index: 139.3 2000 (price index)/109.1(1992 price index) • Use provincial emission shares for 1990, 2000, and 2010 as proxy for provincial output shares; multiplied provincial emission shares by Canadian output data to estimate provincial output for 1990, 2000 and 2010

	Source	Comments/Computation
Exports		• 60% of $ value of transported Canadian oil and gas was exported in 2000 • Assumed that 60% of $ GDP for each province was derived from exports. • Allocating emissions, output and exports for the pipeline industry by province is not an obvious exercise. The pipelines carry oil and gas from production source through one or more provinces so the emissions are tied to a transmission service where physical and value data is reported by receipt and disposition. In this exercise a gross assumption is applied to allocate exports. A possibly more refined assumption would necessitate a province by province analysis of pipeline kilometers that carry exportable oil and gas.

10.6. Petroleum Refining

	Source	Comments/Computation
Coverage		• 100% coverage to CO_2 emissions resulting from combustion; other GHGs not covered
1990 and 2000 Emissions	CEOU (1999)	
2010 BAU Emissions	CEOU (1999)	
Output	CEOU (1999) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• Convert into 2000$ using 'refined petroleum products' price index: 146.8(2000 price index)/100(1986 price index)
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 export data for petroleum refineries by NAICS code (324110) by Canada and provinces

10.7. Pulp and Paper

	Source	Comments/Computation

Coverage	Inventory (2001)
	
	StatsCan (1999)
		• The pulp and paper industry includes six sub-sectors (4 digit SIC).
		  ○ Sawmill and Planning Mill Products (2512)
		  ○ Pulp (2711)
		  ○ Newsprint (2712)
		  ○ Paperboard (2713)
		  ○ Building Boards (2714)
		  ○ Other Paper Industries (2719)
		• The NRCan Office of Energy Efficiency estimated that the average level of emissions per establishment for the sawmill and planning mill product industries in 1997 was 1 Kt. Given this low level of average emissions per establishment, the emissions from the sawmill and planning mill product industries are not covered under the pulp and paper sector.
		• Since emissions from sawmill and planning mill product industries made up 10% of the total emissions from the pulp and paper sector in 1997 (StatsCan, 1999), only 90% of emissions are thus assumed to be covered.

	Source	Comments/Computation
1990 and 2000 Emissions	CEOU (1999)	• 90% of total emissions for the pulp and paper sector
2010 BAU Emissions	CEOU (1999)	• 90% of total emissions for the pulp and paper sector
Output	CEOU (1999) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• 1986$ converted into 2000$ using 'refined petroleum products' price index: 152.3(2000 price index/100(1986 price index)
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 export data for pulp, paper and paperboard mills by NAICS code (3221) by Canada and provinces

10.8. Iron and Steel

	Source	Comments/Computation
Coverage	Inventory (2001)	• In the Inventory (2001), the iron and steel industry includes three sub-sectors (4 digit SIC). ○ Ferro-Alloys (SIC 2911) ○ Steel foundries (SIC 2912) ○ Other Primary Steel Industries (SIC 2919) • The emissions of the iron and steel industry are assumed to be completely covered.
1990 and 2000 Emissions	CEOU (1999)	• Total emissions
2010 BAU Emissions	CEOU (1999)	• Total 2010 BAU emissions for the iron and steel sector include: ○ Combustion = 14.2 Mt ○ Non-Combustion = 1.7 Mt ○ Non-Energy = 0.3 Mt ○ Total = 16.2 Mt
Output	CEOU (1999) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• 1986$ converted into 2000$ using 'primary metal' price index: 127.7 (2000 price index)/100(1986 price index)
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 export data for iron and steel mills NAICS codes (331110, 331514, and 331221) by Canada and provinces

10.9. Chemicals

	Source	Comments/Computation
Coverage	Inventory (2001)	• In the Inventory (2001), the chemical industry includes three sub-sectors (4 digit SIC). ○ Industrial Inorganic Chemicals (SIC 3711) ○ Industrial Organic Chemicals (SIC 3712) ○ Chemical Fertilizers and Fertilizer Material (SIC 3721) • The emissions for the chemical industry are assumed to be completely covered, including industrial process emissions.
1990 and 2000 Emissions	CEOU (1999)	• Total emissions
2010 BAU Emissions	CEOU (1999)	

	Source	Comments/Computation
Output	CEOU (1999) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• 1986$ converted into 2000$ using 'chemical and chemical products' price index
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 export data for chemical sector by NAICS codes (325120, 325130, 325181, 325189, 325190, 325310, 325313, 325314, and 325410) by Canada and provinces

10.10. Non-Ferrous Smelting and Refining

	Source	Comments/Computation
Coverage	Inventory (2001)	• In the Inventory (2001), the smelting and refining industry includes two sub-sectors (4 digit SIC). ○ Primary Production of Aluminum (SIC 2951) ○ Other Primary Smelting and Refining of Non-Ferrous Metal Industries (SIC 2959) • The emissions for the smelting and refining industry are assumed to be completely covered, including industrial process emissions.
1990 and 2000 Emissions	CEOU (1999)	• Total emissions
2010 BAU Emissions	CEOU (1999)	Total 2010 BAU emissions
Output	CEOU (1999) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• 1986$ converted into 2000$ using 'primary metal' price index: 127.7 (2000 price index/100(1986 price index
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 export data for non-ferrous smelting and refining by NAICS codes (331313 and 3314) by Canada and provinces

10.11. Cement

	Source	Comments/Computation
Coverage	Inventory (2001)	• In the Inventory (2001), the cement industry includes one sub-sector (4 digit SIC). ○ Hydraulic Cement (3521) • The emissions for the cement industry are assumed to be completely covered, including industrial process emissions.
1990 and 2000 Emissions	CEOU (1999)	• Total emissions
2010 BAU Emissions	CEOU (1999)	• Total 2010 BAU emissions
Output	CEOU (1999) Industry Price Indices 1990-2001 (Statscan 62-011-XPB)	• 1986$ converted into 2000$ using 'non-metallic mineral products' price index: 131.9 (2000 price index)/100(1986 price index)
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 2000 export data for cement manufacturing by NAICS code (327310) by Canada and province

10.12. Other Manufacturing (Lime, Glass and Motor Vehicle)

	Source	Comments/Computation
Coverage	Inventory (2001)	• Among this broad industrial group of activities, only three sub-sectors are proposed to be covered in a DET: o Motor Vehicle Industry (SIC 3231) o Primary Glass and Glass Containers Industry (SIC 3561) o Lime Industry (SIC 3581)
1990 and 2000 Emissions	CCS (2002)	• Climate Change Secretariat reported emissions for Canada in an unpublished report • Emissions for Canada allocated on the basis of province's export share
2010 BAU Emissions	CCS (2002)	• Climate Change Secretariat reported emissions for Canada in an unpublished report • Provincial emissions estimated on the basis of province's export share
Output	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• Trade Data Online reported manufacturing shipments for Canada by NIACS codes • Provincial output estimated on the basis of province's export share
Exports	Strategis Trade Data Online http://strategis.ic.gc.ca/sc_mrkti/tdst	• 1999 export data for lime (32741), glass (327214 and 327215) and motor vehicle (3361 and 336211) manufacturing by NAICS codes by Canada and provinces

11. APPENDIX II – INDUSTRY ALLOCATION CAP

The federal discussion paper released in May 2002 considered four options for the implementation of the Kyoto Protocol. The options ranged from an upstream "broad as practical" system that would cover close to 80% of Canada's GHG emissions to a cap-credit-and trade system supported by targeted measures. The federal government's current approach of achieving 55 Mt of reductions from the DET is based on the 4th option in the discussion paper.

All four options propose to achieve 74 Mt from Action 2000, Budget 2001 initiatives, and sinks. Option four closes the remaining 166 Mt of the expected 240 Mt Kyoto gap in 2010 through the following measures:

- Credit for Clean Energy Exports - 70 Mt
- Domestic Emission Trading - 55 Mt
    - New reductions - 25 Mt
    - Offsets - 20 Mt
    - Private sector purchases - 10 Mt of international credits
- Targeted measures - 25 Mt
- Government purchases of international credits - 16 Mt

The 55 Mt reduction target was conceived within the context of a DET that could achieve 25 Mt of reductions from a coverage somewhat broader than large final emitters and 20 Mt from domestic offsets outside the system. The option assumes an additional 10 Mt in private sector purchases of international credits. When compared with option three, where no credit for clean energy exports is assumed and private sector purchases of international credits is 76 Mt, the 55 Mt target for the DET in option four appears to be heavily subsidized by the assumption of credit for clean energy exports. The overview of the Climate Change Draft Plan, released on October 24th, 2002 is consistent with option four of the federal discussion paper in assuming credit for clean energy exports, a DET that is open to domestic offsets and the purchase of international permits, and complementary targeted measures.