EMISSION TRADING SYSTEMS AND TRANSPORTATION

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INTRODUCTION

This paper provides an analysis of the latest trends regarding the use of emission trading systems (ETS) to manage environmental issues such as climate change caused by transportation. While ETS is used mainly in the aviation sector, emissions from other transportation sectors may be included in ETS in the future for different reasons. To assess the likelihood of such an inclusion, this paper analyzes the main components of ETS and their applicability to the different transportation sectors. Adding new economic requirements such as an ETS to deliver transportation services could add volatility to operating costs. Some cost impacts assessment will also be included in the analysis to assess this potential additional volatility.

ENVIRONMENTAL CONCERNS

The transportation sector in Canada is a major source of emissions of greenhouse gases (GHG) (Table 1) and criteria air contaminants (CAC) (Table 2). GHG emissions from transportation increased by 26% between 1990 and 2006, at a faster rate than Canada's overall emissions, which increased by 22% over the same period. This growth was unevenly distributed among all the modes. GHG emissions from heavy-duty road vehicles have shown the fastest growth with an increase of 60% while emissions from rail activities decreased by 14% over the same period.

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[1] Views expressed in this paper benefited from exchanges between the author and colleagues from Transport Canada and from the Market Based Measures Task Force of the ICAO. The author thanks also reviewers of this article for their useful comments. However, the views expressed herein do not necessarily reflect those of either Transport Canada or the ICAO.

Table 1 Greenhouse Gas Emissions in Canada 1990-2006 (kt)

Sector	1990	2006	Change
Light Duty Road	69,908	87,522	+25%
Heavy Duty Road	28,510	45,680	+60%
Rail	7,000	6,000	-14%
Marine (domestic)	5,000	5,800	+16%
Air (domestic)	6,400	8,400	+31%
Pipelines	6,900	9,660	+40%
Off-Road	27,000	27,000	0%
Total Transport	150,718	190,062	+26%
TOTAL	592,000	721,000	+22%
Transport's Share	25%	26%	

Data Source: Environment Canada (www.ec.gc.ca)

In 2006, the transportation sector was responsible for 35% of nitrous oxides (NO_x), 11% of Volatile Organic Compounds (VOC), 5% of Particulate Matters of 2.5 μ or less (PM2.5) and 5% of sulphur oxides (SO_x) emissions in Canada.

Table 2 Criteria Air Contaminants in Canada 2006 (kt)

Sector	NOx	VOC	PM2.5	SOx
Light Duty Road	215	241	2	2
Heavy Duty Road	285	18	7	3
Rail	111	3	4	5
Marine (domestic)	113	4	9	78
Air (domestic)	67	11	1	5
Pipelines	47	0.3	0.2	2
Off-Road	393	40	35	15
Total Transport	1,230	316	57	109
TOTAL	3,538	2,782	1,189	2,079
Transport's Share	35%	11%	5%	5%

Data Source: Environment Canada (www.ec.gc.ca)

Given the importance of the transportation sector as a source of emissions, a successful emission reduction strategy should include the transportation sector in its targeted sectors.

A MARKET-BASED INSTRUMENT

An Emissions Trading System (ETS) is called a market-based instrument because a well-designed ETS tackles market forces to reach its environmental goal at the lowest cost for the economy.

In effect, by sending the same price signal to a group of regulated emitters, the ETS guides them in their choices between:

1) Reducing their own emissions if their abatement unit cost is smaller than the market price, or
2) Buying their reductions from other emitters if their abatement unit cost is greater than the market price.

As opposed to a tax, under an ETS it is the regulated emitters that generate the price signal, not the regulator. Moreover, it is easier to target a level of emissions with an ETS because targeting a quantity of emissions with a tax would likely require a number of adjustments of the tax to reach the needed level to limit emissions. Hence, especially when the regulator cannot determine what is the marginal damage cost of, say, one tonne of emissions, it might be appropriate to use an ETS to reach a given environmental target.

HOW ETS WORKS

Under the ETS classic form of a "cap and trade", the regulator creates a limited number of "compliance units" (called either allowances, permits or credits, and hereafter called **units**). Each unit allows for the emission of one tonne of the regulated pollutant once. The sum of available units equals the ETS environmental goal: the cap. All regulated emitters must remit to the authority the number of units that correspond to the level of their regulated emissions during a defined compliance period (generally, every year)[2].

The essential elements of an ETS include:

1. A **regulatory framework** that specifies the details of the ETS including what activities are regulated (e.g., civil aviation) and who shall participate (e.g., airlines)

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[2] See: US-Environmental Protection Agency: Tools of the Trade: A Guide to Designing and Operating a Cap and Trade Program for Pollution Control

2. An **allocation** system that distributes units among participants. This could be free of charge (e.g., based on past emissions), at a fixed unit cost, by auction, or by using a basket of methods. The number of units defines the cap.
3. A **monitoring** system that measures on-going emissions for each participant (this could be based on the carbon content of fuel for carbon dioxide).
4. A **reporting** system that allows the authority to record and verify level of emissions of each participant for a given period (usually a year).
5. A **tracking** system that identifies the owner of each unit and their status (i.e., active, retired or canceled)
6. An **exchange** or market place where units can be traded (it could be an established exchange).
7. A **compliance** system under which each participant surrenders units in proportion of reported emissions (e.g., one unit per tonne of CO_2 equivalent emitted) or sees itself being imposed a fine for emissions in excess of surrendered units.

CONDITIONS TO BE A COST-EFFICIENT TOOL

ETS are particularly cost-efficient when a number of suitable conditions are present:

1) The environmental damages are similar for each tonne of emission and for all regulated emitters;
2) The abatement unit costs are likely to be different among regulated emitters;
3) The abatement options are numerous and not well-known by the regulator;
4) The number of regulated emitters is large enough to create a competitive market;
5) The monitoring, reporting and verification of the emissions of regulated emitters are credible and relatively inexpensive for both the regulator and the regulated emitters.

SUITABLE ETS FOR TRANSPORTATION

Criteria air contaminants (CAC) such as NOx and PM do not meet all the suitable conditions to implement an ETS. In particular, environmental damages from CAC could vary significantly in economic value depending on where the emission sources are located and when emissions occur. This may make the implementation of a CAC ETS particularly challenging. However, one would note that despite this difficulty, countrywide ETS have been established with success in the United States for SO_2 and for NOx[3]. The successful ETS in the United States were designed for fixed industrial emitters for which monitoring, reporting, and verification functions are affordable and credible. For mobile sources, these functions are expected to be expensive for numerous sources such as light road vehicles. Hence, a CAC ETS applied to transportation sources is likely to have at best a partial coverage of the transportation sources unless monitoring techniques improve significantly.

Greenhouse gas (GHG) emissions such as carbon dioxide cause environmental impacts irrespective of where or when the emissions happen. The most common GHG is carbon dioxide for which emissions are directly proportional to fuel burnt by vehicles. The value of transportation services (by litre of fuel burnt) and the abatement options are not the same for all vehicles and are not well known to the regulator. Carriers and vehicle operators are numerous and will operate in a competitive market for units. Since fuel consumption is already monitored and sometimes even reported, monitoring, reporting and verification functions could be achieved at a reasonable cost for both the emitter and the regulator, at least for a significant group of emitters. Hence, the suitable conditions to implement a GHG ETS seem to be present. The rest of the analysis in this paper focuses on the possibility of implementing a GHG ETS, and leaves aside CAC emissions.

AVIATION GHG FOOTPRINT

As it is difficult to fly without burning fossil fuel and therefore without emitting carbon dioxide (CO_2), open[4] emissions trading

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[3] See: http://www.epa.gov/airmarkt/resource/cap-trade-resource.html

[4] An open ETS recognizes for compliance units created out of the system per se. For instance, Certified Emissions Reductions from the Clean Development Mechanism could be used instead of units created for the open ETS.

systems (ETS) are suggested as a tool to reduce the net environmental footprint of air traveling.

Large airline carriers offer their travelers the possibility of buying « offset credits » to reduce the net impact of the greenhouse gas emissions associated with their journey. In Canada, since May 28, 2007, Air Canada has been collaborating with Zerofootprint (a specialized organization selling offsets) whose Web site helps travelers make a voluntarily payment proportional to their CO_2 emissions tied to their journey. On its side, WestJet buys offset credits on behalf of their travellers who make their reservations using Offsetters.ca (founded in 2005).

The International Civil Aviation Organization (ICAO) launched in June 2008 on its Web site (www.icao.int) a carbon calculator that allows the estimation of a traveler's GHG footprint during air travel between two specific airports. Based on the generally used plane performance between two given cities, the calculator is easy to use and allows travelers to be aware of their carbon footprint. A traveler willing to offset her or his carbon footprint could buy offset credits on the market and retire them on a voluntary basis.

A Mandatory ETS for Aviation in Europe

In July 2008, the European parliament adopted a law the purpose of which is mandatory integration of civil flights from and to European airports into the European emissions trading system (EU-ETS), also called the European carbon market.

Rules that will regulate the inclusion of civil aviation into the EU-ETS may be amended, but the November 2008 Directives[5] provide interesting insight. Aviation GHG emissions would be subject to the ETS starting in January 2012. The aviation annual cap would be equal to 97% of the annual average emissions of the 2004-2006 period for 2012, and down to 95% starting in 2013. However, 15% of these units would be auctioned and another 3% would form a reserve to allocate to new airlines and to fast growing airlines. Thus,

[5] url: http://eur-lex.europa.eu/

of the 2004 -2006 average emission levels, only 82.45% of the units in 2012 and 80.75% starting in 2013, would be allocated free of charge to established airlines and these units that define the cap would likely sum up to less than the level of emissions of CO_2 if the air transportation continued to grow.

The level of activity in 2010 (measured in tonne-kilometres) would be critical for the allocation process because the number of units received by the airlines free of charge would depend on their market share during that year. This would be true for both the year 2012 as well as the subsequent period that will start in 2013.

The aviation ETS would be open and unilaterally linked to the EU-ETS. Airlines with a shortage of units would be able to buy units from the EU-ETS or from one of the project-based Kyoto Mechanisms (i.e., Joint Implementation (created by the Art. 6 of the Kyoto Protocol) and the Clean Development Mechanism (created by the Art. 12)). The tied transfer of money to the sellers can be seen as a financial contribution of the aviation sector to the global effort of reducing net GHG emissions. Units created for aviation in Europe would not be usable for compliance by the regulated emitters subject to the EU-ETS.

Even though a significant proportion of the required units would be distributed free of charge, the marginal opportunity cost per flight for the airlines represents the entire GHG emissions. In fact, independently of the units' allocation, since the level of current or future allocation would not depend on the level of activities, all regulated GHG emissions represent an additional cost for the airlines either as a need to buy additional units (an expense) or as the impossibility of selling surplus units (revenue lost).

An interesting economic issue would be to assess the extent to which airlines pass that marginal cost on to travellers. If it was a large proportion, that could generate windfall profits, especially if the demand price elasticity is low. Such an assessment would not be easy to make.

The price of units on the aviation ETS would likely be very similar to the unit price on the EU-ETS. Since there is no limit on the volume of units bought by airlines from other ETS, and this volume would be relatively small compared to the EU-ETS market, analysts expect to see the EU-ETS price prevail on the civil aviation ETS[6]. The aviation price could even be lower if the supply of the project-based Kyoto mechanisms is large and cheap[7].

Forecasting the carbon price three and a half years down the road is not a trivial exercise. Because units are bankable – they can be put aside for compliance in a subsequent commitment period – the current price should reflect the discounted value of expected prices in the future. Since the latter depends on many factors (often themselves difficult to predict, including the future targeted GHG reductions) one can only guess. In 2009, the EU-ETS unit price varies currently around 10 € per tonne of CO_2[8]. This corresponds to about C$ 16 a tonne of CO_2 or approximately 4¢ a litre of fuel. On average in 2008, price was approximately 25 € per tonne.

Some specialists describe the inclusion of aviation under an emission cap as a means for that sector to share the burden of GHG reductions at a unit cost similar to the large industrial sectors. This is because, at 4¢ a litre or even at 10¢ a litre, known price-elasticities show that CO_2 intensity reductions would not compensate for the growth in demand for transportation.

The new EU Directives by which GHG emissions from civil aviation would be subject to an ETS include the possibility of excluding foreign airlines, if they are subject to a similar obligation in their own country. The interpretation of similarity and reciprocity will nourish interesting discussions in the coming months.

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[6] In theory, any sale of units to outsiders reduces the supply of units within the exporting ETS, pushing up the equilibrium price. However, if the volume of net export is small compare to the market size that price increase would not be significant.

[7] The EU-ETS imposes a maximum limit on the number of CERs and ERUs usable for compliance, but not on aviation. Hence if the supply at low price of these two types of unit is large enough to fulfill all the aviation needs, the aviation marginal cost could be lower than the EU-ETS price.

[8] url: http://www.ecx.eu/

WHAT MODES COULD BE COVERED BY AN ETS?

Transportation emissions in an ETS should be measured and reported in an accurate and credible way at a low administrative cost for both the regulated entities and the regulator. This is unlikely to be the case for a large number of small emitters such as individual light duty road vehicles. However, the regulator may choose to send the "carbon price signal" to a large group of small emitters by imposing, upon fuel distributors, the obligation to cover the carbon content of their fuel to a category of final users[9]. This is called the upstream approach because it regulates carbon early in the distribution chain[10].

In addition, numerous sources, such as commercial vehicles, could be monitored at a small additional cost if the International Fuel Tax Agreement (IFTA) already covered these sources[11]. Vehicles targeted by the program are: a motor vehicle used, designed, or maintained for transportation of persons or property and:

1) Has two axles and a gross vehicle weight or registered gross vehicle weight exceeding 26,000 pounds or 11,797 kilograms; or
2) Has three or more axles regardless of weight; or
3) Is used in combination, when the weight of such combination exceeds 26,000 pounds or 11,797 kilograms gross vehicle or registered gross vehicle weight.

Noting that domestic aviation and rail emissions are subject to a Memorandum of Understanding under which emissions are monitored and reported, the direct coverage of many segments of the transportation sector appears to be feasible at reasonable administrative costs.

ABSOLUTE VERSUS INTENSITY TARGETS

The most contentious element to determine in designing a new ETS is the allocation method: how units defining the cap would be allocated. The allocation has an impact on the perception of the stringency of

[9] See for instance the Western Climate Initiative's proposal for the year 2015.
[10] Canada's National Climate Change Process Using Tradeable Emissions Permits to help achieve domestic greenhouse gas objectives options report April 2000
[11] This is because fuel consumption is monitored and reported under that program and because CO2 emissions could be calculated by the volume of fuel burnt.

the ETS. With an intensity target approach, the sum of individual targets defines the overall target, which appears flexible. Before linking two ETS for instance, the equivalency of the stringency of the two ETS is often assessed in order to anticipate the potential consequences for the environment of establishing the linkage. It is therefore relevant to look closely at the two approaches.

One ETS allocation method defines individual targets by multiplying a so called "intensity target" by the level of observed "production" of each entity. For instance, an electricity producer that faces an intensity target of 300 g of CO_2 equivalent per kWh of production and then produced 200 TWh of electricity during the year would receive a target of 60 Mt of CO_2 equivalent for its production. Therefore, on one hand, with an allocation based on intensity targets, if production increases, individual emission targets increase as well as the overall target is the sum of individual ones. On the other hand, an absolute cap defines the overall emission objective, and this is allocated among regulated entities. Even if production fluctuates, the overall cap would not be affected. After the fact, it is possible to compare the free of charge allocation received by each entity under a so-called hard cap by comparing the allocation of regulated entities with their production. For instance, in our previous example, if the allocation of the same producer had been 50 Mt, its implicit intensity target would have been 250 g per kWh.

TWO DYNAMICS

The dynamics of the two approaches differ. To maintain the equivalency of a stable absolute target year after year, "intensity targets" have to be adjusted to take into account level of production changes by the regulated entities. During economic growth periods, intensity targets have to be reduced in advance to take into account that production increases. Typically, for a given year, the initial emission intensity targeted (1–g)(E/P) would have to be reduced at a rate that compensates production (P) growth. This could be formulated in the following way:

$$AET = (1 + y)^n P \times \{(1 - g)(E/P) \times (1 - x)^n\}$$

Where:

AET: the absolute emission target
y: average annual growth rate of production in %
n: years after base year
P: production of the base year
g: targeted emission reduction compared to base year in %
E/P: emission intensity of the base year
x: annual rate of emission reduction in % need to obtain AET

DIFFERENT METRICS

Because the formula uses "years passed the base year" as a power, maintaining the equivalent of a fixed cap with an intensity target approach means that the cumulated metrics for a given year are different for the economic growth $(1+y)^n$ and the intensity reduction $(1-x)^n$. For instance, for an Average Annual Growth Rate of 3% of the production and –3% of intensity reduction, the cumulative production increase is greater than 34% after 10 years while cumulated intensity reduction needed to maintain the absolute cap equivalency is less than 27%.

Table 3 Comparison of cumulative changes in production and intensity to maintain the equivalency of an absolute emission cap

	Slow Growth		Average Growth	
Year	Cumulated y	Cumulated x	Cumulated y	Cumulated x
1	1.5%	-1.5%	3.0%	-3.0%
2	3.0%	-3.0%	6.1%	-5.9%
3	4.6%	-4.4%	9.3%	-8.7%
4	6.1%	-5.9%	12.6%	-11.5%
5	7.7%	-7.3%	15.9%	-14.1%
6	9.3%	-8.7%	19.4%	-16.7%
7	11.0%	-10.0%	23.0%	-19.2%
8	12.6%	-11.4%	26.7%	-21.6%
9	14.3%	-12.7%	30.5%	-24.0%
10	16.1%	-14.0%	**34.4%**	**-26.3%**

In other words, the –18% intensity targets in 2010 compared to 2006 levels combined with further annual reductions of –2% announced in the *Regulatory Framework for Air Emissions* (2007) would call for minus 30% of intensity reduction by 2016, which would likely correspond to an actual absolute reduction unless the economy shows an average annual growth rate of more than 3% over that period.

DIFFERENT DEGREE OF CERTAINTY

As long as the rate of intensity reduction compensates the production growth (as long as annual $x = y$), a given absolute target could be reached with intensity targets. If the intensity target were reduced at a slower pace (if annual $x < y$), then the intensity target approach would be "weaker" than an absolute cap. Conversely, if the reduction were faster than production growth (if annual $x > y$), then the intensity target would be "tougher" than the absolute cap. In all cases, because production increases could be difficult to forecast accurately, an intensity target generates a greater level of uncertainty regarding the actual cap that ETS would have.

One would note that having P, the level of production, as a factor in the allocation formula, creates an incentive to maintain production while maintaining the incentive to reduce the intensity of emission of that production. While this approach reduces the probability of carbon leakage – the displacement of production in an area with low or no carbon emission constraint – it reduces the incentive of structural production shifts towards low carbon content production.

Intensity Targets and Carbon Leakage

An intensity-based allocation would be proportional to production level of firm i :

$A_{it} = P_{it} \times (1 - g_t) (\Sigma E_{i0}/\Sigma P_{i0})$

Where :

A_{it} : the allocation of units free of charge to firm i during year t

P_{it} : the production of firm i during year t

g_t : the reduction factor at year t of the ETS ($0 < g_t < 1$).

$(\Sigma E_{i0}/\Sigma P_{i0})$: the emission intensity of firm i's sector during the base year

Emissions of firm i depends on the emission intensity of its production:

$E_{it} = P_{it} \times (E_{it}/ P_{it})$

Where :
E_{it} : the emissions of firm i during year t
P_{it} : the production of firm i during year t
(E_{it}/P_{it}) : the emission intensity of firm i during the year t (assumed independent of production level)

The compliance cost for firm i would be proportional to the difference between its level of emissions and the free of charge allocation and of the unit price:
$C_{it} = (E_{it} - A_{it}) \times p_t$

Where :
C_{it} : compliance cost for firm i during year t
E_{it} : the emissions of firm i during year t
A_{it} : the allocation of units free of charge to firm i during year t
p_t : price of compliance units

When « free of charge allocations » depend on production, the compliance cost of increasing production is lowered by the proportional « free of charge allocation », and the compliance cost reduction of decreasing production is less than the full value of the emissions reduction:

$$\frac{\delta C_{it}}{\delta P_{it}} = [(E_{it}/ P_{it}) - (1 - g_t) (\Sigma E_{i0}/\Sigma P_{i0})] \times p_t$$

However, if the allocation is independent of production level, the full value of emissions changes affect the compliance cost:

$$\frac{\delta C^*_{it}}{\delta P^*_{it}} = (E_{it}/ P_{it}) \times p_t$$

DEALING WITH UNCERTAINTY

The regulator may choose to deal with uncertainty regarding the achievement of the overall target by defining the intensity targets directly as a function of the production level. This could be done with a delay of one year without compromising too much the accuracy of targeting a given absolute emission level. In practice, the regulatory framework would have to accommodate changing rates that would be defined from year to year based on production levels of regulated activities.

For ETS regulated carriers, unit price fluctuations would add to the level of uncertainty regarding the price (or value) of their inputs. The carbon price on the largest exchange, the European climate exchange, fluctuated greatly prior to the first commitment period that started in 2008. In fact, because units created for the « pilot phase » (years 2005 to 2007) were not bankable to be used in the first commitment period (years 2008 to 2012), and because units were in surplus at the end of the pilot phase, unit price reached a low level toward the end of 2007. In 2009, after showing one year of relative stability at about 25 € a tonne of CO_2, carbon price is down at about 8 to 10 €/ tonne of CO_2 eq. Carbon price fluctuations add uncertainty to the transportation industry, an industry facing important changes in fuel prices.

CONCLUSION

An Emissions Trading System (ETS), by sending a single price signal on externalities such as carbon dioxide emissions, is a market-based instrument that uses market forces to achieve a quantitative target at the lowest cost. An ETS appears to be a mechanism both applicable and suitable for greenhouse gas emissions from transportation but less so for criteria air contaminants because of the difficulty of monitoring and reporting emissions from mobile sources in a verifiable way. While some large emitters could be regulated directly by the ETS, small sources, in particular private light duty vehicles could receive the same price signal by including the carbon content of fuel at an upstream level in the fuel distribution chain. At the current carbon prices, transportation sources may not reduce emissions significantly, while additional uncertainty would be introduced to the industry's cost structures. However, including transportation sources into an ETS approach could be seen as an equitable approach to a climate change mitigation strategy. Consequently, this avenue deserves further investigation.

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