Sustainable Prosperity
Making markets work *for* the environment.

DISCUSSION DOCUMENT

Pricing Electricity for Sustainability: Climate Change and Canada's Electricity Sector

January 2010

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Pierre-Olivier Pineau (HEC – Montreal) provided much of the background and content for this document. Sustainable Prosperity would like to acknowledge that contribution, and thank Dr. Pineau for his thought leadership on this important issue.

Sustainable Prosperity would also like to thank Jane McDonald and Sylvain Audette for their thoughtful comments and suggestions.

Abstract

There is a strong and direct link between electricity pricing and efforts to address climate change. The electricity generation sector is the single largest source of Canadian GHG emissions, although electricity generation emission factors vary widely across the country. If Canada is to develop a strong approach to reducing GHG emissions, it must focus on the country's electricity sector, using electricity and carbon pricing approaches that are consistent with the principles of sustainability.

Several provincial utilities already are experimenting with market-based pricing approaches for electricity and carbon that are consistent with the principles of sustainability. The experience gained through these efforts should be closely observed and shared. There remains, however, a large scope for strengthening electricity pricing in Canada in support of sustainability.

1. Sustainability and the Electricity Sector: Canada's Challenge

1.1 Introduction

This paper argues that Canada needs to develop a strong approach to reducing greenhouse gas (GHG) emissions in the country's electricity sector, based on electricity and carbon pricing approaches that are consistent with the principles of sustainability.

Reducing GHG emissions is a central policy challenge, because they are the key driver of human-induced climate change. The effects of climate change are already being observed, and are projected to increase considerably in the coming decades (United Nations Intergovernmental Panel on Climate Change [IPCC], 2007a). Consequences of climate change include extreme weather events, less resilient ecosystems (providing fewer ecological goods and services such as clean air and fresh water), change in crop productivity, and greater stress on water resources. In order to limit the increase of global average temperature to "only" 2 to 2.4°C, a reduction of GHG emissions between 50% and 85% from 2000 level is required by 2050 (IPCC, 2007b).

If GHG emission reductions are necessary to limit changes in the Earth's climate, there are also other important positive consequences of such reductions. Indeed, as more than 80% of Canadian GHG emissions are energy related (from the extraction and burning of fossil fuels), reducing GHG emissions is strongly linked to reducing fossil fuel consumption.[1] Co-benefits (that is, multiple economic, environmental and social benefits associated with a particular strategy or initiative) from reducing energy-related GHG emissions are numerous: improved energy security (from reduced energy imports); cleaner air (from less smog); reduced health care costs (from the improved health due to less smog); and increased long-term competitiveness from innovations in energy efficiency. These co-benefits are discussed in NRTEE (2005) and Stern (2007), among other publications.

The paper is organized into two parts:

- **Part 1** provides an overview of the links between electricity pricing and climate change; and
- **Part2** reviews current and emerging trends in electricity pricing related to encouraging conservation and reducing GHG emissions from the electricity sector.

1.2 Market Prices and Market Failures

Since the collapse of many communist states in the early 1990s, there is a strong worldwide agreement that in most cases, the allocation of goods and services is better achieved under a well functioning market price system. The interaction of supply and demand determines the market price, rather than having prices set by governmental plan or dictate. Such free interface between buyers and sellers allows consumers to express their preferences directly in the market (so that these preferences do not have to be discovered and interpreted by planners) and directly rewards suppliers if they provide adequate products (or not if they do not). At the same time, the price consumers "see" for any given product or service is meant to reflect the full cost of actually producing and/or delivering it. Many goods and services in our society are provided through such a system, including even vital goods such as food, housing and *some* types of energy, such as oil and natural gas.

[1] Capturing CO_2 and storing it underground is an alternative to reducing fossil fuel consumption, but an expensive one that could only partially offset GHG emissions, since the available storage is limited. This process is currently only used in enhanced oil and gas recovery projects in Canada (Weyburn), Norway (offshore) and Algeria (In Salah), in favorable fiscal environments (e.g., subsidies in Canada and a carbon tax in Norway).

Electricity mostly escapes this market price system, however. Rather, electricity prices in Canada tend to be established by government institutions on the basis of planned average cost pricing or a variation of average cost pricing. There are, however, cases when such free markets fail to work adequately, resulting in market prices and available quantities not reflecting the real value of products. This leads to inefficient outcomes, with either too many or too few products sold, compared to the optimal situation. These cases are called "market failures" (Box 1). In such cases, governments have a legitimate role in the market to correct the market failure. For example, governments can take action by: reducing the market power (through competition laws); providing the products or paying a supplier to do so; regulating or taxing to account for the externality; and, ensuring that information is as transparent and as widely available as possible to all markets participants.

Given that early electricity markets were characterized by natural monopoly features and market power issues and that they displayed public good features, governments historically have been involved in the electricity sector. Due to the need to protect consumers from monopoly pricing, but also to allow the electric utility to earn a return that covers costs, average cost pricing, in which residential customers paid a uniform "postage stamp" price, became the norm in Canada. [2]

Box 1. Market Failures

There are four general types of market failures, each calling for some type of government interference in the market, to improve the outcome (e.g., see Case *et al.*, 2002):

1. ***Market power***. Some buyers or sellers have more power than others in the market and can directly influence prices (e.g., some alleged examples are OPEC, Microsoft or Wal-Mart; this latter example being a possible example of a large wholesale buyer influencing suppliers).
2. ***Public good***. Some products are such that it is very difficult to prevent consumers from benefitting from them once they are produced, and are also such that one's consumption does not affect the consumption of others. In these cases, consumers have little individual interest to pay for their own consumption – hoping a "free ride" will be available. Governments are therefore in a legitimate position to make sure these goods are still provided, and paid for through taxation. Fireworks, the security offered by the police and the army, justice, primary and secondary education are traditional examples of public goods. Reliability in the electricity sector is another example.
3. ***Externalities***. An externality arises when the production or use of a product has an impact that affects people beyond the producer or the user.. Producers and consumers, not directly gaining or losing from these impacts, are not ready to pay for these impacts, even though there are some real consequences. Noise from neighbors is a traditional example of a negative externality. GHG emissions are another.
4. ***Imperfect information***. When some information is unknown to either the buyer or the seller, the market price and quantity may not reflect the correct evaluation of the product by either party, leading to inefficient decisions. Examples of such cases happen in second-hand cars markets (the seller knows more about the car than the buyer) or in energy-using products (such as refrigerators or cars). In these latter cases, future energy consumption has to be fully known and understood when making an investment decision, but it is not always the case due to imperfect information.

[2] Until recently, the practice for industrial customers was to offer them declining price blocks.

1.3 Climate Change and the Electricity Sector

Canadians emitted 750 million tons (Mt) of CO_2-equivalent GHGs in 2006, (Environment Canada, 2008a).[3] This is about 22% more than the 1990 emission level and about the same as in 2000 (Environment Canada, 2008b).

The electricity sector is the single largest source of Canadian GHG emissions (Figure 1).[4] This stationary GHG emission source is responsible for 16% of all emissions, accounting for 117 Mt of CO_2 emissions in 2006. The three other energy-related GHG sources are other stationary sources (28%), transportation (different mobile sources responsible for 25% of all emissions) and fugitive sources (9%).[5] The four largest other stationary sources are the fossil fuel industry (9%), the residential sector (5.5%), the commercial and institutional sector (4.5%) and the manufacturing industry (3%, for a combined 22% of all emissions). These four sub-sectors emit GHG as a by-product of heat generation, from burning oil, natural gas and coal. Provincial breakdowns of emissions by source vary widely, depending on their industrial structure and their access to hydropower for electricity production.

The remaining “non-energy-related” GHG sources are agriculture (mostly methane, from livestock, and N_2O resulting from the use of nitrogen fertilizers), industrial processes (releasing GHGs from chemical processes), land use changes (removal/addition of forest), waste (methane from landfills) and solvent.

There are two reasons to consider the electricity sector as a key sector in any broadly based effort to reduce GHG emissions in Canada. First, it is the largest single source of GHG emissions. Second, as transportation currently relies almost entirely on oil, any shift away from it to reduce GHG emissions will require an alternative energy source – and that alternative source will primarily be electricity.[6] Already, major car companies are offering or announcing hybrid, plug-in hybrid and all-electric cars. In addition, there is a large development potential for public transit and rail, both of which can be entirely electrified. These two trends will further increase the demand on power plants and on the electricity network.

Currently, emissions from conventional oil production and oil sands extraction represent the largest share of fossil fuel industry emissions, a stationary source of GHGs (Environment Canada, 2008b). With the decreasing use of oil in transportation, fossil fuel industry-related emissions will correspondingly decrease, because less gasoline will have to be produced. In addition, if Canadians are to shift away from using electricity for heating purposes to more appropriate alternative heat sources (e.g., co-generation, geothermal heat pumps, solar energy and natural gas), then the price signals consistent with sustainability have to be put in place in the energy sector in general, and in the electricity sector in particular.

Consequently, as electricity demand continues to grow in the future, particularly from increased used in transportation, the foundations of the sector have to be sustainable. As this paper demonstrates, however, these foundations are currently not sustainable, due to major flaws in electricity markets and pricing structure. These flaws result in important foregone economic gains, higher environmental damages, and a redistribution of environmental wealth that is socially indefensible.

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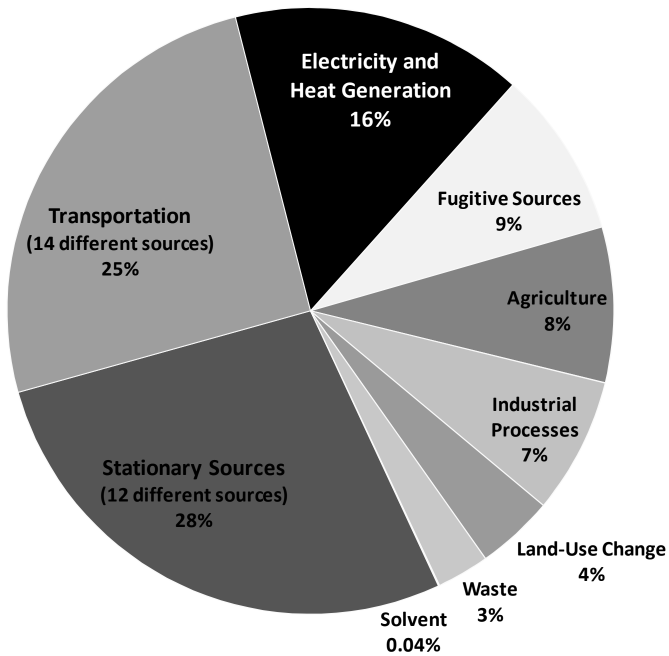
[3] The primary GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). For more information on all GHGs and those dealt with under the Kyoto Protocol, see the GHG entry of the glossary of IPCC (2007a). In international GHG accounting, national totals exclude emissions from “Land Use, Land-Use Change and Forestry Sector”. Without this source of CO_2 (and sometimes sink) the official Canadian 2006 GHG total is 721 Mt.

[4] The electricity sector is labeled “Electricity and Heat Generation” in official accounting, but heat generation represents less than 1% of emissions from electricity and heat in Canada (Environment Canada, 2008b).

[5] Fugitive sources are leaks of GHG (mostly methane) in the process of extracting, producing, refining and distributing coal, oil and natural gas.

[6] Biofuels and hydrogen can technically be alternative fuels. They will be used, but only to a limited extent because producing these fuels in large quantities is problematic in terms of land use (for biofuels), life-cycle impacts, cumulative energy demand and, for hydrogen, costs, distribution and safety.

Figure 1. Canada's 2006 GHG Emissions: 750 Mt
(Environment Canada, 2008a)



2. Current and Emerging Trends in Electricity Pricing in Canada

Part 2 presents an overview of provincial electricity markets in Canada. It reviews current pricing mechanisms to encourage conservation and reduce GHG emissions from the electricity sector and two pricing tools that are being explored in Canada.

2.1 Overview of Provincial Electricity Markets

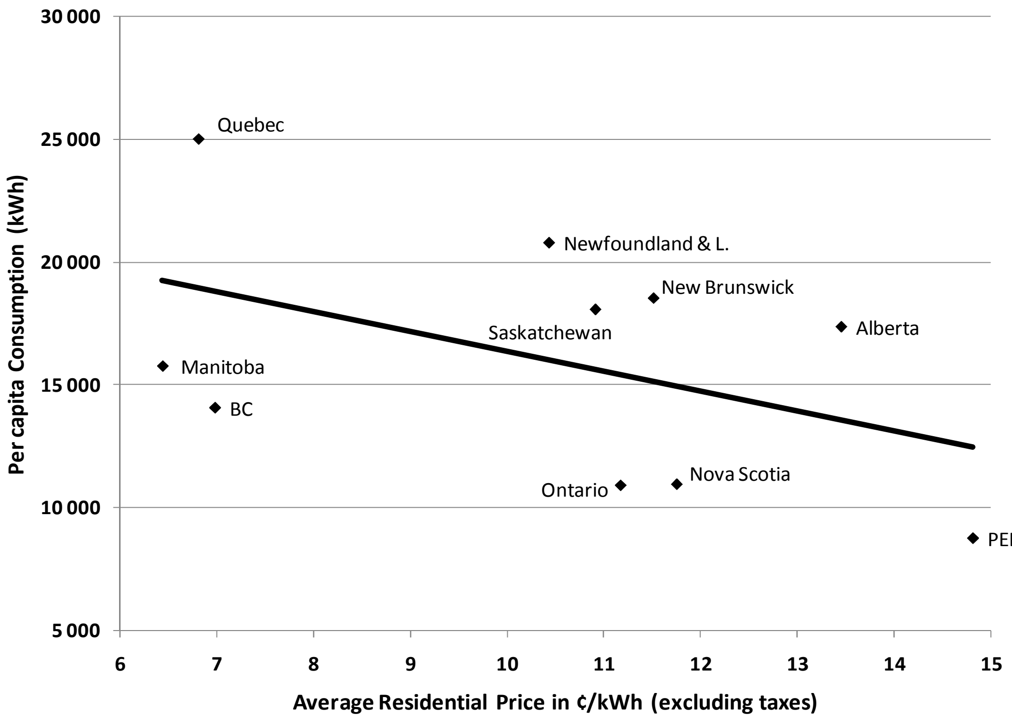
Canadian electricity markets (and U.S. electricity markets as well) are characterized by particular disparities in consumption and price levels. As illustrated in Figure 2, some provinces, such as Quebec, have extremely high consumption and low prices, while others, such as Prince Edward Island (PEI), have low consumption and high prices. Indeed, the ratio of per capita consumption between the highest consumption province and the lowest one is 2.86. This is more than the comparable ratio of total energy use per capita, which is only 2.28 in Canada[7], and more than the ratio of per capita energy use for transportation or in the residential sector: 2.18 and 2.08 respectively.

Provincial differences are also significant in terms of prices. Electricity is up to 2.3 times more expensive in the highest-price province, PEI, compared to the lowest-price province, Manitoba. Such price differentials are found across Canada: in a majority of provinces, residential consumers pay more than 10 cents a kilowatt-hour (kWh), on average, while in British Colombia , Manitoba and Quebec they pay

[7] This is the 2006 ratio of total energy consumption per capita in Alberta (403 Gigajoules, GJ) and in PEI (177 GJ). The average energy consumption per capita in Canada was 229 GJ in 2006 (Statistics Canada, 2009b).

seven cents a kWh or less (on average). Similar differences exist for commercial and industrial electricity prices (Hydro-Quebec, 2008a). For comparison purposes, between 1990 and 2008, the highest *maximum/minimum* price ratio for unleaded regular gasoline across Canada was 1.66, with an average ratio of 1.28 for this period (Statistics Canada, 2009c). Numerous websites monitor gas prices across Canada to warn consumers about price differences. However, for electricity, where price differentials are much greater and long-lasting, there is relative silence (Alberta, with its deregulated electricity market, is the exception).

Figure 2. Provincial Per Capita Annual Electricity Consumption and Average Price
(Statistics Canada, 2008 and Hydro-Quebec, 2008a)



Many factors, beyond price, explain differences in consumption: industrial structure; temperature (yearly heating and cooling "degree days"); and income levels, just to name the major ones.

Price differences, however, have their roots in two totally different sources: technology used in generation; and type of price regulation. As shown in Figure 3, four provinces have their electricity generation sector dominated by hydropower: British Columbia, Manitoba, Quebec and Newfoundland and Labrador. Except for the latter, which exports most of its low-cost electricity to Quebec, these provinces have extremely low production costs. Other provinces, with more supply from coal, natural gas and nuclear power plants, have higher production costs These higher (operating) costs lead to higher prices.

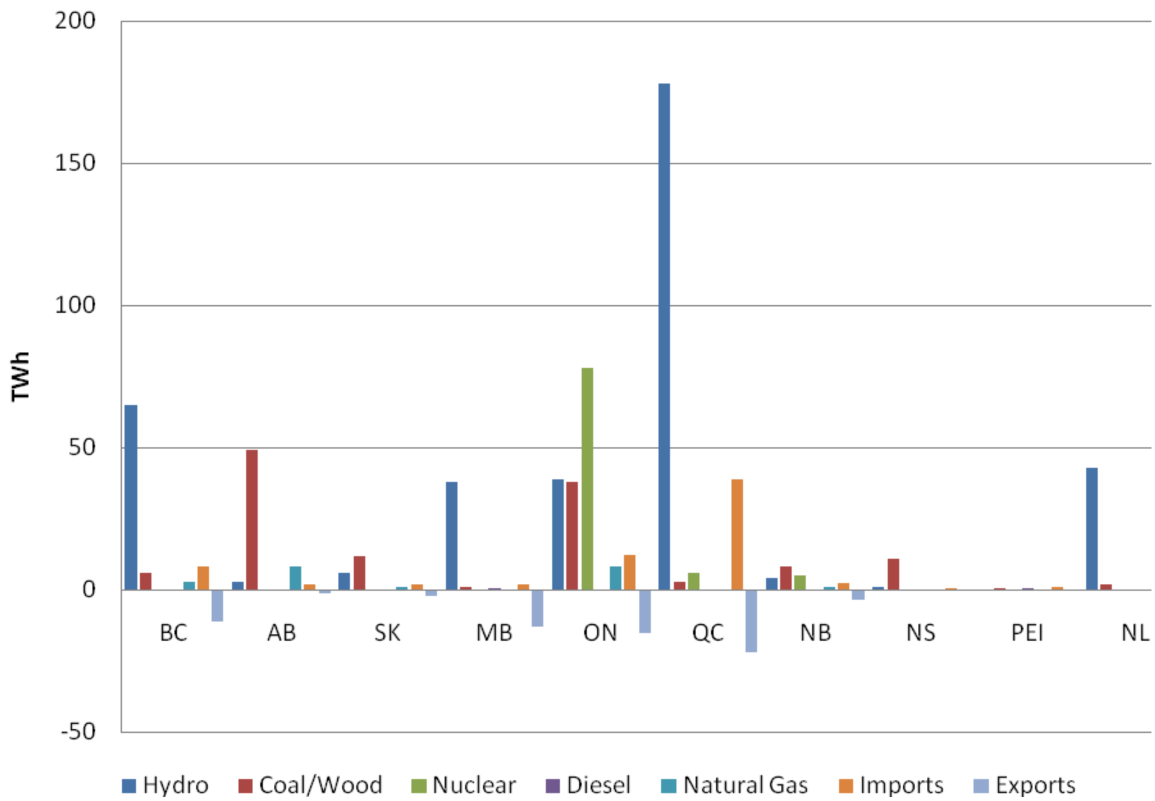
However, the type of price regulation also plays an important role in price levels. All provinces, except Alberta and to some extent Ontario, sell electricity according to "average cost" principles. In their case, even if an hourly market price is determined in an open spot market[8], most consumers (residential and small businesses) are not directly exposed to these market prices because of the "Regulated Rate Option" in Alberta, and of the "Regulated Price Plan" in Ontario.[9] These plans allow consumers to pay at any given

[8] Operated by the Alberta Electric System Operator (www.aeso.ca) and, in Ontario, by the Independent Electricity System Operator (www.ieso.ca).

[9] Consumers in these two provinces have also the choice to opt for competitive contracts, under which they directly pay the market price. These contracts are not popular, however.

time a different price than the market price. For instance, on January 14th 2009, at 9.20 a.m., Ontario consumers under the regulated plan paid 5.6 or 6.5 cents a kWh (depending on their individual cumulative consumption, see Table 1, in section 2.2.1) when the market price was actually 13.16 cents a kWh (Ontario, 2009). However, over the planning period, the regulated and market prices converge, because the regulated price in these two provinces is based on market price forecasts (and not on costs, as in other provinces), plus or minus adjustments to settle past differences.

Figure 3. Provincial Electricity Production by Source, Imports and Exports, 2007
(Statistics Canada, 2009a)



In the case of British Columbia and Quebec, provincial regulation guarantees access to an important amount of energy, which is sold at historical low cost. In British Columbia, the "Heritage Contract" guarantees about 49 terawatt-hours (TWh)[10] of energy, every year, at a price of 2.53cents a kWh (British Columbia Utilities Commission, 2003). In Quebec, the "Heritage Pool" provides an annual 165 TWh of energy to consumers at a price of 2.79cents a kWh (Hydro-Quebec, 2008b). A similar framework, called "Prescribed Generation Assets," exists in Ontario for nine nuclear and hydro plants operated by Ontario Power Generation. By regulation, the production of these plants (between 60 and 70 TWh annually) cannot be sold at market price: the nuclear production (about 50 TWh) is sold at a regulated 5.68 cents a kWh, while the hydro production (about 20 TWh) is sold at 3.79cents a kWh (OEB, 2008a). The additional generation from Ontario Power Generation and other producers is sold at market price.

In all provinces except Alberta and Ontario, utility boards or commissions approve "average cost" rates, based on the total estimated cost of supply in their province, including a "reasonable" rate-of-return for the owner of the electricity company. In five provinces (British Columbia, Saskatchewan, Manitoba, Quebec and New Brunswick), the provincial government is the owner. In the remaining five (PEI, Nova

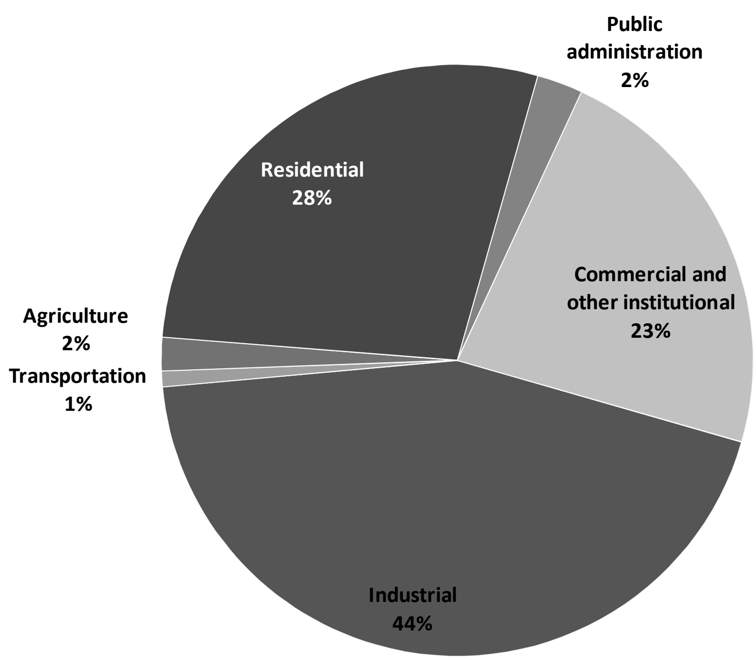
[10] 1 TWh = 10^9 KWh

Scotia, Newfoundland and Labrador, Ontario and Alberta), investor-owned companies also generate electricity.

In the case of Manitoba, for 2007-2008, this type of price regulation resulted in the sale of 21 TWh within the province, for an average revenue of 5.22cents a kWh (including distribution costs). On the other hand, 10.6 TWh of exports produced an average revenue of 5.90cents a kWh, excluding distribution costs (Manitoba Hydro, 2008). In the previous year, equivalent numbers were 5.07 and 7.22 cents a kWh, again illustrating the important financial gap between the provincial price and the regional value of electricity.

Taking the combined "low-cost" hydro production of just British Columbia, Manitoba, Ontario and Quebec, there are 250 TWh annually sold in Canada at about three cents a kWh (not including transmission and distribution costs).[11] This represents about 50% of the Canadian electricity demand, reaching 527 TWh in 2006, as shown in Figure 4. Consumers of all types benefited from these low prices, though the benefits were not evenly distributed across Canada or across income groups.

Figure 4. Canada's Electricity Demand by Sector in 2006: 527 TWh
(Statistics Canada, 2008)



An energy subsidy is defined as "any government action that lowers the cost of energy production, raises the price received by energy producers or ***lowers the price paid by energy consumers***" (UNEP, 2002, emphasis added). Thus, this current type of price regulation in the Canadian electricity sector represents a subsidy to consumers.[12] Indeed, many electricity consumers in Canada pay a lower price than the market price they would pay, simply because their provincial government regulates the price of electricity to its production cost plus allowed rate of return and only allows exports after provincial needs are satisfied. This policy has two immediate consequences:

- Investments in energy efficient equipment and the use of alternative energy are deterred by the low cost and availability of electricity (a "substitution effect", in economic terms, favoring more electric-intensive equipment; and

[11] However, the total hydropower production in 2006 was 319 TWh by utilities, plus 33 TWh by industries (paying very low, if any, water rights) for a total of 352 TWh of hydroelectricity production (Statistics Canada, 2008).

[12] Similar definitions can be found in other sources, such as IEA (2000) and EIA (2000).

- Consumption of electricity is inflated by its artificially low price (an "income effect", in economic terms, favoring higher consumption, simply because of its relative low costs).

Under article 92A of the Canadian Constitution, *Laws respecting non-renewable natural resources, forestry resources and electrical energy*, the electricity sector is outside federal jurisdiction. This explains why such diversity in prices, consumption levels and regulatory frameworks is observed (the same could be said about the situation in the United States). There is little coordination among provinces beyond technical and reliability issues, which occurs through the North American Electric Reliability Corporation and its eight regional entities.

This situation is far from optimal, however, because of the resulting market distortions in investment and consumption choices. Furthermore, from a planning and theoretical perspective, pooling resources and operating at a larger scale brings many benefits, such as avoiding higher-cost generation options when lower-cost ones exist. Larger scale operations can, however, have shortcomings: vulnerability increases, because failures can spread through the interconnected system (e.g., this is what happened, during the blackout in central Canada and the northeastern United States in August 2003), and the high cost of building out transmission lines can also offset the gains in pricing efficiency that might result.

Despite these issues, the international trends in electricity market are toward integration, progressively harmonizing regulation and prices in different jurisdictions (Box 2). In Canada, however, no plan exists to better integrate electricity sectors, either East-West within Canada or North-South with the United States.

Box 2. International Trends in Electricity Market Integration

Efforts to formalize and harmonize the institutional framework of the electricity sector have been made in regions around the world, from Europe and Australia (see below), to Latin America (e.g., the Andean Energy Alliance) and Africa (e.g., the Southern African Power Pool) .

Four initiatives are briefly highlighted here: ***U.S. failed attempt: Standard Market Design in Regional Transmission Organizations (RTOs)***. The U.S. Federal Energy Regulatory Commission (FERC) pushed, until 2005, for the creation of RTOs using a standard market design. This would have removed state regulation power in electricity pricing and provided a framework for more competition and electricity exchange across jurisdictions. However, resistance from states losing some regulatory power and from consumers losing their exclusive access to local low-cost electricity prevented this policy to be implemented (FERC, 2005; Benjamin, 2007).

- ***European Union common rules for the internal market in electricity***. A 2003 directive by the European Union (EU) forced all member countries to open their transmission network under common rules, open investment in generation and to offer supply choice to all consumers by 2007. Although disparities still exist among member countries, due to the lack of transmission capacity and consumer resistance (particularly in lower-cost countries, such as France), transparency over electricity supply and price increases, notably through new organizations such as the association of European Transmission System Operators (connecting system operators from all EU countries) and EuroPEX (Association of European Power Exchanges).
- ***NordPool: the first integrated international electricity market***. Nordic countries (Norway starting in 1991, Sweden joining in 1996, Finland in 1998, Eastern Denmark in 2000 and Western Denmark in 2007) are the first group of countries to harmonize their national electricity regulation to allow hourly spot trading among four different countries. Consumers can choose their electricity supplier and a common electricity price – only subject to transmission constraints – characterizes the market across jurisdictions.
- ***Australia's National Electricity Market***. Since 1998 (2005 for Tasmania), all Australian jurisdictions (except the state of Western Australia and the Northern Territory) started to trade electricity in a common market. Residential consumers were given choice over their electricity supplier and a single market price – subject to transmission constraints – characterizes the market. The interconnected grid spans over 4,000 km, North to South (National Electricity Marketing Management Company [NEMMCO], 2008). This is about the distance between Halifax and Calgary or Vancouver and Montreal.

2.2 Canadian Experience with Pricing Electricity for Sustainability

The growing Canadian experience with applying different types of pricing signals for electricity is worth exploring. Several such mechanisms have been introduced on a limited basis or are being explored by electrical companies in a number of provinces. This experience holds important lessons for Canada in looking to reform electricity pricing in support of sustainability.

2.2.1 Increasing Block Prices

Residential electricity consumers can be billed according to real-time market prices only in Alberta and, to a lesser degree, Ontario. In other provinces, regulated “increasing block prices” or “step-rate” prices are used (in Ontario also, for most residential consumers). This tariff corresponds to an average cost price that has two steps (and possibly more, in theory), with an increasing price for electricity consumption beyond the first step threshold. See Table 1, where this “step-rate” is illustrated for British Columbia, Ontario and Quebec.

The step-rate is still an “average cost” price because the price faced by consumers is an average of all production costs. However, it does send a better price signal to consumers because as their consumption increases, they pay a higher price – reflecting to some extent the higher production cost of that higher consumption. The step-rate also seeks to protect lower income consumers by ensuring that they can buy a given quantity of electricity at a lower price.[13]

As shown in Table 1, in British Columbia, Ontario and Quebec (which, together account for 75% of the Canadian population), most residential consumers pay a monthly charge, a first price for their consumption up to the threshold and then a higher price. Step 1 and 2 prices are lower in British Columbia and Quebec than in Ontario, partly because the Ontario step price is adjusted every six months to market conditions, while prices in the other two provinces can only be adjusted yearly, when the provincial regulator approves an increase. Prices in British Columbia and Quebec are maintained at a low level because of the high proportion of hydropower sold at the low “heritage price”, as noted above. It is also worth noting that the Ontario price is a sum of two components: an “electricity” charge and a bundle of other charges totaling 3.77cents a kWh.[14] In British Columbia and Quebec, energy, distribution and transmission prices remain bundled together.

[13] For example, in BC, the BC Utilities Commission required that the increasing block price be revenue neutral when it was introduced in 2008. This meant that the price per kwh for the first block of consumption fell relative to the price before. Thus, if consumers kept consumption within the first block, they would pay less than under the uniform price.

[14] These charges, specific to Toronto in this example, are the distribution charge, the network service charge, the wholesale market service charge and the debt-retirement charge. The amount of some of these charges varies across local distribution companies.

Table 1. Step-Rate Residential Tariff in British Columbia, Ontario and Quebec, 2009

	British Columbia	Ontario (Toronto)		Quebec
	Conservation Rate (Residential Inclining Block)	Regulated Price Plan		Rate D
		Summer (*May 1–Oct 31*)	Winter (*Nov 1–April 30*)	
Fixed charge /month	$3.77	$16.3		$12.36
Step 1 price /kWh	5.91¢	5+3.77 = 8.77¢	5.6+3.77 = 9.37¢	5.45¢
Threshold /month	675 kWh	600 kWh	1,000 kWh	913 kWh
Step 2 price /kWh	8.27¢	5.9+3.77 = 9.67¢	6.5+3.77 = 10.27¢	7.46¢
	As of April 1, 2009	As of May 1, 2008	As of Nov 1, 2008	As of April 1, 2009
	BC Hydro (2009a)	OEB (2009), Toronto Hydro (2009)		Hydro-Quebec (2009a)

Table 2 illustrates the annual electricity consumption of three types of consumers: those living in apartments; those in single attached houses; and those in single detached houses. In general, electricity consumption increases with the size of homes. The percentage of total electricity consumption purchased at step 1 price decreases as home size increases. For example, British Columbia consumers living in apartments buy 100% of their electricity at step 1 price, while only 62% of the consumption of those living in single detached houses is sold at that price. In all cases, a majority of the electricity consumption in these three provinces is sold at the lower step 1 price.

In British Columbia, consumers living in apartments do not, on average, fully use their "allocation" of electricity sold at step 1 price. Rather, they average only 6,528 kWh per year, when they could have used up to 8,100 kWh at 5.91cents a kWh. A similar feature exists in Ontario, though the price differential there between step 1 and 2 is much lower.

As, on average, electricity consumption grows with income (e.g. Pineau, 2008), most consumers paying the step 2 price have a larger income. This means that though step 2 prices are higher, they represent a small share of consumers' incomes. On the basis of that, one study of the very steep increasing block tariffs of California suggested that consumers tend to be unresponsive to the increasing marginal price they face (Borenstein, 2008), although real-life experience in California after their electricity market meltdown of 2001 – and the increase in prices that resulted – did show that higher prices can result in lower consumption. The Borenstein study also suggested that means-tested programs are a better equity tool (for income redistribution) than increasing block prices. Indeed, these step-rates allocate cheap quantities of electricity to consumers who usually are not targeted by welfare programs. Furthermore, higher-income households tend to use their full allocation of cheaper electricity much more frequently than lower-income households.

Table 2. Household Electricity Consumption and Amount Covered at Step 1 Price
(OEE, 2009)

		Apartments	Single Attached Row House	Single Detached
British Columbia	% of households	24%	14%	62%
	Annual Electricity Consumption (kWh)	6,528	9,707	13,088
	Annual Consumption at Step 1 price: ***max 8,100***	***>100%***	***83%***	***62%***
Ontario	% of households	11%	18%	71%
	Annual Electricity Consumption (kWh)	4,864	9,484	11,501
	Annual Consumption at Step 1 price: ***max 9,600***	***>100%***	***>100%***	***83%***
Quebec	% of households	33%	16%	51%
	Annual Electricity Consumption (kWh)	12,680	20,217	21,544
	Annual Consumption at Step 1 price: ***max 10,950***	***86%***	***54%***	***51%***

2.2.2 Time-of-Use Prices

To better reflect real-time prices, time-of-use (TOU) pricing is being implemented in British Columbia, Ontario and Quebec. Smart meters are being installed, allowing electricity consumption to be monitored second-by-second, rather than as a cumulated amount at the end of the billing period (as it is still the case for most consumers).

Table 3 shows how current TOU programs in Ontario and Quebec charge different amounts for one kWh, depending on the time of the day. In Ontario, prices vary between 7.77 and 12.57cents a kWh, while in Quebec extremes are both lower and higher: 3.55 to 18.06cents a kWh. Not all TOU programs have such "critical peak" electricity price in Quebec, however.

Ontario has the most ambitious goal: to have all homes and businesses equipped with smart meters by 2010. As of September 2008, local distribution companies across Ontario had installed 1.7 million smart meters (Conservation Bureau, 2008a). However, only 20,000 consumers had the TOU price as of July 2008 (OEB, 2008b). The Quebec TOU program is a pilot program in four cities that started in December 2008 and is scheduled to end in March 2010. In British Columbia, a *Smart Metering & Infrastructure Program* has been announced and should be implemented by 2012, but no details are available to date.

While TOU programs provide better real price signals to consumers, price levels should still correspond, at least to some extent, to market prices. This is not always the case. For example, the lowest off-peak price in Quebec would not even cover the Ontario transmission, distribution and other charges (3.55cents versus 3.77 cents a kWh, respectively). Even with TOU prices, Quebec consumers still pay (indirectly) subsidized electricity prices, except, perhaps, during critical peak periods.

Table 3. Residential Regulated Time-of-Use Rates in Ontario and Quebec (in cents per kWh), 2009

	Ontario Smart Meters			Quebec "RÉSO" Tariff				Quebec "RÉSO+" Tariff			
	All year	*Summer*	*Winter*	*Summer*		*Winter*		*Summer*		*Winter*	
	WKD	Weekdays	Weekdays	WKD	Weekdays	WKD	Weekdays	WKD	Weekdays	WKD	Weekdays
6 -7		7.77									6.10/8.06
7-11		10.97	12.57								6.10/8.06 or **18.06** up to 25 times*
11-17	7.77	12.57	10.97	4.60 /6.56	6.10 /8.06	4.29 /6.27	6.52 /8.50	4.60 /6.56	6.10 /8.06	3.55 /5.50	6.10/8.06
17-20		10.97	12.57								6.10/8.06 or **18.06** up to 25 times*
20-21			10.97								
21-22											6.10/8.06
22-6		7.77			4.60/6.56		4.29/6.27		4.60/6.56		3.55/5.50
	WKD=Weekends and holidays										
	Summer: May 1–Oct. 31; *Winter* : Nov. 1–April 30			First 15 kWh per day / beyond 15 kWh *Summer*: April 1–Nov. 30; *Winter* : Dec. 1–March 31							
	Ontario prices include electricity price and all charges (total of 3.77¢/kWh, Toronto Hydro charges).							*Up to 25 times per winter, Hydro-Quebec can call (or e-mail) consumers one day in advance to announce a “critical peak” period, with a price of 18.06¢/kWh.			
	Toronto Hydro (2009) and OEB (2009)			Hydro-Quebec (2009b)							

Note: BC Hydro is introducing the *Smart Metering & Infrastructure Program*. It will reach approximately 1.8 million residential and commercial BC Hydro customers by late 2012 (BC Hydro, 2009b:24)..

2.2.3 Demand-Side Management and Energy Efficiency

In addition to step-rate and TOU pricing, several electricity companies in Canada are promoting a better use of electricity through demand-side management (DSM) and energy efficiency programs.

These programs typically provide rebates for energy efficient appliances and light bulbs, support for expert energy assessments and grants for home retrofits, among other initiatives. Table 4 illustrates direct DSM spending in British Columbia, Ontario and Quebec for 2005, 2006 and 2007. While it is true that the upfront cost of an avoided MWh is high (from $86 to $232) when compared to the production cost of one MWh (from less than $30 to $100 or more), it is clear that the avoided cost is in fact a savings in cost, and one that recurs every year, while the production cost is a pure cost. This means that the investment per avoided MWh will save, over the years, many times the cost of producing one MWh.

Despite being successful and cost-effective (when investment costs are assessed against avoided future costs), the yearly savings are marginal compared to the electricity produced and imported in these three provinces: less than 1% in British Columbia, and less than 0.5% in Ontario and Quebec. In addition, measurement of the energy saved is always challenging, "since savings represent the absence of energy use or demand. Savings are determined by comparing measured use or demand before and after implementation of a program, making suitable adjustments for changes in conditions" (EVO, 2007). At least in the case of Ontario, the reported "data quality is a concern due to missing data and the application of somewhat different methodologies" (Marbek Resource Consultants, 2008).

In any case, there is a wide recognition in the energy efficiency literature that "adequate pricing is a necessary condition for promoting energy efficiency" (WEC, 2008). The primary principle is that price must provide the right market signals and reflect the opportunity cost of the use of the resources, along with negative externalities when they exist. Indeed, among the eight different energy efficiency barriers identified by the Ontario Power Authority, the first is *price signals* (OPA, 2007). Other barriers to energy efficiency include the lack of awareness, the limited product and service availability, consumer preferences, limited or uncertain finance, the level of transaction effort required, the risk that the energy efficient product may not perform as promised, split incentives and institutional, regulatory, or legal barriers. (See IEA (2007) for more details on market barriers and market failures inhibiting energy efficiency improvements.)

2.2.4 Carbon Pricing in Canada and Electricity Pricing Signals

GHG emissions driving climate change represent perhaps the most extraordinary market failure in human history. Four features mark this failure (Stern, 2007):

- climate change is an externality with global causes and global consequences;
- climate change will have long-lasting impacts, with future costs borne by future generations;
- uncertainties about the timing and the scope of impacts is high; and
- these impacts likely will have significant effects on the economy, not merely marginal ones.

Despite the increasing recognition of the seriousness of climate change, its causes and the existence of a market failure, governments around the world have not introduced any significant policies to deal with GHG emissions. The two most discussed approaches are: an absolute ceiling on allowed emissions, leading to a "cap-and-trade" system; and a levy imposed on every emission of GHG, leading to a "carbon (or CO_2) tax".[15]

[15] This levy should in principle be applied to all GHGs, including methane and N_2O, and not only to CO_2.

Despite limited attention to these approaches at national and international levels, two initial and encouraging steps have been taken by two Canadian provinces. These initiatives address fossil fuels (gasoline, diesel, natural gas, coal, propane, and home heating fuel):

- ***Quebec fossil fuel duty***. Since October 2007, fossil fuel distribution companies in Quebec have had to pay a duty equivalent to about \$3/ton of CO_2 (Gouvernement du Québec, 2007). This amount corresponds to the amount each distributor has to pay, per ton, to reach an annual contribution of \$200 million to the "Green Fund" created by the government, to promote energy efficiency initiatives. This annual total contribution is fixed by decree by the government.
- ***British Columbia Carbon Tax***. In July 2008, BC introduced a \$10/ton of CO_2 tax, applied to fossil fuels sold in British Columbia. This tax rises by \$5 a year for the next four years, reaching \$30/ton by 2012. This tax is revenue neutral, with an equivalent decrease in other individual and corporate taxes (Province of British Columbia, 2009).

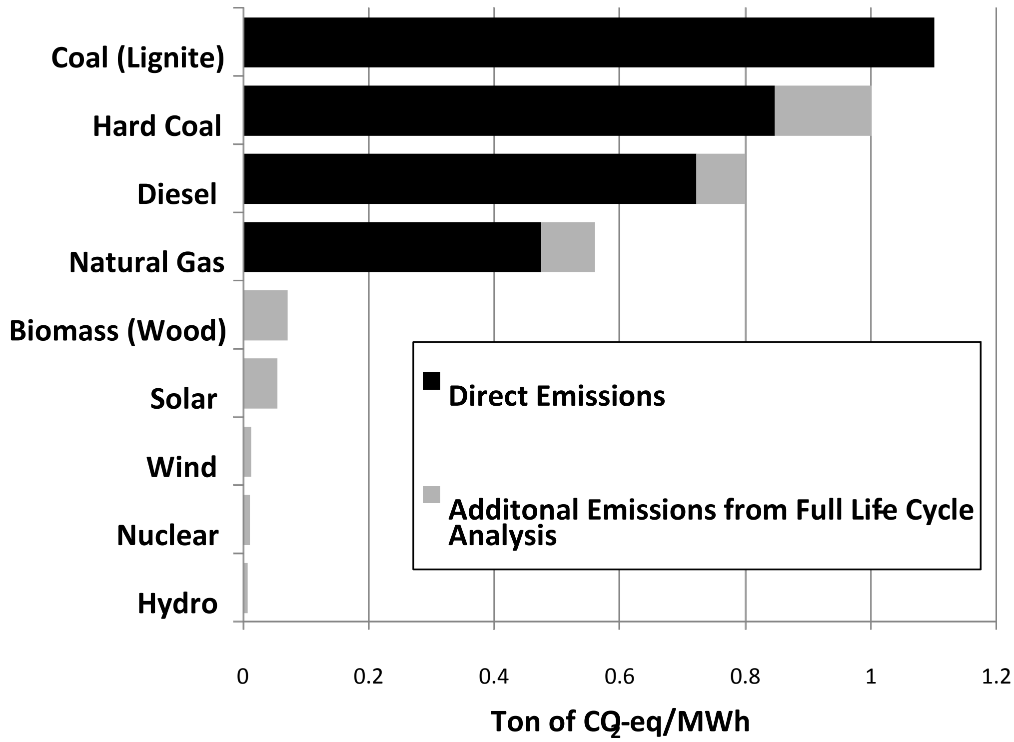
These levies are intended to internalize, to some extent, the GHG externality based on the fact that consumers, in their attempts to get the most out of their money, will start investing in less GHG-intensive transportation modes and heating sources, and will also use less fossil fuel when they keep their current stock of GHG-emitting equipment.

Given that electricity production in British Columbia and Quebec is dominated by hydropower (Figure 3), these carbon levies will not affect the price of electricity. However, these levies will accentuate an already problematic market distortion: because electricity is relatively cheaper than alternatives in these jurisdictions compared to other provinces (e.g., Alberta and Ontario), electricity consumption is higher than what it would be if electricity trade was fully open among provinces and no amount of energy was protected for local consumers. People use more electricity because the prices are still low relative to other means of getting the same services (think heat, where low electricity prices can out-compete natural gas).

To send a correct price signal to energy consumers, not only must a price on GHG emissions be implemented, but also a price for electricity that fully reflects its market value. Figure 5 shows how much GHG is emitted per MWh, both directly (at the generation site) and indirectly (through up- and down-stream activities related to electricity generation).[16] Coal-produced electricity leads to GHG emissions of about 1 t/MWh (equivalent to 1 kg/kWh), while natural gas-produced electricity is responsible for about half this amount. Nuclear and hydropower emit almost no GHGs (with emissions only coming from uranium mining and the construction of power plants and lines).

[16] Like extraction activities, dam building, photovoltaic panel construction, etc.

Figure 5. GHG emissions per MWh of Electricity from Different Sources
(Wesser, 2007)



If a carbon tax similar to British Columbia's was implemented in Alberta, then the electricity price would rise by about one cent a kWh each time the carbon tax increased by $10/ton. From its current level of about 11.5cents kWh (Figure 2), the Alberta residential price would reach 14.5cents a kWh with a $30/ton carbon tax, while the British Columbia electricity price would remain at 5.91cents a kWh (and 8.27cents a kWh, after the threshold). The opportunity cost for BC Hydro, already selling to consumers in that province largely below the export value most of the time, would rise by an amount equivalent to the carbon tax. But there is also an environmental cost in this policy, as well. Every MWh of hydropower *not exported* by one province results in more electricity being produced by fossil fuels in another province. Provinces with little hydropower have few non-fossil fuel alternatives and cannot import much from "hydro" provinces. Provinces in this latter group generally keep their hydropower for themselves, and because aggregate electricity use is higher than it would be with prices closer to marginal costs of generation, any hydropower generated is typically fully consumed.

3. Conclusions

If sustainable development is to become a reality in Canada, it will only be through some significant changes in our current investment and consumption patterns.

In any broadly based effort to reduce GHG emissions in Canada, the electricity sector emerges as a significant and necessary participant. First, it is the largest single source of GHG emissions. Second, as transportation currently relies almost entirely on oil, any shift away from it to reduce GHG emissions will require an alternative energy source – and that alternative source will be primarily electricity

However, electricity markets currently are not designed to promote the optimal use of electricity, and electricity trade across Canada does not allow for the most efficient investment in, and operations of, the electricity system. Recent concerns over electricity supply and the environmental impacts of electricity production mean that many provincial governments are now struggling to develop policy that balances the development of secure electricity generation with the mitigation of its environmental impacts. Finding a way forward, given these objectives, may involve full social pricing of electricity. Several provincial utilities already are experimenting with market-based pricing approaches for electricity and carbon that are consistent with the principles of sustainability. The experience gained through these efforts should be closely observed and shared. There remains, however, a large scope for strengthening electricity pricing in Canada in support of sustainability.

Electricity pricing reform on its own will not solve the challenge of reducing GHG emissions. However, such a shift is consistent with our belief in price signals and markets. Indeed, refusing to adopt such price signals for electricity and denying the cost of externalities are in direct contradiction with our economic principles. Canadian society, and the world, cannot grow and prosper on such a fundamental inconsistency.

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