Effect of Carbon Taxation Programs on Electricity Generation

Research Paper for ENVR S-130

Global Climate Change: The Science, Social Impact and Diplomacy of a World Environmental Crisis

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1.0 Introduction

The Intergovernmental Panel on Climate Change (IPCC) stated in their Summary for Policy Makers (SPM) that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (IPCC, 2007, p.2). Considering that consensus must be reached on each sentence in the SPM by government delegations from the some 130 member countries of the IPCC, the absolute certainty of this statement is alarming.

After about 20 years of public debate, about 150 years of scientific study, and about 250 years of industrial activity, the effect on our climate from anthropogenic emissions of carbon dioxide (CO_2) is "unequivocal". Though it is rightfully argued that the science will continue to be developed and the debate will continue to occur in a public arena (Weiskel, 2008), the general consensus of our time is that production of CO_2 primarily from fossil fuel combustion needs to be abated to mitigate against climate change.

According to James Hansen at al (2008), the current concentration of CO_2 in the atmosphere is 385 parts per million (ppm) and it is growing at a rate of about 2ppm per year. It is presented by Hansen et al (2008) that should anthropogenic CO_2 emissions cease, the "gap between equilibrium temperature for current atmospheric composition and actual global temperature is ~1.4°C." (p.6). This "warming in the pipeline" as coined by Hansen is due to the long half life of CO_2 in our atmosphere and the feedback loop from effects of the existing elevated CO_2 concentrations.

By focusing on the climate forcing of these slower feedbacks, Hansen et al (2008) argues that 350ppm CO_2 is a good base target for society though this level is about 70 ppm CO_2 above pre-industrial levels. They argue that effective action in reducing concentration can only be achieved via forward thinking policy changes to phase out coal unless carbon is captured plus carbon sequestration using agricultural and forestry practices (p.14). While this target is more aggressive than other targets which range up to 550ppm CO_2, there is a general consensus that policy changes are required (IPCC, 2007, p.18)

Fossil fuels remain available in such quantities that our continual reliance could force the climate past the “tipping point” and into the “point of no return” (Hansen et al, 2008, p.12). Kharecha & Hansen (2008) presented a figure showing a range of estimates for fossil fuel supplies in gigatonnes (Gt) of carbon and atmospheric equivalents of CO_2 based on 1 ppm CO_2 equaling approximately 2.12 Gt of carbon (p.3). This is illustrated in Figure 1.

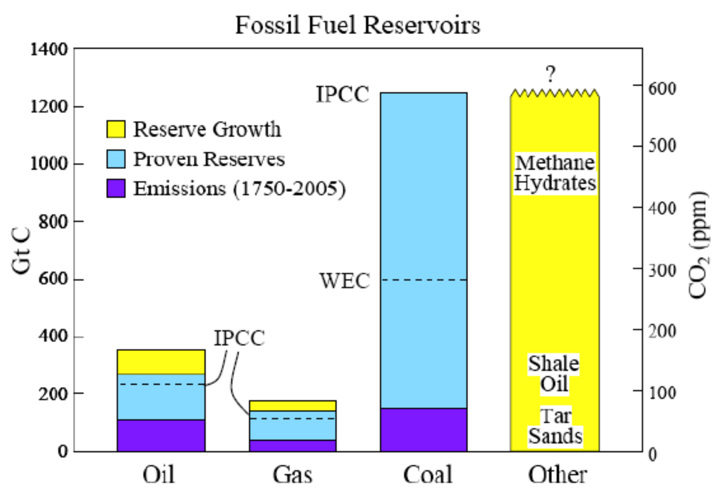

Figure 1 Global Fossil Fuel Supplies (Source: Kharecha & Hansen, 2008)

The purpose of this paper is to argue that a simple, well-defined economic instrument, such as a carbon tax, can be politically accepted acknowledging that it will provide financial incentive for electrical utilities to plan and invest in low carbon generation.

2.0 Role of Electricity Generation in Climate Change

Energy supply accounts for approximately 26% of total anthropogenic greenhouse gas (GHG) emissions in 2004 in terms CO_2 equivalent (IPCC, 2007, p.5). Many technologies currently exist to reduce the current carbon intensive energy production scenario. This is illustrated in Pacala & Socolow (2004) where they presented fifteen options where current technology exists to allow each option to be "ramped up" to each reduce a total of 25 Gt of carbon emissions over 50 years (p.968). As per Dr. Moomaw, the number of "wedges" required for climate equilibrium is available for discussion; however, feasible solutions can be implemented now to create change in society's continual forcing on the global climate.

There are six potential wedges that are directly related to electricity generation (Pacala & Socolow, 2004, p.970). This equates to a cumulative total of 150 Gt of carbon emission reductions over 50 years. These options from Pacala & Socolow that relate to energy generation are:

1. Increase efficiency of coal plants to 60% which could double the power output with advanced technology;
2. Replace 50%-efficient coal powered plants with gas power to increase gas power by a factor of four;
3. Capture CO_2 at a moderate starting rate of 800 gigawatt (GW) of coal;

4. Replace coal power with nuclear power at a rate of 700 GW which is twice capacity;

5. Replace coal power with wind power at a rate of two million 1 megawatt (MW) wind turbines which is about 50 times capacity; and

6. Replace coal power with photovoltaics at a rate of 2000 GW which is about 700 times capacity.

While the feasibility and carbon effects of some of these solutions can be argued (e.g., nuclear), the work completed by Pacala & Socolow emphasizes the dual points of: a) society's ability to effect change in CO_2 emissions with current technology; and b) the overall opportunity represented by changes to energy production in our "tool box" to address climate change.

3.0 Examination of Carbon Tax as an Incentive

It is widely put forth by scientists, panels and activists that substantive policy change is needed to realize a dramatic reduction in carbon emissions (Cooney, 2008; Gore, 2008; Hansen, 2008, p. 15; Sims et al, 2007, p. 305;). An economic tool eliminates often cumbersome regulatory mechanisms and processes and uses market forces to address climate change.

Carbon tax is one such tool being put forth. Within the Canadian context, it is being touted in the "Green Shift" platform of a federal political party. It is very simply promoted in the Green Shift Book (Liberal Party of Canada 2008) as follows: "By taxing pollution and making polluters pay, businesses will not only be encouraged to reduce the amount of GHGs they emit into the atmosphere, but it will also help stimulate innovation, the key to economic growth".

Undoubtedly this Canadian example is political positioning for the next election; however, it could have significant impact on the energy systems in Canada if implemented. Putting a price on carbon via taxation is often touted as the quickest way to stimulate technological changes as other mechanisms, such as a cap and trade system, often take several years to formulate (Pelly, 2008). One proven historical example is the switch from electric and oil fired boiler to biomass cogeneration for district heating in Sweden in the 1990's based on economic incentives from federal carbon taxation (Johansson & Turkenburg, 2004, p.8).

As per Pelley (2008), it has been modeled that if the price of CO_2 rose by $20 per tonne by 2050, the emissions in Canada may drop by as much as 60 percent below current levels. As with other jurisdictions and economies, government administrations are subject to vocal concerns and lobbying of industry groups who express concerns on economic implications of raising the cost of energy. As per Dr. Moomaw, other regulated or economic mechanized environmental protection measures, such as control of sulphur dioxide or ozone depleting substances, have historically spurred innovation and related economic growth. Putting a cost on carbon does not raise the cost of energy with a broad brush; rather it only increases prices of carbon intensive energy sources thereby encouraging efficiency and use of low carbon energy sources.

The secondary economic benefits of a revenue neutral carbon taxation program are described in a study completed in Canada by National Round Table on the Environment and the Economy (NRTEE). These include energy security, clean air and improved quality of life, reduced health care costs, capacity in new environmental technologies, targeting growth export markets and developing country needs, leveraging and commercialization of government funded research, news jobs and regional development, increased value-added knowledge based industries, and maintaining Canadian competitiveness (NRTEE, 2005, pp.15-19).

4.0 Case Study: Nova Scotia, Canada

4.1 Scope of Case Study Review

Using Nova Scotia, Canada, as a case study, an elementary evaluation of carbon taxation is provided at a rate of $20 per tonne based on Pelley (2008). In context of the federal plan that is being put forth by the Official Opposition Party, the price on carbon is proposed to start at $10 per tonne with annual increases to $40 per tonne in four years.

Given that political debates typically follow party lines (Smith and Myrden, 2008) and may not reflect government priorities, the financial impact of the carbon tax on Nova Scotians in their electricity purchase is reviewed in this paper. The effect on typical Nova Scotian families is being cited as a reason for the Provincial government to dismiss carbon taxation. The scope of this research paper does not include an economic assessment of new technologies for increased efficiencies in power plants, carbon capture and storage, or the other potential solutions suggested by Pacala & Socolow, 2004; rather it is assumed that increased costs of electricity generation due to a tax on carbon are passed directly to consumer. While it anticipated that innovation will be spurred from price points on carbon, this effect is not expected to be "immediate" in consideration of relative terms of elected timeframes.

The purpose of the case study review is to determine if economic impact to the "pocket book" of an average Nova Scotian family by carbon taxation is significant considering electricity only. The scope of this case study review does not include detailed assessment of tax structures nor does it include secondary benefits as per NRTEE (2005). This preliminary case study review is based on 2010 estimated business-as-usual practices with a revenue neutral carbon tax of $20 per tonne. An estimation of tax benefits is provided based on the Green Shift Book as prepared by the Liberal Party of Canada (2008); it does not represent a detailed economic assessment.

4.2 Context of Energy Use and Generation

Nova Scotia Department of Energy (NSDE) completed a background paper to the Nova Scotia Climate Change Plan for subsequent public consultation. This is within the framework of a legislated goal under the *Environmental Goals and Sustainable Prosperity Act* (Province of Nova Scotia, 2007). The purpose of the Climate Change Plan is ultimately to meet the Provincial target of a 10% reduction in GHGs from 1990 levels by the year 2020 (NSDE, 2007).

The per capita production of GHGs by Canadian Provinces was reviewed by Natural Resources Canada (NRCan). Nova Scotia is well under Alberta and Saskatchewan levels; however, it remains the fourth largest emitter per capita (NRCan, 2006). This is shown in Figure 2.

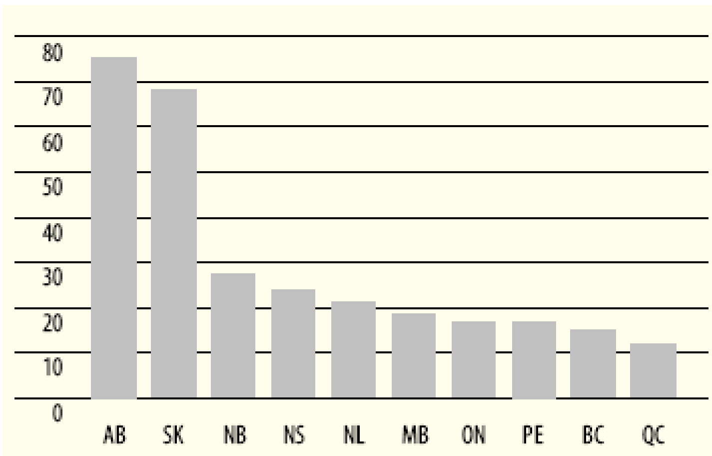

Figure 2 GHG Emissions per Capita, 2005 (tonnes person) (Source: NRCan, 2006)

In terms of electricity generating capacity, it was shown by NRCan (2006) that Nova Scotia has a heavy reliance on coal. This is expected to increase in next decade due to increasing local coal supply from surface and underground coal mining in the Province.

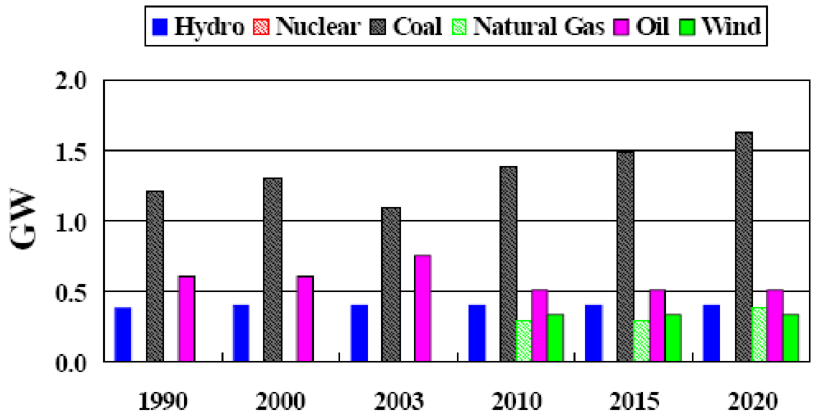

Figure 3 Nova Scotia Electrical Generating Capacity (Source: NRCan, 2006)

4.3 Effect of Carbon Tax on Residential Electricity Consumers

In order to complete a preliminary review on the economic effect of a $20/tonne carbon tax on residential consumers in Nova Scotia based on projected 2010 business-as-usual scenario, data is required for the calculations related to population and household income, residential energy demand, and makeup of fuel sources.

- The population is expected to remain stable at about 940,000 (NRCan, 2006, p.70);
- The average household income is estimated to be approximately $64,000 assuming, for simplicity, 3 persons per household (interpreted from Dodds and Coleman, 2001);
- Residential demand for electricity is expected to be 36% of total energy production in Nova Scotia (NRCan, 2006, p.72) or about 825 MW at a cost of 12 cents per kilowatt hour (kWhr) (Nova Scotia Power); and
- Fuel sources for electricity generation approximately compromised of coal at 50%, oil at 16%, wind and hydro at 13% each, and natural gas at 10% of the total fuel mix in Nova Scotian power plants (interpreted from NRCan, 2006, p.72).

Based on the above and as shown in Table 1 in Appendix A, the cost of electricity per average household in Nova Scotia is about $2000 per annum without a carbon taxation program. Based on Table 2 in Appendix A, approximate increase in cost of electricity generation in Nova Scotia is almost 50%. This is based on electricity generation sources (NRCan, 2006) and stated carbon taxation rates by unit for different types of generation sources (Liberal Party of Canada, 2008). This calculation does not take into account various efficiencies of power plants as operated by Nova Scotia Power. Further, it makes a conservative assumption of the business-as-usual scenario for power generation as previously stated, i.e., no change in technology or fuel sources.

It is estimated that the revenue neutral taxation plan would result in an average tax reduction for the typical Nova Scotian family of about $500 annually. This is an estimate based on tables provided in the Green Shift Book (Liberal Party of Canada, 2008, p.35); it is not a detailed taxation analysis. As calculated in Table 3 in Appendix A, the average annual increase in cost of residential electricity for the typical household is about $935. This results in a net increase in out-of-pocket expenses of $435 for a typical Nova Scotian family. This equates to about 0.7% of income before taxes or about $8.40 per week.

Based on this preliminary estimate of average net impact to typical households in Nova Scotia from a revenue neutral $20/tonne carbon taxation plan, it can be concluded that change in out-of-pocket expenses is about 1% of average disposable income (interpreted from Dodds and Coleman, 2001). A determination of significance is difficult, but it can be concluded that this may be a “tough sell” politically without some additional short term tax relief provincially to low and medium income earners.

The incorporation of many of the potential technological solutions to reduce carbon intensity of energy generation, such as those suggested by Pacala & Socolow (2004), will further reduce the net effect on Nova Scotians. Further, secondary benefits, as presented by NRTEE (2005), will have an indirect positive effect on the finances of Nova Scotian households. Finally, the implications of mitigating climate change effects by implementing the carbon tax and its subsequent effect on energy generation sources and technologies has value to Nova Scotians.

5.0 Conclusion

As climate science becomes increasingly alarming in its certainty of vast global implications from ongoing fossil fuel combustion, scientists are now regularly calling for policy to instigate dramatic changes in our energy generation practices, particularly related to coal (Hansen et al, 2008). Other scientific papers are clearly showing solutions that can be implemented today to reduce our reliance on carbon intensive fuel and inefficient energy generation (Pacala & Socolow, 2004). Despite this clear “call to arms” by the scientific community and other leaders (Gore, 2008), the media, the public and government administrations remain ambivalent to the changes that can and must occur.

Carbon taxation is but one of the economic incentives available to governments. It is being discussed in the federal realm of both Canada and the United States. Incorporation of all the benefits of putting a price on carbon – direct and indirect – into a mature public debate can create public and political will to lower CO_2 atmospheric concentrations toward the goal of 350 ppm CO_2.

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Table 1 Calculation of Power Usage and Cost for Residences

2,293	MW in NS (1)
36%	Residential use (2)
825	MW of residential use in NS
825,480	kWhr of residential use
$ 0.12	cost per kWhr (1)
$ 99,057.60	cost in NS kWhr
940,000	population (3)
2.2	persons per household (3)
427,273	households in NS
$ 0.23	cost per household hourly
$ 166.92	cost per household monthly
$ 2,003.07	cost per household annually

Sources

1 Nova Scotia Power, n.d.
2 NRCan, 2006
3 Dodds and Colemen, 2001

Table 2 Estimation of Increased Power Costs with $20/tonne Carbon Tax

Approx MW	***Type of Fuel for Generation***	***Change based on carbon tax***	
413	Coal, 50% (1)	23.8%	(2)
124	Oil 16% (1)	4.1%	(2)
99	Wind, 12% (1)	0.0%	(2)
99	Hydro, 12% (1)	0.0%	(2)
83	Natural Gas, 10% (1)	1.4%	(2)
825	Total residential use in NS (1)	46.7%	Weighted Increase

Sources

1 See prior table
2 Interpreted from Green Shift Book, 2008

Table 3 Estimation of Change to Electricity Cost by Household

Cost of electricity	$ 2,003.07	per household annually (1)
Cost with carbon tax	$ 2,938.08	per household annually (1)
Income tax returned	$ 500.00	per household annually (2)
Net cost implication	$ (435.01)	per household annually
Net cost implication	$ (8.37)	per household weekly
Household average income	$ 64,000.00	per household annually (3)
Percentage of income	0.68%	per household annually before tax

Sources

1 See prior table
2 Interpreted from Green Shift Book, 2008
3 Interpreted from Dodds and Colemen, 2001