ERG/200609

# Meeting NSPI's 2010 $SO_2$ emission reduction cap

Larry Hughes, Mandeep Dhaliwal, and Nikita Sheth
Energy Research Group
Department of Electrical and Computer Engineering
Dalhousie University
Halifax, Nova Scotia, B3J 2X4

17 July 2006

## 1. Background

In 1998, the federal, provincial, and territorial ministers of Energy and the Environment signed *The Canada-Wide Acid Rain Strategy for Post-2000*. One of the objectives of the strategy is "to meet the environmental threshold of critical loads for acid position across Canada" through a number of actions, including the establishment of sulphur dioxide ($SO_2$) emission reduction targets in eastern Canada (CCME, 2006).

Nova Scotia is both an area that exceeds critical $SO_2$ loads from trans-border emissions and a major emitter of $SO_2$ (CCME, 2006). In order to benefit from other jurisdictions reducing their emissions and to be seen to be playing its part, Nova Scotia is required to reduce its $SO_2$ emissions from a 1994-1999 cap of 189,000 tonnes (CCME, 2006), to a 2005 cap of 141,750 tonnes, to a 2010 cap of 94,500 tonnes (Royal Gazette, 2005).

One of the principal reasons for Nova Scotia's per-capita emissions being some of the highest in the country is Nova Scotia Power's reliance on coal for electrical generation. Given NSPI's dominance in the emissions of $SO_2$ in the province, it has been allocated over three-quarters of the required reductions.

In its 2001 Energy Strategy, the province of Nova Scotia outlined its plan to reduce its 1994-1999 cap, first by 25 percent by 2005, and then by a further 25 percent (of the original cap) by 2010. NSPI was to undergo the same allocation reduction in percentage terms (Energy Strategy, 2001). Table 1 shows the $SO_2$ limits for the province in general and NSPI in particular.

**Table 1: $SO_2$ allocation for Nova Scotia and NSPI[1]**

| Initial year(s) of cap | Provincial cap (tonnes) | NSPI's cap (tonnes) |
|---|---:|---:|
| 1994-1999 | 189,000 | 145,000 |
| 2005 | 141,750 | 108,750 |
| 2010 | 94,500 | 72,500 |

[1] In the 2003 Annual Progress Report for *The Canada-Wide Acid Rain Strategy for Post 2000*, Nova Scotia's cap of 94,500 tonnes for 2010 is footnoted as follows "Nova Scotia's forecast 94.5 kt by 2010 is a reduction target for existing sources and is not meant to be a cap." Whether this will make a difference come 2010 has yet to be established.

When Nova Scotia originally proposed these objectives in their 2001 Energy Strategy, there was an underlying assumption that meeting the 2010 caps would be achieved with little difficulty, given the availability of offshore natural gas (Energy Strategy, 2001):

> *A further 25% reduction by 2010 of $SO_2$ from the existing facilities' total, including NSPI, can be achieved through greater penetration of natural gas into the industrial and utility sector, and the continued use of low-sulphur coal.*

With the Sable Offshore Energy Project in rapid decline (Hughes, 2006), coupled with the lack of any significant offshore discoveries, it appears unlikely that natural gas will make a significant impact on NSPI's attempt at $SO_2$ emissions reduction.

## 2. NSPI's $SO_2$ emissions

NSPI's sulphur dioxide emissions are the result of generating electricity from three fuel sources, coal[2], heavy fuel oil (HFO), and light fuel oil (LFO); a fourth fuel, natural gas, is also used but is assumed to have zero $SO_2$ emissions. Of these four fuels, coal is the principal fuel used by NSPI (see Table 2).

**Table 2: NSPI's generation by fuel type (MWh)** (Toner, 2006)

| | Coal | HFO | LFO | Natural Gas | Total |
|---|---|---|---|---|---|
| 2002 | 8,742,343 | 276,560 | 44,796 | 1,664,877 | 10,728,576 |
| 2003 | 9,114,406 | 1,566,969 | 69,382 | 123,166 | 10,873,923 |
| 2004 | 9,433,441 | 1,684,403 | 70,768 | 96,755 | 11,285,367 |
| 2005 | 9,053,892 | 1,612,817 | 24,391 | 200,051 | 10,891,151 |

Coal is the dominant source of NSPI's $SO_2$ emissions. NSPI's $SO_2$ emissions by fuel and caps between 2002 and 2005 are shown in Table 3.

**Table 3: NSPI's $SO_2$ emissions and caps – 2002 through 2005 (tonnes)** (Toner, 2006)

| | Coal | HFO | LFO | Natural Gas | Total | Cap |
|---|---|---|---|---|---|---|
| 2002 | 128,851 | 2,826 | - | 0 | 131,677 | 145,000 |
| 2003 | 123,411 | 13,832 | - | 0 | 137,244 | 145,000 |
| 2004 | 120,770 | 15,251 | 54 | 0 | 136,075 | 145,000 |
| 2005 | 89,307 | 14,426 | 39 | 0 | 103,772 | 108,750 |

[2] Unless otherwise indicated, all references to "coal" refer to both coal and petroleum coke or petcoke.

As Table 3 shows, NSPI was able to reduce its $SO_2$ emissions by 31,463 tonnes from 2004 to 2005.[3] However, in 2005, NSPI's average unit fuel cost increased by 25 percent over 2004 levels to $30 per MWh; this was due in part to the use of low sulphur coal in the fuel mix (Emera, 2006).

In 2004, NSPI's $SO_2$ emissions were about six percent below the cap; in 2005, this margin had slipped to about five percent.

## 3. $SO_2$ intensity

$SO_2$ intensity is a measure of the number of kilograms of $SO_2$ emitted for each MWh produced by a given fuel. $SO_2$ intensity falls as the number of kilograms of $SO_2$ emitted per MWh declines. An $SO_2$ intensity of zero means that there are no $SO_2$ emissions associated with the combustion of the fuel.

The $SO_2$ intensity for NSPI's coal-fired generation is shown in Table 4 (this is simply the result of dividing each entry in Table 3 by the corresponding entry in Table 2 after converting tonnes to kilograms). The "Average" in Table 4 refers to the $SO_2$ intensity of NSPI, determined from the total $SO_2$ emissions divided by the total generation for a given year.

**Table 4: NSPI's $SO_2$ intensity by fuel (kg per MWh)**

| | Coal | HFO | LFO | Natural Gas | Average |
|---|---|---|---|---|---|
| 2002 | 14.74 | 10.22 | - | 0.00 | 12.27 |
| 2003 | 13.54 | 8.83 | - | 0.00 | 12.62 |
| 2004 | 12.80 | 9.05 | 0.76 | 0.00 | 12.06 |
| 2005 | 9.86 | 8.94 | 1.60 | 0.00 | 9.53 |

## 4. The 2010 cap

The 2010 provincial sulphur dioxide emission cap for NSPI is 72,500 tonnes. Meeting this cap will require reducing $SO_2$ emissions by 36,250 tonnes from the existing allocation of 108,750 tonnes. However, assuming that NSPI attempts to keep its $SO_2$ emissions at 95 percent of the 72,500 tonne cap, NSPI's cap would be 69,182 tonnes. If

[3] NSPI's $SO_2$ emissions reduction in 2005 can be attributed to a number of factors, not only the switch to low sulphur coal. For example, in 2005, NSPI reduced it use of coal and heavy and light fuel oil, increased its use of natural gas, purchased power, and hydroelectricity (the last two of which are not shown in Table 3 as they are both non-$SO_2$ emitting) (Emera, 2006).

NSPI were to maintain its 2005 $SO_2$ emissions level of 103,772 tonnes, the actual emissions reduction it would have to achieve would be 34,590 tonnes (103,772 – 69,182).

This section considers two ways of meeting the 2010 cap: first, using coal with a lower $SO_2$ intensity and second, replacing high sulphur coal with non-$SO_2$ emitting fuel sources.

### 4.1. Changing $SO_2$ intensity of coal

One way in which the $SO_2$ emissions can be reduced is to use coal with a lower sulphur content and hence a lower $SO_2$ intensity. In 2005, the coal used by NSPI emitted 89,307 tonnes of $SO_2$ while generating 9,053,892 MWh of electricity. If the same volume of electricity was to be generated from coal in 2010 and no additional sulphur-emitting fuels were to be used, the $SO_2$ emissions from coal would have to decline to 54,717 tonnes (89,307 – 34,590).

To achieve this level of emissions, the $SO_2$ intensity of the coal would be 6.04 kg per MWh (see Table 5). This is about 60 percent of the current $SO_2$ intensity of coal used by NSPI in 2005.

**Table 5: Coal $SO_2$ intensity for 2010**

| | |
|---|---|
| Production volume | 9,053,892 MWh |
| $SO_2$ emissions | 54,717 tonnes |
| $SO_2$ emissions ÷ production volume | $\frac{54{,}717{,}000kg}{9{,}053{,}982MWh}$ |
| $SO_2$ intensity | 6.04 kg per MWh |

### 4.2. Avoiding $SO_2$ emissions

At the other extreme, $SO_2$ emissions can be avoided entirely by removing or replacing the source of the $SO_2$, notably the coal, reducing $SO_2$ emissions by 34,590 tonnes to NSPI's cap of 69,182 tonnes. If the $SO_2$ intensity is known, the volume of electricity can be calculated.

Assuming that NSPI's $SO_2$ intensity were to remain at 2005 levels of 9.86 kg per MWh, this would mean reducing electrical production by 3,506,691 MWh (see Table 6). This is about 28 percent of NSPI's 2005 total generation.[4]

**Table 6: Electrical generation equivalent to 34,590 tonnes of $SO_2$**

| | |
|---|---|
| Intensity | 9.86 kg $SO_2$ per MWh |
| Quantity of $SO_2$ | 34,590 tonnes |
| Quantity ÷ intensity | $\dfrac{34{,}590{,}000kg}{9.86\dfrac{kg}{MWh}}$ |
| MWh | 3,506,691 MWh |

Table 7 shows NSPI's fuel mix for 2010; it assumes that with the exception of coal, electricity volumes produced by heavy fuel oil, light fuel oil, and natural gas remain unchanged, the $SO_2$ intensities for all fuels remain constant, and that the demand for electricity is the same as in 2005. If demand does not increase over 2005 levels, and NSPI can obtain 3,506,691 MWh of electricity from other sources that do not emit $SO_2$, the provincial cap can be met (clearly, if demand increases, it will be necessary to find additional fuel sources that do not emit $SO_2$).

**Table 7: NSPI's required fuel mix for 2010**

| | Coal | HFO | LFO | Natural Gas | Other source(s) | Total |
|---|---|---|---|---|---|---|
| MWh generated | 5,547,201 | 1,612,817 | 24,391 | 200,051 | 3,506,691 | 10,891,151 |
| $SO_2$ intensity | 9.864 | 8.944 | 1.599 | 0 | 0 | - |
| $SO_2$ emissions | 54,718 | 14,425 | 39 | 0 | 0 | 69,182 |

## 5. Reducing $SO_2$ emissions

Officials with NSPI have stated that the 2010 $SO_2$ cap is firm and will be met; this being the case, it is necessary to:

- Find about 3,500 GWh[5] of replacement electricity that do not emit $SO_2$ within the next 42 months (the time remaining until 1 January 2010), or
- Arrange for contracts for a continuous source of low sulphur coal starting in 2010, or
- Some combination of the above.

---

[4] NSPI's production volume in 2005 was 12,483,000 MWh (NSPI, 2006).

[5] For brevity, the 3,506,691 MWh will be expressed as 3,500 GWh. A GWh (gigawatt-hour) is 1,000 megawatt-hours

The remainder of this section expands upon the methods discussed in section 4, making a number of suggestions on how NSPI can reduce its $SO_2$ intensity to meet its 2010 cap.

### 5.1. Coal

In addition to using a lower sulphur content coal as suggested in section 4.1, there are other possible approaches to using coal that should be considered:

- Using a coal with a higher heat rate (with the same or lower sulphur content); that is, the available energy per unit of coal is higher.

  This idea, although reasonable, would probably lead to higher fuel costs, as costs increase as heat rates increase. However, whether it would be possible to find a coal with a sufficiently higher heat to reduce the quantity of coal combusted is open to question.

- Removing the sulphur from coal, either before combustion (usually by gasifying the coal) or after (by "scrubbing").

  Coal gasification is not a new technology, having been used in the 19$^{th}$ century for "town gas" (USDOE, 2006). Considerable research has taken place since then, resulting in the development of IGCC (Integrated Gasification Combined Cycle) generating stations; some of the benefits associated with IGCC is higher efficiency (40 percent and up) and almost complete $SO_2$ removal (EPA, 2006). A number of IGCC stations are in operation worldwide; there are at least five stations in operation in the United States (EPA, 2006).

  Installing a Flue Gas Desulphurization unit ("scrubber') onto the Lingan generating station, NSPI's original proposal, was turned down by a majority of stakeholders in June 2006. The postponement will delay the installation of the FGD unit until sometime in 2010 or even later.

  Technologies to remove $SO_2$ are becoming more commonplace; for example:

  - Ontario Power Generation operates two flue gas desulphurization units on the 1,975 MW Lambton coal-fired generating station. In 2004, the FGD units removed 95 percent of the $SO_2$ emitted by the combustion of coal. Total $SO_2$ emissions from OPG's fossil fleet fell from 157,805 tonnes in 2003 to 116,912 tonnes in 2004 (OPG, n.d.).

- As part of its $1 billion $SO_2$ emissions reduction program, Inco has spent $115 million completing its $SO_2$ fluid bed roaster at their Sudbury facility to reduce $SO_2$ emissions from 265 kilotonnes per year to 175 kilotonnes per year by the end of 2006. Inco plans to lower its $SO_2$ emissions to 66 kilotonnes by 2015 (Inco, 2006).

- Increasing the thermal efficiency of the power station; that is, increasing the number of MWh generated for the same quantity of coal.

  Since NSPI is running its existing coal fired plants at close to their maximum efficiency (estimated in the range of 35 percent), it is unlikely that it would be possible to increase the operating temperatures and pressures of existing steam cycles to allow coal to be burnt at higher temperatures. Although supercritical plants can operate up in the range of 43 to 45 percent (IEA Clean Coal Centre, n.d.) efficiency, it is unlikely that a plant could be given environmental approval and constructed by the 2010 cap date.

  Large-scale co-generation and district heating is another possible way of increasing the thermal efficiency of a power station; however, in order to displace an equivalent amount of $SO_2$, the fuels being used for space heating must produce sulphur emissions. According the CCME (2006), emissions from industrial and other sources in 2000 were about 27,000 tonnes, not only less than the amount by which NSPI is to reduce its $SO_2$ emissions, but the sources are distributed across the province, making $SO_2$ emissions reduction using district heating insignificant.

- Some combination of the above.

### 5.2. Demand Side Management

It has been suggested that NSPI should implement a Demand Side Management (DSM) program to reduce $SO_2$ emissions. This is a laudable goal, since it can also reduce the energy costs of individual consumers, something that can be of great benefit, especially to those on low-income.

Removing over 3,500 GWh by DSM would be no small feat, given NSPI's size. For example, Table 8 shows NSPI's annual sales in GWh by sector; in 2005, the size of each sector was roughly equal to the number of GWh that would have to be removed to meet the $SO_2$ reduction cap.

**Table 8: NSPI's annual sales in GWh by sector (Emera, 2006)**

| Sector | 2003 | 2004 | 2005 |
|---|---|---|---|
| Residential | 3,819 | 4,039 | 4,000 |
| Commercial | 3,001 | 2,965 | 3,004 |
| Industrial | 4,091 | 4,196 | 4,197 |
| Other | 586 | 473 | 436 |
| Total sales | 11,497 | 11,673 | 11,637 |

NSPI presented two sets of projections for the potential reduction in electricity usage by 2007 associated with their proposed conservation and efficiency plan (DSM program) in the 2005 rate hearings in documents submitted to the UARB:[6]

- Appendix F (Load Forecast Report), which shows reductions of 43 GWh and 16 GWh by their residential and commercial customers, respectively; industrial customers show no reductions associated with the DSM programme (NSPI, 2005a). The overall reductions are calculated to be 59 GWh.

  With the DSM programme in place, NSPI projects system growth to increase to 11,922 GWh in 2006, an increase of 1.2 percent over 2005. Without the DSM programme in place, the growth in demand is projected to be 1.7 percent.

- The conservation and efficiency plan document projects reductions of 59.97 GWh, 10.51 GWh, and 1.1 GWh for NSPI's residential, commercial, and industrial customers, respectively (NSPI, 2005b). The total demand reduction is 71 GWh. System demand increases to 11,910 GWh.

There are other approaches to demand reduction:

- Re-bulbing the province with Compact Fluorescent Lights. NSPI has about 240,000 residential customers with five or fewer CFLs; if NSPI was to purchase and install 1 million bulbs in these houses, the demand reduction would vary between 82 and 133

[6] The difference in expected reductions between the Load Forecast and the conservation and efficiency plan document was not explained by NSPI.

GWh, for 60 watt and 100 watt incandescent replacements, respectively. At an estimated $4 per bulb, this would cost NSPI about $4 million (Hughes, 2005).

- Smart Metering. Smart meters are metering devices that can record consumption at different times of the day, week, and season, thereby allowing the energy supplier to charge rates more closely related to the fuels used to generate the electricity. One of the benefits of smart metering is that customers often shift their loads from high-cost to low-cost times. The rates, commonly referred to as Time-of-Use, are in limited use in Nova Scotia, but are in widespread use in Europe (Italy has recently re-metered the entire country (Sauter, 2005)) and are growing in populating in some North American jurisdictions (Ontario has a plan to install meters throughout the province by 2010).

  Re-metering all 400,000 of NSPI's residential consumers at $300 per meter and $50 per installation will cost about $147 million. Although this is recouped from the consumer, NSPI would probably be expected to bear the cost until it was paid by the consumer. However, time rather than cost may be the issue – re-metering this many consumers over 42 months would require about 10,000 meters to be installed each month (500 per day).

  The results of a trial smart meter study in Woodstock, Ontario showed that the average consumer reduced consumption by 15 percent (CBC, 2005). If the Woodstock experience could be repeated in Nova Scotia, a 15 percent reduction in NSPI's 2005 residential demand of 4,000 GWh would mean, under ideal conditions[7], a fall in $SO_2$ emissions of about 6,000 tonnes ($4{,}000 \times 0.15$ GWh $\times 9.86$ kg per MWh).

### 5.3. Renewables

It has also been suggested that $SO_2$ emissions can be reduced by adopting renewable generation technology, notably wind. Replacing over 3,500 GWh of electricity from $SO_2$ sources by 2010 is problematic:

- NSPI has commitments to purchase no more than about 282 GWh from independent

[7] "Ideal conditions" means that the 600 GWh of demand reduction ($4{,}000 \times 0.15$ GWh) would have to be met by a coincident reduction in coal generation. There would be no $SO_2$ reduction if, for example, NSPI chose to reduce generation from low- or non-sulphur sources, such as natural gas or hydroelectric.

power producers over the next 9 to 29 years (Emera, 2006). Not all of these producers are actually in operation at this moment.

- The capacity required to meet the 3,500 GWh cap would depend upon the capacity factor of the equipment. In Table 9, the capacity, number of turbines, and cost for three different capacity factors are shown.

**Table 9: Total capacity, number of turbines, and cost to meet $SO_2$ reduction cap**

| Capacity factor | Capacity required (MW) | Number of 1.75 MW turbines | Cost ($2 million/MW) |
|---|---|---|---|
| 25% | 1,598 | 913 | $3,196,347,032 |
| 30% | 1,332 | 761 | $2,663,622,527 |
| 35% | 1,142 | 652 | $2,283,105,023 |

Currency fluctuations coupled with increasing construction costs are pushing up the price of turbines; in the U.S. Northwest, prices have increased by as much as 70 percent (Mulick, 2006).

- Due to rising worldwide demand for wind turbines, delays of up to 36 months have been encountered in their manufacture (GlobeNet, 2006). Furthermore, site selection and environmental assessments would delay the startup of any large-scale wind facility. It is unlikely that the number of turbines shown in Table 9 could be supplied to Nova Scotia within the next 42 months.

- The availability of the wind turbines does not necessarily mean that there will be a replacement of 3,500 GWh of electricity from $SO_2$ fuels. The intermittent nature of wind means that NSPI must keep spinning reserve available to meet any sudden or unexpected reduction in output from the wind; this should not be from fuels that will contribute to the $SO_2$ burden.

For example, in the U.S. Northwest, Bonneville Power Authority is having difficulty matching wind turbine output with hydroelectric supply because of seasonal variations in water levels as well as fish stock issues (Mulick, 2006).

### 5.4. Co-firing coal with biomass

Co-firing is the process of burning a biomass source (woody or herbaceous) with another fuel such as coal. It offers a number of advantages, including a reduction in $NO_x$ and $SO_2$

emissions; however, there are disadvantages, such as a decline in boiler efficiency and the potential for boiler corrosion. These disadvantages can be minimized with the careful selection of the biomass material. Furthermore, the combustion of biomass is carbon neutral, resulting in a lowering of $CO_2$ emissions (Sims, 2002).

In Europe, there is a growing market for co-firing coal with wood pellets, the result of rising coal costs (making pellets more attractive) and a drive to reduce air emissions such as $SO_2$ and $CO_2$ (REW, 2006). Wood pellets are more attractive than wood chips as they are easier to handle and transport, have lower moisture content, and are less prone to rotting.

Given the known availability of waste biomass in Nova Scotia (WLRI, 2004), further studies should be performed to determine the feasibility of co-firing with wood pellets.

### 5.5. Industry shutdown

An extreme solution that most Nova Scotians would prefer not to consider would be the closure of industries that are high volume users of electricity. For example, Stora-Enso and Bowater-Mersey, NSPI's two largest consumers, use about 2,000 GWh of electricity annually. If these consumers were to shutdown and NSPI stopped generating the equivalent volume of electricity from high-sulphur coal, this would meet over half the $SO_2$ emissions reduction cap.[8]

### 5.6. Compliance Fuels

Another alternative that has been suggested is for NSPI to purchase compliance fuels to meet the $SO_2$ reduction caps.[9] There are three questions that must be addressed when considering the use of compliance fuels:

- What fuels are to be used?

  Given NSPI's present generation mix, there are a limited number of possible low-

[8] Note that this is simply an example, the authors are not suggesting that either Stora-Enso or Bowater-Mersey should stop operations in the province.

[9] In NSPI's submission to the Air Emissions Strategy, it was suggested that the cost of compliance fuels (low and ultra-low sulphur coal) would be about $100 million annually for a 95 percent reduction (NSPI, 2006).

sulphur compliance fuels: coal, oil, and natural gas.[10]

- What countries will supply the fuels?

  Nova Scotia has indigenous supplies of high-sulphur coal and limited supplies of natural gas; its offshore oil field shutdown in the late 1990s. With over 90 percent being shipped out of the province, Nova Scotia's natural gas would appear to be of little help to the province. Furthermore, with the Sable project in rapid decline (Hughes, 2006) and Deep Panuke hinging on a decision by EnCana's board in late 2007 (EnCana, 2006), it would be folly to base an $SO_2$ reduction scheme on such an unsure source.

  There has been some talk of the construction of two liquefied natural gas regasification facilities on Nova Scotia's eastern shore (ref); however, with a shortage of LNG carriers and difficulty in finding long-term suppliers, there is some concern over whether either of these facilities will be built. Furthermore, the principal reason for constructing these facilities is to supply natural gas to the United States, not Nova Scotia.

  NSPI obtains fuel from Russia (coal), Columbia (coal), Venezuela (pet-coke), and the U.K. (oil). All of these sources are problematic: Russia has shown that it can break a contract at a moment's notice; workers in Columbia's coal-fields are brutalized; the war-of-words between Venezuela and the United States could escalate and result in a cessation of shipments to North America; and the U.K.'s North Sea oil fields have peaked and are in rapid decline.

- What will be the cost of these fuels?

  The cost of almost all energy sources is increasing dramatically. There are many reasons for this, from the growing demand for oil and coal in China, India, and the United States, to the declining number of countries that have energy to export, to

[10] Other fuels include municipal solid waste and biomass (discussed elsewhere in this paper). Given the reaction of Nova Scotians to the combustion of municipal waste in the early 1990s, and subsequent government legislation, it would seem unlikely that there will be any major shift towards using municipal waste as a fuel source in the near future. Furthermore, even if municipal waste were to be used, there are issues with its heating value, give inconsistencies in the waste stream.

international geopolitics. Without major new energy finds over the next decade, prices will continue to increase; even if new sources of fossil fuels are found, their costs will probably be considerably higher than today because they will have to be extracted from frontier regions.

### 5.7. Air emission fees

The Nova Scotia government has established a set of fees associated with a number of air emissions, including sulphur dioxide. At $3.85 per tonne of $SO_2$, these fees are remarkably low compared to other jurisdictions in North America. For example, the rate associated with sulphur dioxide emissions set by the U.S. EPA is on the order of $2,500 per ton (the fee is subject to an annual increase). The EPA's fees are three orders of magnitude greater than those set by the Nova Scotia government (EPA, n.d.; EPA, 1997; Choices, 2005).

In Nova Scotia's present air emissions fee schedule, sulphur dioxide has next to no value. For example, if NSPI's $SO_2$ emissions remained at 108,750 tonnes in 2010, the excess $SO_2$ emissions would be 36,500 tonnes (108,750 – 72,250); at $3.85 per tonne, NSPI would be subject to a penalty of about $140,000.

However, if the penalty was raised to $2,500 per tonne (close to that used by the U.S. EPA), the cost to NSPI would be over $90 million. The true cost of NSPI's emissions becomes evident when they are subject to environmental penalties such as those imposed by the EPA.

### 5.8. Emissions trading

In the United States, $SO_2$ emissions can be bought and sold, subject to EPA regulations. If NSPI were forced to buy emissions credits at EPA rates, they could meet their emissions requirements; however, the cost could become prohibitive (see previous section).

## 6. Recommendations for the Integrated Resource Plan

NSPI is required to developed an Integrated Resource Plan that will, in less than 42 months, allow NSPI to remove about 30,000 tonnes of $SO_2$ emissions. Any successful emissions reduction scheme must address these two issues: time and quantity.

Since neither NSPI nor Emera nor the provincial government have shown any leadership in moving NSPI off coal and onto other forms of generation[11], it is clear that NSPI will be using coal as its primary energy source for years and probably decades to come. This being the case, when NSPI burns coal, it should be burnt as cleanly and efficiently as possible.

However, there are other environmental issues, most notably climate change, which Nova Scotians can no longer afford to let NSPI ignore. Accordingly, the following should be taken into consideration when NSPI develops its IRP:

- Research should be conducted into the costs (capital and operating) and benefits (including environmental and social), as well as the lead times, into the following:
  - The construction and operation of an IGCC plant, fueled with coal (indigenous or imported).
  - Identifying sources of biomass, as well as the costs and benefits associated with pelletized biomass co-firing in NSPI's existing coal-fired units. Research should also be conducted on co-firing biomass with high-sulphur coal from Cape Breton. The analysis should also determine the benefits of reducing NSPI's reliance on foreign coal, reducing $SO_2$ emissions, and reducing $CO_2$ emissions.

  The results of this research should be compared with NSPI's existing FGD proposals and then used to determine which of these technologies will be the best suited to meeting NSPI's $SO_2$ emissions reduction cap.
- NSPI must reduce its $CO_2$ emissions along with its $SO_2$ emissions because removal of $SO_2$ will reduce the concentration of tropospheric aerosols, resulting in an increased

[11] NSPI's adoption of renewable energy from independent power producers has been slow at best and the long-term commitment is miniscule when compared to NSPI's total generation volume. The provincial government's Electricity Act of 2004, based upon the Final Report of the Electricity Marketplace Governance Committee, allows NSPI to ignore the province's so-called "renewable energy standards" as there are no penalties associated with failing to met the standards. However, it is not as if the EMGC and the provincial government were unaware of possible RPS programs, a 10 year program to reduce NSPI's greenhouse gas emissions by one megatonne by the Kyoto compliance deadline of 2012 was proposed in 2003 by Hughes (2003). The program would have required NSPI to add 100 GWh of renewables to its energy mix each year for 10 years; this would have put Nova Scotia about halfway towards reaching a provincial Kyoto-equivalent greenhouse gas emissions target (six percent below 1990 levels).

heating of the atmosphere (IPCC, 2001). NSPI should develop a 10 year plan to reduce its $CO_2$ emissions, presently around 10 megatonnes per year, by 10 percent (that is, one megatonne[12]) by 2015. This will require the retirement of an existing coal-fired unit that produces one megatonne per year.

- NSPI should be required to develop a tidal electricity program, as outlined in the EPRI report issued earlier this year (EPRI, 2005). The program should be accelerated with a goal of installing a tidal generating farm of at least 100 MW within six years. The output from the farm could be used to meet part of NSPI's one megatonne offset.

If NSPI is reluctant to pursue any of these suggestions, the provincial government should raise the sulphur dioxide air emissions fee 10-fold each year over the next three years (to $10 in 2007, $100 in 2008, and $1,000 in 2009). This will put into focus the importance of removing $SO_2$ from the atmosphere. The fees collected can go into funding research into alternatives to fossil-energy use in Nova Scotia.

## Acknowledgements

The authors would like to acknowledge the assistance of Mr. Aaron Long of the Energy Research Group for his comments on this report.

## References

CBC, 2005. CBC News Online, *In depth: Energy – Smart meters: FAQs*, 3 November, http://www.cbc.ca/news/background/energy/smartmeters.html, Accessed 14 July 2006.

CCME, 2006. Canadian Council of Ministers of the Environment, *2003 Annual Progress Report on The Canada-Wide Acid Rain Strategy for Post-2000*, ISSN 1488-948X

Choices, 2005. Choices magazine, *Lessons learned from $SO_2$ allowance trading*, Robert Stavins (author), First quarter, http://www.choicesmagazine.org/2005-1/environment/2005-1-11.htm. Accessed 16 July 2006.

EPA, n.d. Environmental Protection Agency, *Acid Rain Program $SO_2$ Allowances Fact Sheet*, http://www.epa.gov/airmarkets/arp/allfact.html

EPA, 1997. Environmental Protection Agency, *Acid Rain Program: Notice of Annual*

[12] Nova Scotia's Kyoto target ($CO_2$ emissions 6 percent below 1990 levels) would require an emissions reduction of about two megatonnes of $CO_2$. Since NSPI contributes slightly less than half of the province's emissions, NSPI's Kyoto target was calculated to be about one megatonne.

*Adjustment Factors for Excess Emission Penalty*, http://www.epa.gov/fedrgstr/EPA-AIR/1997/October/Day-07/a26531.htm

EPA, 2006. Environmental Protection Agency, *Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies*, EPA-430/R-06/006, July, http://www.epa.gov/airmarkets/articles/IGCCreport.pdf. Accessed 16 July 2007.

EPRI, 2005. Electric Power Research Institute, *Nova Scotia Tidal In-Stream Energy Conversion (TISEC): Survey and Characterization of Potential Project Sites*, George Hagerman (author), December.

Emera, 2006. Emera Corporation, *2005 Annual Financial Report*, May.

EnCana, 2006. EnCana news release, *EnCana and Nova Scotia establish framework for Deep Panuke natural gas development*, 30 June.

Energy Strategy, 2001. Government of Nova Scotia Energy Strategy, *Seizing the Opportunity*, vol. 2, December.

Globenet, 2006. *Plans for wind turbine production in B.C.*, 20 January.

Hughes, 2003. Larry Hughes, Kathleen Bohan, Khosrow Jafapur, Howlan Mullally, Jaspreet Singh, Energy Research Group, Dalhousie University, *Review of EMGC's Recommendations for a Renewable Portfolio Standard for Nova Scotia*, June. Available from http://dclh.electricalandcomputerengineering.dal.ca/enen/rps.pdf

Hughes, 2005. *Comments and recommendations regarding NSPI's Conservation and Energy Efficiency Plan 2006*, submission to UARB, December.

Hughes, 2006. Larry Hughes, Energy Research Group, Dalhousie University, *Notes on Sable Natural Gas Production December 1999 to November 2005*, Report ERG/200601, January.

IEA Clean Coal Centre, n.d. Clean Coal Technologies, http://www.iea-coal.org.uk/content/default.asp?PageId=65. Accessed 14 July 2006.

IPCC, 2001. Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis*.

Inco, 2006. *Inco launches new state-of-the-art facility to reduce emissions in Sudbury by 34 per cent*, 23 June, http://www.inco.com/investorinfo/newsreleases/default.aspx?posting_id=3679, Accessed 15 July 2006.

Mulick, 2006. Chris Mulick, *Challenges emerge for wind power*, Tri-city Herald, Kennewick, Washington, 12 July, http://www.tri-cityherald.com/tch/local/story/7956605p-7850113c.html. Accessed 15 July 2006.

NSPI, 2005a. Nova Scotia Power Incorporated, *Appendix F, Load Forecast Report*, submission to UARB rate hearings. May.

NSPI, 2005b. Nova Scotia Power Incorporated, *Conservation and Energy Efficiency Plan 2006*, submission to UARB rate hearings, November.

NSPI, 2006. Nova Scotia Power Incorporated, *Nova Scotia Power Technical Conference Lingan 3 LNCFS and Lingan 3 & 4 FGD*, 6 and 7 March.

OPG, n.d. Ontario Power Generation, *Sustainable Development Report 2004*.

REW, 2006. Renewable Energy World, *A fuel of convenience - why pellets are packing the power*, Jackie Jones (author), May-June.

Royal Gazette, 2005. Nova Scotia Royal Gazette, Part II – Regulations.

Sauter, 2005. Raphael Sauter, personal communication, January.

Sims, 2002. Ralph Sims, *The Brilliance of Bioenergy in Business and Practice*, James X James.

Toner, 2006. Terry Toner, Nova Scotia Power Incorporated, e-mail correspondence, 10 July.

USDOE, 2006. U.S. Department of Energy, *Pioneering Gasification Plants*, June 2006, www.fossil.energy.gov/programs/powersystems/gasification/gasificationpioneer.html. Accessed 16 July 2006.

WLRI, 2004. Whale Lake Research Institute, *A Study of Biomass Inventory, Costing, Processing Logistics and Equipment for the Production of Fuel Ethanol and Co-Products in Nova Scotia*, Report prepared for Nova Scotia Department of Energy and Biovision Technology Inc., July.