Reducing Sulphur Emissions from Heavy Fuel Oil Use — *A Quantitative Assessment of Economic Instruments:*

Executive Summary

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1.0 Introduction

The National Round Table on the Environment and the Economy (NRTEE) has initiated a program on Ecological Fiscal Reform (EFR) to investigate the use of various economic instruments to address environmental concerns. The case study on reducing sulphur emissions from use of heavy fuel oil (HFO) focused on the relative merits of using economic instruments – for example, increased product tax or capital cost allowance incentives – compared with more common approaches, such as regulation, in meeting environmental policy objectives.

Previous experience from EFR case studies indicates the right conditions must be present to investigate the practical application of economic instruments, since environmental concerns that are already being addressed farther along in the policy development process present limited opportunities for a new approach. A preliminary review revealed favourable conditions to study the use of economic instruments to reduce sulphur emissions from HFO use, as follows:

- while Environment Canada had discussed action to address sulphur levels in HFO, the issue was still at the "problem definition" stage;
- the application of economic instruments had been considered in the department's Notice of Intent (NOI); and
- experience in the European Union (EU) suggests economic instruments can be successfully employed to reduce sulphur pollution from HFO use.

This Executive Summary presents background information on HFO and its use, as well as the key findings and conclusions of the cost-effectiveness analysis comparing economic instruments to regulation.

2.0 What is heavy fuel oil?

HFO is a low-grade fuel primarily used in industrial boilers and other direct source heating applications (i.e., blast furnaces). It is also used as a principal fuel in marine applications in large diesel engines. Given its high boiling point and tar-like consistency, HFO typically requires heating before it can be moved through pipes or dispensed into a boiler or other heating vessel to be burned.

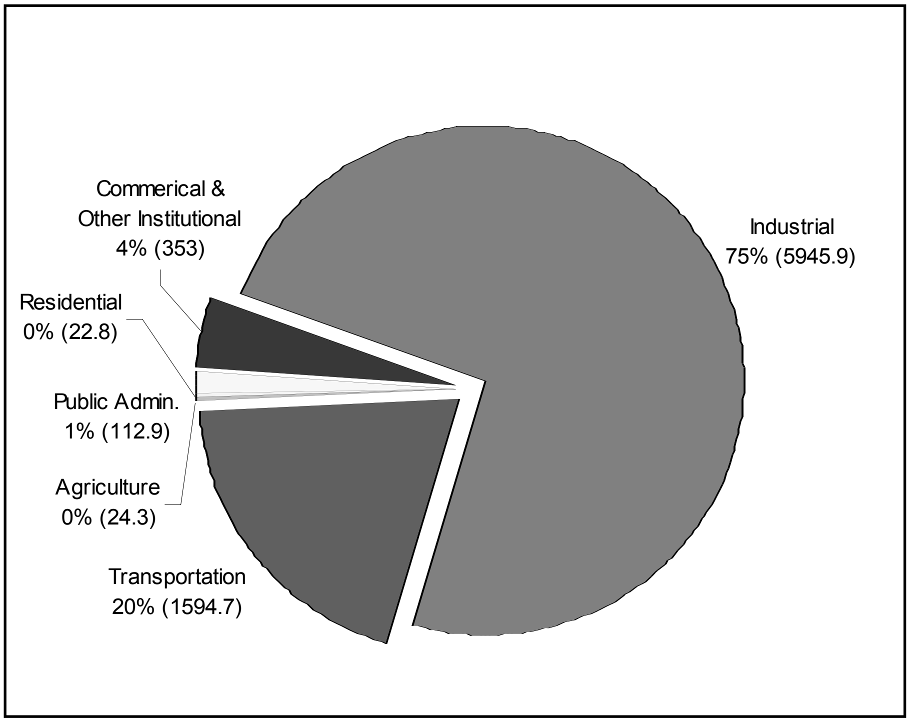
HFO is the least expensive of the refined oil fuels and can only be used by facilities that have preheating capabilities. HFO is typically high in sulphur and other impurities that are released into the air when the fuel is burned.

Who uses heavy fuel oil?

HFO is predominantly used in central and eastern Canada. HFO use in western Canada is limited, largely due to the availability of natural gas (NG). There is little or no HFO use in northern Canada. As shown in Figure 1, the three largest consumers of HFO are the industrial, transportation,[1] and commercial and institutional sectors, which collectively account for more than 98 percent of HFO use in Canada. The industrial sector accounts for 75 percent of this use.

[1] The majority of HFO use in the transportation sector is in marine applications.

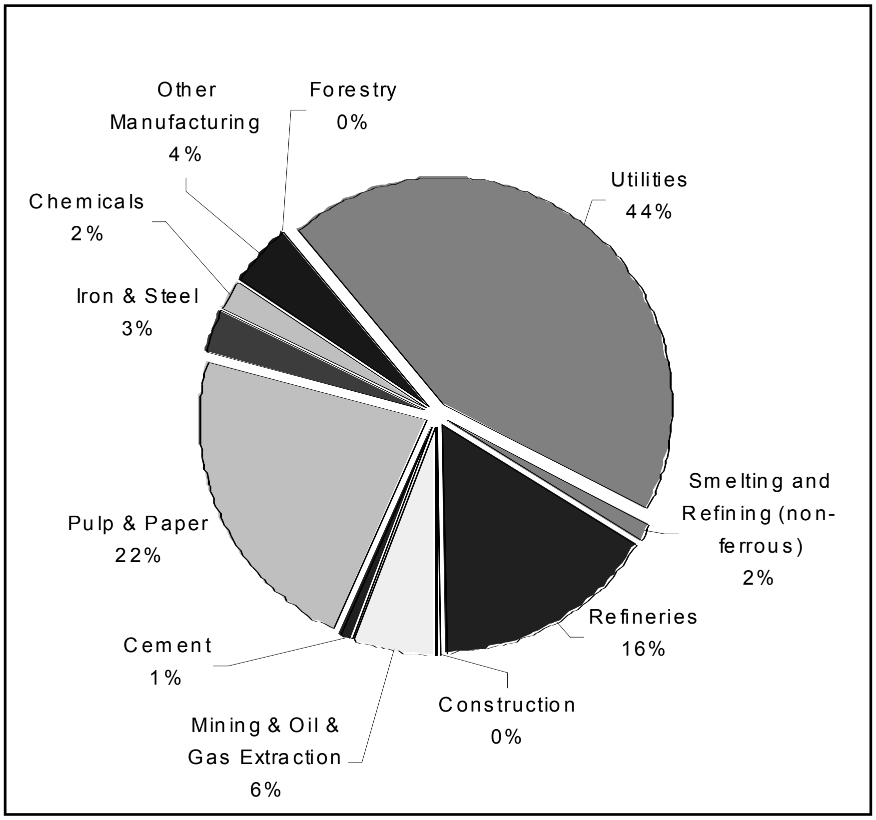
Figure 1: HFO Use in Canada in 2000 by Sector (1000 m3)



Source: Information derived from *Energy Supply-Demand in Canada*, Statistics Canada 2000.

This case study focused on regions and sectors where HFO use is greatest. Provinces included in the study were British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. Sectors included were utilities, pulp and paper, refineries, iron and steel (see Figure 2), and the institutional sector (municipalities, universities, schools and hospitals). Transportation was not included in the case study principally because HFO use in this sector is found in marine applications — a significant portion of the HFO sold in Canada for this purpose is likely to be burned elsewhere and governed by other, international regulations.

Figure 2: Industrial HFO Use by Sector 2000



Source: Information derived from *Energy Supply-Demand in Canada*, Statistics Canada 2000.

4.0 Why is it important to address sulphur levels in heavy fuel oil?

HFO use releases sulphur dioxide (SO_2), a key component of acid rain, into the atmosphere. The sulphur contained in HFO also forms sulphate particles (SO_4) that contribute to the formation of fine particulate matter ($PM_{2.5}$), a pollutant with substantial implications for public health.[2] Therefore, reducing sulphur emissions from HFO use reduces the release of pollutants into the air and benefits the environment and public health.

Currently, there is no regulated national standard for sulphur levels in HFO. On the contrary, trends suggest that the sulphur content of HFO produced in and imported into Canada is increasing. The trend toward higher-sulphur HFO could increase over time as other jurisdictions (e.g., the EU) move to lower the sulphur content of the fuels they use, resulting in increased export of their higher-sulphur HFO. At the same time, the availability of sweet crude (crude that is low in sulphur content) is diminishing globally, which may contribute further to increasing use of higher-sulphur HFO in Canada.

[2] The combustion of fossil fuels also results in emissions such as oxides of nitrogen, carbon dioxide, other fine particulates and volatile organic compounds. Actions to reduce sulphur emissions must ensure that other pollutants do not increase as a result of these actions.

5.0 What did the analysis consider?

A cost-effectiveness analysis was used to determine how economic instruments compare to regulation in controlling sulphur emissions from HFO use. The regulatory approach was selected as the base case for comparison, with the date for implementation set at 2010.[3] All other management options (i.e., the increased tax, the Accelerated Capital Cost Allowance and emissions trading) were compared to the regulatory base case, which resulted in four scenarios. In addition, three other scenarios examined the following combinations of options, for a total of seven scenarios:
(1) regulation plus Accelerated Capital Cost Allowance (ACCA); (2) product tax plus emissions reduction rebate; and (3) regulation plus emissions trading.

The analysis is based on the ability of each management option to satisfy three key criteria: environmental effectiveness; economic efficiency; and the equitable distribution of costs and benefits, both regionally and sectorally. A more thorough description of the analysis is presented in the full report, *Reducing Sulphur Emissions from Heavy Fuel Oil Use—A Quantitative Assessment of Economic Instruments*. For the purposes of this overview, the analysis involved the following steps:

- establishing the key market assumptions, such as fuel pricing;
- estimating HFO use and SO_2 emissions in 2010;
- defining the likely technical (i.e., pollution-control equipment) and management options;
- creating the economic models; and
- conducting the analysis and summarizing results.

6.0 What factors were most important to the outcome?

Monte Carlo analysis was used as part of the detailed evaluation in the quantitative assessment. Monte Carlo analysis is a statistical methodology that is used to weigh the relative importance of variables like fuel price and predict how uncertainties associated with such variables could influence outcomes. The observations from the Monte Carlo analysis were as follows:

- Overall, SO_2 reductions can be predicted with a higher degree of certainty than can compliance costs (the costs associated with complying with the respective scenarios). The range of uncertainty for compliance costs is therefore wider than that for predicted outcomes.
- The most important variables in achieving the policy objective for the regulatory scenario are the price of HFO and its substitutes — NG and Low Sulphur HFO (LS HFO) — followed by the cost to refiners of investing in abatement equipment and, lastly, the starting quantities of HFO use across the sectors.
- For the tax-rebate option, under which a product tax is applied based on the sulphur content in and an equivalent rebate is if firms achieve the equivalent to the 1-percent policy objective in emissions reduction using abatement control equipment, the price of HFO and its substitutes is the most

[3] The year 2010 is when regulation would most likely be implemented, based on the tentative schedule discussed in Environment Canada's NOI.

important variable and a key determinant of the outcome. Elasticity of demand (which refers to how a change in price translates to a change in consumption) is also a key contributor to greater uncertainty for the outcome as a result of the tax compared with regulation. The cost to refiners of investing in abatement equipment and the starting quantities of HFO are less important variables, similar to the observations in the regulatory option.

This analysis suggests the price of HFO and its substitutes are of critical importance to the attainment of the policy objective. In particular, the price differential between HFO and LS HFO is a key determinant of the cost-effectiveness of compliance. Factors that may affect the relative pricing of HFO and LS HFO by 2010 are: world prices for the different grades of HFO; the price differential between sweet and sour crude oil; the availability of synthetic crude oil; asphalt demand; NG prices; and the cost of fuel switching. Thus, it is difficult to predict with any certainty the relative prices of HFO and LS HFO in 2010.

The HFO case study revealed that energy management is of critical importance to the sectors that were reviewed. Decisions on fuel type, quality and cost are important factors in the daily and, in some cases, hourly management of energy within facilities. Decisions about fuel switching are shorter term, in contrast with decisions about somewhat longer-term investments as (e.g., investing in abatement equipment). Decisions about larger and longer-term investments will also be substantially affected by fuel prices.

Thus, the uncertainty associated with energy markets and fuel prices in the future is critical to understanding and predicting how sectors will respond to a given approach.

7.0 What were the findings of the analysis?

The key findings presented below are from section 6.0 of the full report on quantitative assessment.

The cost-effectiveness analysis provides a number of insights that are useful to reaching conclusions on the relative merits of using economic instruments compared with regulation:

1. In the regulatory scenario, the objective of 1-percent sulphur by weight in HFO was significantly exceeded under both the real-time limit (140 percent of the policy objective) and the averaging limit (113 percent of the policy objective). This was due to fuel switching (in particular, the replacement of HFO with NG) by facilities, as well as to adoption of flue gas desulphurization (installation of abatement equipment) by refiners. Both switching to NG and the use of abatement equipment result in large reductions (99 percent and 90 percent in SO_2 emissions respectively) that exceed the policy objective. This overcompliance may result in higher compliance costs than is justified by the policy objective.

2. Investigation of the ACCA demonstrated limited savings to industry relative to overall compliance costs. Thus, the ACCA alone would not provide sufficient incentive to industry to invest in technology (e.g., abatement equipment) to reduce sulphur emissions from HFO use. However, the ACCA is capable of lessening the financial impact of increased tax or regulation. The ACCA may also help to address unequal regional impacts.

3. The combination of increased product tax with emissions reduction rebate may result in more uncertainty in achieving the policy objective compared with the regulatory scenario. This is due in part to the significant uncertainty that exists in demand elasticity, which is key to setting a tax

rate that achieves the policy objective. If the demand elasticity is too high, then the tax increase will not be sufficient to trigger reductions in the demand for HFO sufficient to achieve the policy objective. Conversely, a demand elasticity that is too low will result in a tax rate that is high and in overshooting the policy objective. In turn, exceeding the policy objective results in higher compliance costs relative to the costs of the policy objective However, the tax can be used flexibly to achieve the desired policy objective, mitigate the inherent uncertainty in the tax instrument and reduce unnecessary compliance costs.

4. In the modelling, a tax schedule (function) was estimated as the basis of a national tax rate to achieve the objective of 1-percent sulphur by weight in HFO. Given the ability to alter the tax rate to affect the policy outcome, the tax schedule can be modified in response to observations about the effectiveness of the tax-rebate combination. Flexibility in the tax schedule allows for flexibility in the tax-rebate scenario — that is, the tax schedule can be altered over time if response to the tax measures overachieves or underachieves the desired 1-percent objective. Furthermore, the tax-rebate scenario also allows firms flexibility. They can pay tax and do nothing to reduce emissions or they can avoid the tax burden by investing in pollution abatement equipment at a more opportune time.

5. In the tax-rebate scenario, adjusting the tax rate can shift sulphur emissions from HFO use closer to the 1-percent objective; however, the effectiveness of this option is constrained by the price differential between LS HFO and HFO — the higher the price differential, the greater the ability for the tax to be used to offset compliance costs and more closely achieve the policy objective. In the model, the low assumed price differential resulted in an outcome for the tax-rebate scenario that was identical to the outcome for the regulatory scenario.

6. Without a rebate mechanism, the tax-alone option (e.g., just a tax on HFO or a tax on emissions for refiners is only slightly less cost-effective than the regulatory option, since firms are faced with both a tax increase on the HFO they continue to burn and fuel switching/abatement equipment costs. Emissions are not reduced as much relative to the regulatory base case or the tax-rebate option. Thus, the tax-rebate option is preferable to the tax-alone option.

7. Refiners present a special case and should be accommodated within the tax-rebate scenario. Since the cost of residual fuel oil is lower for refiners who generate the fuel as a by-product of the refining process, special consideration is required for refiners. Specifically, the tax instrument must determine the price point for changing behaviour (i.e., investing in abatement equipment) to provide an incentive to reduce emissions rather than just pay the tax and continue to burn residual fuel oil.

8. A note on elasticities: the literature indicates that demand responses to changes in fuel oil prices in the residential sector are greater with price increases and smaller with price decreases. As prices (taxes) increase, investments in abatement equipment or boiler conversions are made in response to the price increase. However, as prices drop, the investments and gains have already been made and cannot be reversed. Thus, the demand response to a subsequent price decrease may be less (i.e., the demand elasticity is smaller for a price drop than for a price increase). In applying this observation to our scenarios, an understanding of this differentiation in demand elasticities

would be important to facilities that would be making capital investments; however, it would not apply to facilities that retain the ability to fuel switch between HFO and NG.

9. The implication of this observation is that tax rates should not be set high initially if there is uncertainty in the demand response, since subsequent downward adjustments may not erase economic inefficiencies resulting from the high tax rate. Instead, taxes should be phased-up and demand responses observed. Tax increases can then be used to achieve the policy objective and minimize compliance costs.

10. A product tax may be faster to implement than a regulation. Results in Europe have shown that a sulphur tax can achieve the environmental target within a relatively short time.

11. This analysis has shown that emissions trading may be cost-effective relative to taxes and regulations, and may allow maximum flexibility to achieve the environmental target. However, results from other jurisdictions suggest the need to further examine transaction costs and the capacity to develop regional markets before deciding on the feasibility of an emissions trading program for HFO.

12. The flexibility inherent in the tax-rebate and emissions trading scenarios also provide for a more measured response by industry in the event that regulators wish to achieve more stringent policy objectives in the future.

8.0 What can be concluded from these findings?

As in most policy investigations, the performance of individual options varies across the criteria, suggesting that selecting one option over another involves some trade-offs. Thus, the ultimate choice depends on the relative value that is assigned to the criteria, along with a more detailed assessment of costs and benefits. This observation is especially true when considering the equitable distribution of costs and benefits.

The conclusions from the analysis were as follows:

1. The tax and rebate combination represents the option with the greatest degree of flexibility, largely through the ability to adjust the tax to satisfy both environmental and economic objectives. Flexibility is a critically important feature in light of the uncertainty associated with energy markets and fuel pricing to the year 2010. There is, however, a lower degree of certainty in achieving the environmental objective.

2. Regulation offers greater certainty in achieving the environmental objective, but at the cost of a tendency to overshoot the objective under certain conditions. However, this cost can be mitigated with the addition of emissions trading.

3. ACCA will lessen the financial impact of both these management options, although ACCA alone is unlikely to alter behaviour in the absence of either regulation or a tax instrument.

A key consideration in further investigations is the uncertainty in the HFO market — and the energy market in general. The last several years have demonstrated the volatility of fuel prices and the inability to effectively predict trends over the longer term. Inflated oil and NG prices during the last several heating seasons have illustrated that HFO users who have access to NG have routinely relied on fuel switching to manage costs.

For regions and sectors that do not have access to NG, options to mitigate costs are more limited. Furthermore, the diminishing supplies of sweet crude, a principal source of LS HFO, may increase the cost of LS HFO over the long term. Cost increases in LS HFO would have the highest impact on the Atlantic region and rural-based industries (e.g., pulp and paper). Ultimately, the price of LS HFO in 2010 is a significant source of uncertainty in the analysis.

In conclusion, given the uncertainties noted above, the flexibility of the tax option would likely make it a better choice than regulation, especially when the price differential between LS HFO and HFO is higher (i.e., above 124 percent). An important advantage of using a tax instrument is the ability to alter the tax rate and observe the response in both emissions and HFO demand. Finally, an emissions reduction rebate combined with the tax offers additional flexibility by providing a broader suite of options to reduce sulphur emissions.