

At What Cost?: A comparative evaluation of the social costs of selected electricity generation alternatives in Ontario

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Chapter 1 Introduction

1.1 Electricity generation: an introduction

The benefit humans derive from electricity use is widely acknowledged. However, although electricity generation contributes to human development at a fundamental level, it is also associated with various environmental, economic and social impacts, and these vary depending on the generation alternative employed. Furthermore, these impacts pose a challenge for the efficient and sustainable allocation of resources that are used to generate electricity.

In this thesis, social costs are classified as the sum total of private costs and external costs (i.e. social costs = private costs + external costs). Private costs generally consist of the capital costs, fuel costs and operations and maintenance (O&M) costs that are incurred by producers and are passed along to consumers through the price of electricity. External costs, on the other hand, are present “when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted or compensated for, by the first group” (EC, 2005, p. 9). Essentially, external costs can be considered the “side effects” caused by electricity generation that are incurred by individuals in society or by ecosystems, whose costs are not internalized. Failing to minimize the social costs of electricity generation is an obstacle to the efficient and sustainable allocation of resources. Consequently, when social costs are not minimized it would be possible to re-allocate resources so that at least one person can be made better off without making others worse off and so that progress towards intragenerational and intergenerational equity may take place.

1.2 Electricity generation in Ontario

Planners who are responsible for guiding the province of Ontario's electricity system face a formidable challenge to ensure that the level of installed generation capacity is sufficient to meet demand requirements over the next two decades. Due to a forecasted annual rise in demand, the plan to close the province's coal-fired generating units and the expected decline of some currently installed nuclear generating units, a supply gap of 7,000 megawatts (MW)¹ is forecasted to occur in 2025.²

What is at stake if electricity system planners fail to meet the supply gap with electricity generation alternatives that have the lowest social costs? When social costs are not minimized the price of electricity does not adequately reflect the scarcity of resources used in production or various social and environmental costs that are associated with electricity generation. Consequently, it is likely that consumption will be higher than it otherwise would be due to the presence of the external costs and that such costs would be incurred by the general public and by ecosystems. This would have significant implications for the provincial economy, the public health of Ontarians and the environment. Moreover, the effects of this capacity expansion decision would be felt across different scales throughout Ontario and abroad: impacts would be perceptible at household, municipality, provincial and, in some instances, global levels (Holdren and Smith, 2000).

The current criterion used by the Ontario Power Authority (OPA), which is the government agency charged with ensuring long-term supply adequacy in Ontario, to evaluate generation alternatives is to balance reliability with affordable prices and environmental and social considerations. The OPA's Integrated Power System Plan (IPSP) (scheduled to be published in 2007) will evaluate various electricity generation alternatives to fill the forecasted supply gap and will be used to set the course for

¹ One megawatt is equal to 1,000 kilowatts (kW). One kW is "a standard unit used to measure electric power, equal to one thousand watts. A kilowatt can be visualized as the total amount of power required to light ten 100-watt light bulbs" (Ayres et al., 2004). A conversion table that includes Watt conversion information and other conversion data is provided in Appendix A.

² This figure is net of already planned capacity expansion and conservation and demand-side management initiatives.

electricity capacity expansion in Ontario over the next 20 years. This assessment, however, is not likely to include an explicit social cost assessment.

1.3 Thesis objective and contribution to the literature

In this context, this thesis assesses the social costs of selected electricity generation alternatives in Ontario to determine a capacity expansion plan that is able to meet the anticipated supply gap at the lowest social costs per kilowatt-hour (kWh).³ Secondary data are used to derive social cost estimates for the generation alternatives in the Ontario context. However, since the methodology and the assumptions upon which social cost estimates are based tend to vary in the literature and the reliability of the data may be contentious, the credibility of the estimates is a central concern of this analysis. Consequently, this assessment aims to be consistent, transparent and comprehensive (as advocated by EC, 2005), which is intended to increase the validity of the results.

A literature review reveals that previous social cost research in Ontario contains a number of gaps. Few studies in Ontario have been carried out in a consistent, transparent and comprehensive fashion and the few that have done so have had limited breadth. As a result, this thesis aims to contribute to the literature in this area by adding to the depth and breadth of social cost research in Ontario and by attempting to increase the standard for consistency, transparency and comprehensiveness in such an assessment.

1.4 Methodological framework

The methodological framework used to carry out this assessment is implemented in a five step process (refer to Figure 1-1 for a visual representation). Four generation alternatives are evaluated: natural gas, wind, nuclear refurbishment and new nuclear generation. These alternatives are assumed to be the likeliest candidates to be considered in the OPA's Integrated Power System Plan.

³ Note that “capacity expansion plan” is used interchangeably with “resource allocation plan” and “supply gap decision” throughout this thesis.

Figure 1-1: Methodological framework

Step 1	Determine which electricity generation alternatives to evaluate
Step 2	Evaluate private costs of electricity generation alternatives via LUEC analysis
Step 3	Evaluate computable external costs associated with each generation alternative
Step 4	Aggregate private and external costs for each generation alternative and apply social cost estimates to Ontario capacity planning context
Step 5	Recognize uncertainty in the base case results and employ a sensitivity analysis to mitigate uncertainty

Steps 2 through 4 are applied following from the definition of social costs. A levelized unit electricity cost (LUEC) analysis (step 2), which determines the private cost per kilowatt-hour that needs to be charged for each generation alternative such that the net present value of the annual cash flows (including the cost of capital) is set equal to zero, is used to evaluate private costs. Essentially, the LUEC is the constant price that needs to be charged over the lifetime of a generating unit in order to recover all of the private costs that are incurred. Private cost factors and planning assumptions for each generation alternative are determined by taking an average for each particular variable from the relevant data in the literature. Private cost estimates are evaluated from a public and a merchant perspective which differ in terms of the appropriate discount rate used and whether transfer payments are included (all other assumptions are held constant). The discount rate in the public scenario is based on the long-term cost of public debt, as would be the case if the government was undertaking a project. The discount rate in the merchant scenario, on the other hand, is based on the increased cost of capital that would be expected when a private firm supplies electricity to the market. In the merchant case, the discount rate is higher, reflecting time preference and increased risk. In addition, taxes are included only in the merchant perspective.

For the evaluation of external costs (step 3), the bottom-up damage cost method, which is recognized as the most effective external cost valuation method in the literature, is utilized along with “second-best” valuation methods (EC, 2005). A computable external burden assessment is used to determine the external burdens that should be evaluated for

each generation alternative. This assessment is used to identify the external burdens that have sufficient data availability, monetization ability and are non-negligible relative to other external burdens for each generation alternative. For natural gas generation, climate change and premature mortality costs associated with natural gas-fired emissions are evaluated. For wind generation, premature mortality and climate change costs associated with emissions from wind turbine construction and other miscellaneous costs are estimated.⁴ For nuclear generation alternatives, potentially severe accidents associated with the generating unit and health impacts associated with radioactive emissions are assessed. External costs are then quantified and monetized by adapting the most relevant external cost estimates obtained from the literature to the context of this assessment.

Once private and external costs are estimated, they are aggregated for each respective generation alternative to arrive at social costs (step four). These estimates are used to determine the capacity expansion plan to meet the forecasted supply gap at the lowest social costs. In step five, a sensitivity analysis, which tests the effect on the capacity expansion plan when several key variables are altered, is employed in an attempt to lessen some of the uncertainty associated with the findings.

1.5 Thesis outline

After this brief introduction, in Chapter Two, the research objective is elaborated on and the theory behind social costs, which are comprised of private and external costs, is discussed in relation to the concepts of efficiency and sustainability. In addition, Chapter Two introduces the main elements of the Ontario electricity system as well as the current developments that are forecasted to result in a supply gap in 2025. Chapter Three establishes the means used to derive private and external costs for each generation alternative. In addition, a literature review of previous private and external cost estimates for electricity generation alternatives in Ontario provides a benchmark to evaluate the contribution to the literature made by this thesis. The methodology governing how secondary data are to be incorporated into the assessment and how the results of the

⁴ For wind, miscellaneous external burdens refer to noise disturbance, visual intrusion and land use.

social cost assessment should be utilized to meet the supply gap are conveyed in Chapter Four. Private and external cost estimates are derived for the base case scenario in Chapter Five. Private cost estimates are evaluated from a public and a merchant perspective. These estimates are aggregated for each generation alternative and used to formulate a capacity expansion plan that exhibits the lowest social costs. The discussion in Chapter Six highlights the salient aspects of the findings and comments upon the key implications of the social cost estimates while noting the limitations of the assessment. Finally, Chapter Seven summarizes the findings, draws conclusions about the usefulness of social cost assessments in general and offers suggestions for future research that are stimulated by this thesis.

1.6 Chapter summary

In this chapter, key aspects of the social cost assessment of selected electricity generation alternatives in Ontario were introduced and the context for this thesis was presented. The following chapter provides a deeper understanding of the research objective, beginning with the theory underpinning social costs.