

Engineering Economics Course Project

Carbon Taxes to minimize cO2 emissions in a micro-grid

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# Introduction

This report will identify the best energy production option and carbon tax price to incent the adoption of renewable energy sources and minimize the use of diesel fuel generation in a micro-grid application for a remote Northern Ontario community. The analysis will consider four energy production options (Table 1) that could be purchased today in order to become operational in 2019. These options include a mix of wind, solar, and diesel energy production. The analysis for this project will consider the present worth, the incremental internal rate of return, and the equivalent annual cost for each energy production option. A dollar value for the CO2 tax will be proposed that shall minimize diesel fuel generation and increase the feasibility of the options that include renewable energy sources. The same analysis will be performed using the tax rules of the United Kingdom to provide comparison on the feasibility of the project in that country.

Table 1 - Generation Options



# Problem Statement

This report will determine an appropriate CO2 tax to be applied that will minimize the use of diesel fuel generation in a theoretical micro-grid application in Northern Ontario and compare the feasibility of this project to the same project if it were undertaken in the United Kingdom.

### Assumptions

1. Yearly maintenance cost increase is 5% of the previous year’s maintenance cost.
2. Yearly CO2 emissions increase is 2% of the previous year’s CO2 emissions.
3. Yearly diesel fuel cost increase is 2% of the previous year’s diesel fuel cost.
4. No tax credits or other government incentives for any generation option.
5. 100% utilization rate for all generation options.
6. Same cost of financing for all generation options.

# Economic Analysis

### Levelized Cost of Energy (LCOE)

The concept of LCOE represents the total cost per unit of energy of constructing and operating a power plant over its lifetime (U.S. Energy Information Administration, 2018). LCOE provides a convenient mechanism for comparing the competitiveness of different generation technologies. In this report we only consider the capital costs, fuel costs, and maintenance costs when evaluating each generation option, although a full LCOE analysis would include the cost of financing, operation, and utilization rates for each generation option.

### Present Worth Analysis

The present worth of each option from Table 1 was conducted utilizing the corporate tax rate in Canada of %36.1 (Pearson Canada, Inc., 2017), a before-tax MARR of 20%, and a Capital Cost Allowance (CCA) of 20% (Class 8). After-tax MARR is calculated to be 12.78%. Analysis was conducted assuming a 20 year lifetime for each option.

The Capital Tax Factor (CTF) is calculated to be

The present worth of the capital cost for each generation option is calculated as follows.

Table 2 - Present worth of capital cost



The present worth for all annuities associated with each generation option are calculated as follows. Table 3 shows the present worth of all annuities over a 20 year period for each option. Appendix A shows the Excel calculations used to generate these values.

Table 3 - Present worth of annuities

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Wind + Diesel | Solar + Diesel | Solar + Wind + Diesel | Diesel |
| Present Worth (Annuities) | $133,262.85 | $111,650.51 | $164,417.83 | $109,299.76 |

The total present worth for each option is sum of the present worth of the annuities and the present worth of the capital cost. Table 4 shows the total present worth after taxes for each option with no carbon tax implemented.

Table 4 - Total Present Worth

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Wind + Diesel | Solar + Diesel | Solar + Wind + Diesel | Diesel |
| Present Worth (Total) | -$74,481,057.15 | -$79,583,349.49 | -$76,301,598.17 | -$44,242,700.24 |

The diesel only option is considerably more cost-effective than the others without the inclusion of a carbon tax.

### Factors Missing From Analysis

This analysis does not consider any government incentives for renewable projects such as tax credits for renewable projects or discounted financing options which could help to reduce the cost of the proposed carbon tax. This analysis only considers the maintenance and fuel costs for each plant type but does not account for any other operating costs which may impact the total cost of each plant. This analysis only considers carbon produced during the operation of each plant type and does not account for the carbon produced when manufacturing the plant.

# Appendix A



Figure 1 - Present worth of annuities, Wind + Diesel Option



Figure 2 - Present worth of annuities, Solar + Diesel Option



Figure 3 - Present worth of annuities, Solar + Wind + Diesel Option



Figure 4 - Present worth of annuities, Diesel Option

# Bibliography

U.S. Energy Information Administration. (2018). *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018.* U.S. Energy Information Administration.