



Photo Credit: Greg Trowse

11

ASSESSING THE POTENTIAL ECONOMIC IMPACTS OF A FIVE MEGAWATT TIDAL ENERGY DEVELOPMENT IN THE DIGBY AREA OF THE BAY OF FUNDY

CONCEPT: PRINCIPLES OF INPUT OUTPUT ANALYSIS

An input-output (I/O) model is a mechanism that allows analysis of inter-industry relationships of an economy.

An I/O model attempts to quantify, at a point in time, the economic interdependencies of an economy. I/O accounting is a framework that explicitly recognizes interdependencies among productive industries of the economy and the elements of final demand. Final demand is the demand for goods and services consumed directly by ultimate consumers. Final goods and services are referred to as final because they are not put back into the production process to make some other good. The interdependencies are characterized by the inter-industry structure, which shows the inputs that are combined to produce output. The I/O analysis framework is similar to a financial accounting framework that tracks purchases and expenditures on goods and services in dollars. The I/O framework traces the dollar flows between businesses, as well as between businesses and consumers in an economy. The input-output model is summarized below in matrix form. Details of the model used here follow.

$$X^* = (1-A^*)^{-1} F^*$$

Where: X^* = the vector of total output

$(1-A^*)^{-1}$ = the closed model total requirements matrix (Leontief inverse)

F^* = vector of final demand changes associated with tidal power development

The Nova Scotia input-output (I/O) model forms the basis of the Digby County I/O model. The provincial I/O model for Nova Scotia is based on Statistics Canada data. The provincial I/O direct requirements matrix is adjusted
Continued on next page ...

11 - ASSESSING THE POTENTIAL ECONOMIC IMPACTS OF A FIVE MEGAWATT TIDAL ENERGY DEVELOPMENT IN THE DIGBY AREA OF THE BAY OF FUNDY

Author: Dr. Brian Vanblarcom

WHAT DOES THIS MODULE COVER?

The economic impacts from tidal energy development are largely unknown due to two primary factors: a) a very small number of deployments, with only a handful at the commercial stage, and b) limited analysis using econometric modeling. This section seeks to narrow this gap in knowledge by providing an input-output analysis of the economic impacts of a 5MW tidal facility in the Digby area of Nova Scotia.

This module provides an estimate of the inter-industry impacts of a 5MW tidal facility in the Digby area of Nova Scotia. The module provides summary tables on the following:

- Table 11-1: Capital Cost for a 5MW tidal facility,
- Table 11-2: Total Costs (inputs & outputs) by Economic Sector for Constructing a Commercial Facility,
- Table 11-3: : Annualized Cost Inputs and Outputs by Economic Sector for Constructing a Commercial Facility,
- Table 11-4: Costs by Category of Operating a Commercial Facility, and
- Table 11-5 : Cost Inputs and Outputs by Economic Sector for Operating a 5MW Facility.

KEY IMPACT ESTIMATES INCLUDE:

- Total (multiplied) spending from the development/construction phase of \$46 million, with total income creation of \$14.3 million.
- 240 person years of employment, or 48 jobs per year over each of the five years of the development/construction phase.
- Annual operational total spending generation of \$344,000; annual income creation of \$124,000.
- Annual operation creates two full-time job equivalents.

WHO SHOULD READ THIS MODULE?

This module is for anyone interested in the potential economic impact of developing a 5MW tidal energy project in the Digby area, including potential spending across industries in Digby and estimated number of jobs. These estimates are based on a hypothetical case; actual spending and economic impacts would differ from project to project.

11.0 - INTRODUCTION

This section estimates the potential economic impacts emanating from a 5MW tidal development (generation device and land-based components), as described in Nova Scotia Utility and Review Board in the matter of a hearing to determine Renewable Energy Community Tariffs, March 2, 2011 [Synapse Exhibit M]. The purpose is to quantify the economic significance of tidal energy development. More specifically, this section will examine a hypothetical case study of a 5 MW community-based tidal project in the Digby area of the Bay of Fundy. Digby was chosen for analysis based on a number of potential sites being identified in that area. Fundy Tidal Inc. has received regulatory approval for a 1.95 megawatt tidal power project in Digby County. Small scale tidal developments will be the focus for the case study since the applicable technology/costs/degree of local inputs, etc. for larger (150 MW range) developments are significantly less precise at this point in time.

The study area for the case study is Digby County. In order to estimate the potential economic impacts, an input-output (I/O) model for Digby County was developed. The box to the right of the page contains an overview of I/O analysis.

A key goal of the analysis is to measure the degree to which the expenditures related to tidal energy production generate economic activity in the local economy. The study area input-output model captures both the direct and spin-off (indirect and induced) effects of these expenditures.

The expenditure (cost) inputs that generate the economic impacts are based on cost figures appearing in the publication entitled, *In the Matter of the Electricity Act and In the Matter of a Hearing to Determine the Renewable Energy Community Feed-On Tariffs*, by Nova Scotia Utility and Review Board, published in March 2, 2011. The outputs (impacts) are measured in terms of total sales and income generated locally from initial expenditures related to tidal energy development. The degree to which the expenditure (cost) inputs and the economic impacts (outputs) will be generated/captured locally is unknown at this point in time. The analysis conducted here should be considered a simulation in that the I/O model is based on the structure of the local economy as of the 2006 census, and more importantly, the resulting impacts (outputs) will change in proportion to which the actual expenditures (cost) differ from the current estimates.

It is assumed that 70 percent of the capital costs will be services provided by local firms (*Final Report Renewable Energy Opportunities and Competitiveness Assessment Study*, Nova Scotia Department of Energy, SLR Consulting Ltd., *SLR Project No. 210.05753.00*, September 23, 2010, p. 40). This assumption is critical to the analysis, in that tidal power development expenditures going to non-local firms “leak out of the local economy” and hence reduce the direct/indirect/induced impacts. It is further assumed that all developmental expenditures related to tidal energy are incremental to the study region. In other words, the tidal energy-related spending, outlined in this analysis, occurs in addition to existing levels of economic activity. It is also assumed that the resulting spin-off benefits (for example, additional spending, jobs, and income) are captured in the Digby area economy.

Continued from previous page ... via employment based location quotients (LQs) to approximate the Digby economy. The location quotient, in this case, is a measure comparing the concentration of an industry in Digby County and its concentration in the province of Nova Scotia, as a whole.

The closed model allows the direct, indirect and induced effects of an exogenous change to be captured. Direct effects occur when firms involved in tidal power development buy goods/services from local firms. Indirect effects occur when local firms buy local inputs (goods/services) as a result of the direct impact. The economic activity resulting from the re-spending of income generated by the direct and indirect effects is known as the induced effect. The induced impacts are additional expenditures resulting from increased income brought about by increases in final demand.

There are a few key assumptions related to I/O analysis that should be noted. Firstly, the level of input purchased by an industry is exclusively determined by the level of this industry's output and that there exists no input substitution or economies of scale in the production. Secondly, there are no constraints on industry capacity. Whatever is demanded by industries as inputs can be supplied at current prices. Thirdly, inherent in the induced effects, is that household income flows to residents and residents spend their new income following the existing pattern of expenditures.

Given the assumed leakages from the local economy (related to production of goods/industry profits), the closed model is most applicable due to its ability to capture the induced effects associated with re-spending of income created via the direct and indirect effects. An I/O model framework therefore, provides the ability to answer “what if” questions. For example, what will happen in the economy if final demand due to tidal energy development was to increase by 50 million dollars?

The total economic impact (direct/indirect/induced) on spending across all industries in the Digby County economy from the construction phase is estimated to be \$46 million, with total income creation of \$14.3 million.

11.1 - DEVELOPMENT PHASE

The case study reflects the economic activity generated from creating a 5 MW facility near Digby. The analysis is based on the construction and operation of the 5 MW facility. Total capital costs are estimated at \$10 million per MW (Nova Scotia Utility and Review Board, 2011). The costs for construction of a 5 MW facility are estimated in Table 11-1.

Table 11-1: Capital Cost for a 5MW Tidal Facility

COST CATEGORY	COST FOR 5 MW FACILITY
Development	\$9,500,000
Equipment & Installation	\$33,350,000
Interconnection	\$2,600,000
Reserves (upfront maintenance/working capital)	\$1,130,180
Financing (closing costs/interest)	\$3,813,500
Total	\$50,393,680

Source: Nova Scotia Utility and Review Board in the matter of a hearing to determine Renewable Energy Community Tariffs, March 2, 2011 (Synapse Exhibit M). <http://www.nsuarb.ca/images/stories/pdf/electricity/july2011/comfit.pdf>

In order to assess the total direct/indirect/induced effects (multiplied) of the capital spending on the Digby County economy, the expenditures in Table 11-1 are reduced by 30% (as noted, 70% of inputs are assumed to be supplied locally) and delineated into North American Industrial Classification (NAIC) input categories, as shown in Table 11-2. Development costs were apportioned to Business Services, and equipment/installation costs split on a 50/50 basis with the Manufacturing and Construction sectors. Interconnection costs were considered to be in the Construction industry and Financing and Reserves costs allocated to the Finance Insurance and Real Estate (FIRE) sector. Given that all expenditures took place in a single year, the total expenditure and income effects of the capital expenditures (as derived from the Digby County input-output model), are also shown in Table 11-2. The total economic impact (direct/indirect/induced) on spending across all industries in the Digby County economy from the construction phase is estimated to be \$46 million, with total income creation of \$14.3 million. As would be expected, the total expenditure impacts are concentrated in the Construction and Manufacturing industries, with (direct/indirect/induced) spending of \$13.7 million and \$13.1 million, respectively. Other industries generating significant spending effects are Business Services (\$7.3million), Finance, Insurance and Real Estate (FIRE), with \$7.1 million, and Retail Trade (\$1.4 million).

The combined development/commercial installation time frame for tidal power, however, has been shown to be considerably longer than one year. In absence of a definitive time frame for which the development and construction expenditures shown in Table 11-2 will actually occur, it is assumed that they will take place proportionately in each year, over a five year period. (Please note, no discounting reflecting the time value of money has been applied). The annualized costs would therefore represent one fifth of the total, with annual total direct expenditures of approximately \$10 million per year,

\$7.0 million occurring locally. The resulting impacts are shown in Table 11-3. On an annualized basis (over a five year time frame, with no discounting), total expenditures across all industries are \$9.2 million. Construction and Manufacturing industries see expenditures of \$2.8 million and \$2.6 million, respectively, followed by Business Services (\$1.5 million), Finance, Insurance and Real Estate (FIRE), with \$1.4 million, and Retail Trade (\$282 thousand). Annualized total income creation across all industries is estimated to be \$2.9 million. Using the Oregon Wave Energy Trust, Economic Impacts of Wave Energy to Oregon's Economy, OWET (2009) income-to-employment ratio of \$60,000 per year, the construction phase would be expected to generate 240 person years of employment, or 48 jobs per year over each of the five years of the development/construction phase.

Table 11-2: Total Costs (inputs & outputs) by Economic Sector for Constructing a Commercial Facility (Assumes 70% accrues to local firms.)

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Agriculture	\$0	\$122,791
Forestry and Logging	\$0	\$60,971
Fishing, Hunting, and Trapping	\$0	\$9,305
Support Activities for Agriculture and Forestry	\$0	\$18,398
Mining	\$0	\$95,005
Utilities	\$0	\$383,309
Construction	\$13,492,500	\$13,873,692
Food Manufacturing	\$0	\$306,593
Other Manufacturing	\$11,672,500	\$13,136,669
Wholesale Trade	\$0	\$775,736
Retail Trade	\$0	\$1,408,566
Transportation	\$0	\$69,744
Finance, Insurance, Real Estate	\$3,460,576	\$7,109,756
Business Services	\$6,650,000	\$7,305,038
Accommodation and Food Services	\$0	\$451,167
Other Services	\$0	\$341,087
Hospitals/Health Care	\$0	\$196,700

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Education	\$0	\$197,312
Government (Federal/Provincial/Municipal)	\$0	\$65,869
Households (income from wages and profits)	\$0	\$14,311,918
Total Output (excludes Households Income)	\$35,275,576	\$45,927,709

Table 11-3: Annualized Cost Inputs and Outputs by Economic Sector for Constructing a Commercial Facility (Assumes a five-year time frame.)

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Agriculture	\$0	\$24,558
Forestry and Logging	\$0	\$21,194
Fishing, Hunting, and Trapping	\$0	\$1,861
Support Activities for Agriculture and Forestry	\$0	\$3,680
Mining	\$0	\$19,001
Utilities	\$0	\$76,662
Construction	\$2,698,500	\$2,774,738
Food Manufacturing	\$0	\$61,319
Other Manufacturing	\$2,334,500	\$2,627,334
Wholesale Trade	\$0	\$155,147
Retail Trade	\$0	\$281,713
Transportation	\$0	\$13,949
Finance, Insurance, Real Estate	\$692,115	\$1,421,951
Business Services	\$1,330,000	\$1,461,008

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Accommodation and Food Services	\$0	\$90,233
Other Services	\$0	\$68,217
Hospitals Health Care	\$0	\$39,340
Education	\$0	\$39,462
Government (Federal/Provincial/Municipal)	\$0	\$13,174
Households (income from wages and profits)	\$0	\$2,862,384
Total Output (excludes Households Income)	\$7,055,115	\$9,185,542

11.2 - OPERATIONAL PHASE

The costs for the annual operation of the 5 MW facility are categorized in Table 11-4. The figures in Table 11- 4 are based on those outlined in Nova Scotia Utility and Review Board, In the Matter of the Electricity Act and In the Matter of a Hearing to Determine the Renewable Energy Community Feed-On Tariff, March 2, 2011. Overhaul costs are annualized based on a major overhaul every six years. Total annual operating expenditures are estimated at \$255,000, all accruing locally.

Table 11-4: Costs by Category of Operating a Commercial Facility

COST CATEGORY	COST FOR 5 MW FACILITY
Annualized portion of overhaul (one-sixth of six-year overhaul)	\$100,000
Annual Operations and Maintenance Labour	\$75,000
Annual Other (Administrative, Insurance/Land Lease)	\$80,000
Annual Total	\$255,000

Source: Nova Scotia Utility and Review Board in the Matter of a Hearing to Determine the Renewable Energy Community Tariffs, March 2, 2011 (Synopsis Exhibit M) <http://www.nsuarb.ca/images/stories/pdf/electricity/july2011/comfit.pdf>

The costs from Table 11-4 are divided into economic sectors and inserted in the Digby County I/O model to estimate the total (direct/indirectly/induced) annualized expenditure impacts of the spending attributable to operation of a 5 MW tidal turbine. This is shown in Table 11-5. Finance, Insurance and Real Estate sector will see annual spending impacts of \$113,000, Construction (\$105,000), Business Services (\$80,000), Retail Trade (\$12,000), and Manufacturing (\$9,000). The annual total spending impact across all industries generated is estimated to be approximately \$344,000 per year, with total income creation of \$124,000. The income creation approximates two full time job equivalents.

Table 11-5: Cost Inputs and Outputs by Economic Sector for Operating a 5MW Facility

ECONOMIC SECTOR	TOTAL INPUTS	TOTAL OUTPUTS
Agriculture	\$0	\$975
Forestry and Logging	\$0	\$478
Fishing, Hunting, and Trapping	\$0	\$80
Support Activities for Agriculture and Forestry	\$0	\$147
Mining	\$0	\$415
Utilities	\$0	\$2,879
Construction	\$100,000	\$105,313
Food Manufacturing	\$0	\$2,506
Other Manufacturing	\$0	\$9,524
Wholesale Trade	\$0	\$5,354
Retail Trade	\$0	\$12,006
Transportation	\$0	\$595
Finance, Insurance, Real Estate	\$80,000	\$113,252
Business Services	\$75,000	\$80,103
Accommodation and Food Services	\$0	\$3,919
Other Services	\$0	\$2,668
Hospitals/Health Care	\$0	\$1,706
Education	\$0	\$1,737
Government (Federal/Provincial/Municipal)	\$0	\$562
Households (income from wages and profits)	\$0	\$124,174
Total Output (excludes Households Income)	\$255,000	\$344,219

11.3 - SUMMARY

This section estimated the potential economic impacts emanating from a 5MW tidal facility in the Digby area of the Bay of Fundy. In order to estimate the potential economic impacts, an input-output (I/O) model for Digby County was developed. Project costs are based on The Renewable Energy Community Feed-In Tariffs (Nova Scotia Utility and Review Board, 2011). It is assumed that 70% of the capital and all service costs will go to local firms (SLR Consulting Ltd., SLR Project No. 210.05753.00, 2010).

The development costs are projected at approximately \$10 million per megawatt, meaning \$50 million for the 5MW hypothetical case study. The total economic impact (direct/indirect/induced) on spending across all industries in the Digby County economy from the development/construction phase is estimated to be \$46 million, with total income creation of \$14.3 million. The total expenditure impacts are concentrated in the Construction and Manufacturing industries, with spending of \$13.7 million and \$13.1 million, respectively.

On an annualized basis, over a five-year time frame, the resulting development phase impact of expenditures, across all industries, is \$9.2 million, with Construction and Manufacturing industries seeing expenditures of \$2.8 million and \$2.6 million respectively, followed by Business Services (\$1.5 million), Finance, Insurance and Real Estate (FIRE), with \$1.4 million and Retail Trade (\$282 thousand). Annualized total income creation across all industries is estimated at \$2.9 million. The development/construction phase would be expected to generate 240 person years of employment or 48 jobs per year over each of five years. Employment creation of forty-eight jobs per year is equivalent to approximately one percent (0.7%) of Digby County's total employment of 7,215 (Services Canada, 2002). A critical element in the economic impact of this phase is dependent upon whether the tidal power generation devices are manufactured locally or imported. Furthermore, if the development phase were to generate a successful exporting industry, the economic impacts could be significantly larger than the case study estimates and for an indefinitely longer period of time.

The annual operational phase expenditures are much smaller than the development phase but are ongoing. The yearly total spending impact (direct/indirect/induced) across all industries generated by the operation of the 5 MW tidal device is estimated to be approximate \$344,000 per year, concentrated in Finance, Insurance and Real Estate (\$113,000), Construction (\$105,000), and Business Services (\$80,000). Annual income creation is estimated at \$124,000. The income creation approximates two full-time job equivalents.

REFERENCES

Nova Scotia Department of Energy, Final Report Renewable Energy Opportunities and Competitiveness Assessment Study, SLR Project No. 210.05753.00. SLR Consulting Ltd., September 23, 2010. <http://www.gov.ns.ca/energy/renewables/explore-invest/recent-reports.asp>

Nova Scotia Utility and Review Board, In the Matter of the Electricity Act and In the Matter of a hearing to determine the renewable Energy Community Feed-On Tariffs. March 2, 2011.

Oregon Wave Energy Trust, Economic Impacts of Wave Energy to Oregon's Economy, September 7, 2009. <http://www.oregonwave.org/wp-content/uploads/Economic-Impact-Study-FINAL-mod.pdf>