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Case Study Application of After Tax Analysis to a Renewable Energy Project

Mrs. Christina Jauregui Barboza, Stevens Institute of Technology (SSE)

Christina Jauregui Barboza is an Engineering Management Doctoral Candidate in the School of Systems and Enterprises at Stevens Institute of Technology. She received a Masters of Engineering Degree in Systems Engineering in 2008 and a Bachelor of Engineering Degree in Engineering Management in 2006 both from Stevens Institute of Technology. She holds a teaching assistantship position for the Engineering Management program at Stevens Institute of Technology and has had this position for a total of 5 years, during which she was awarded the Outstanding Teaching Assistant Award. She has industry experience as a Management Engineer for the Port Authority of New York and New Jersey. Her research interests lie in Engineering Management, with a focus on engineering economics and sustainable engineering.

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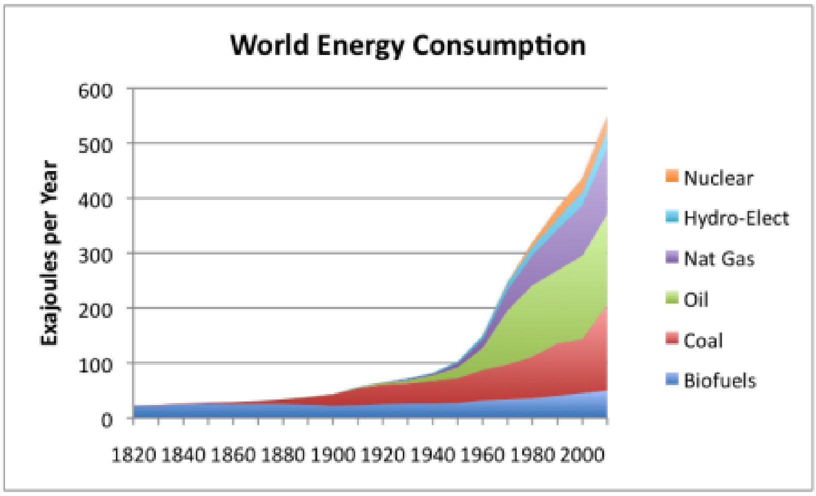
Increases in population and technology will require an increase in the world's energy demand. Figure 1, shows the increase in world energy consumption for the past 200 years and includes a breakdown of the energy sources utilized for consumption[19]. As shown in the figure, the fossil fuels coal and oil have been the major energy sources since 1900. Environmental and sustainability science discuss the IPAT equation, which suggests that the product of the population (P), affluence (A), and technology (T) indicate the human impact (I) on the environment [4]. Therefore, careful consideration of the figures for population, affluence and technology will allow a calculation of the approximate human impact generated on planet Earth.

Figure 1 – World Energy Consumption



As the increasing energy demand will put a strain on the environment if fossil fuel sources continue to be used, renewable energy must be considered and used as a primary source. Although they are currently the most economical and feasible technology available, fossil fuel sources are finite, and reserves are being diminished, continuing the pattern shown in figure 1 would deplete the reserves to a point where extraction is no longer feasible [11]. Fossil fuel sources are economical because the existing technology is already in place and has been reengineered to be cost effective. Whereas, renewable energy is still in its infancy and the extremely high capital cost associated with renewables is often the factor that makes their implementation unacceptable [20].

Therefore, a major success factor for renewable energy projects is economic performance. An after tax analysis (ATA) is an appropriate way to evaluate the economics of implementing renewable energy projects because it considers the inherent taxes from a project's beginning to its end. The decision-making phase is the most appropriate time to complete the after tax analysis because it will determine the point at which financial leverage is established and identify cost parameters to follow throughout construction, implementation and deconstruction of the project. Financial leverage is achieved when a project's total Rate of Return is optimized via borrowing and loans at after tax interest rates that are below the project's Internal Rate of Return (IRR). The utilization of financial leverage can increase a project's risk due to larger loans; however, it can be economically attractive and achievable for companies that have greater borrowing power [18].

For renewable energy projects, the government is essentially a partner in capital investments because they provide financial assistance in the form of tax breaks and production tax credits. Capital expenditures become less burdensome due to depreciation rates, tax rates, investment tax credits and capital gains taxes. Upon completion of the ATA, a sensitivity analysis will determine how variation in the defined factors will affect the internal rate of return. In conclusion, one great benefit of the ATA is the ability to adjust the financing design during the planning stage by manipulating the parameters; and ultimately the most profitable solution can be implemented [18].

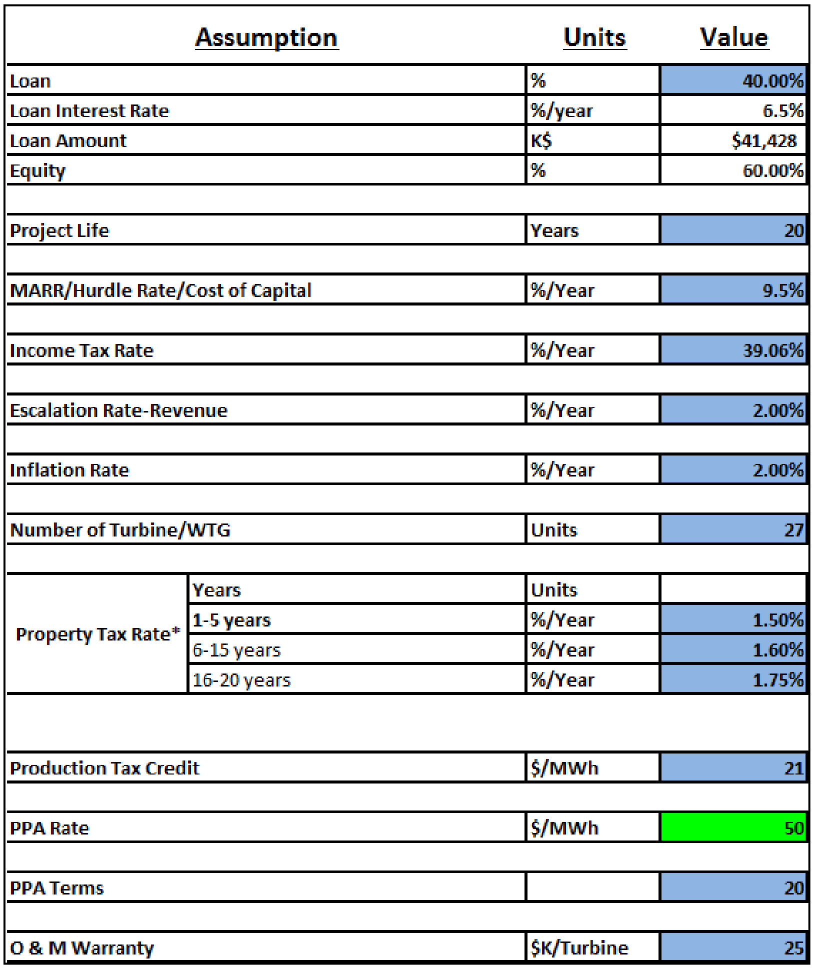
This paper presents a case study depicting the cost of construction, implementation and operation of a commercial wind farm with the application of life cycle costing using ATA. This technique defines the life cycle cost for the entire operation: from financing the project, to purchasing the equipment, and the project revenue. While this approach requires extensive research to determine the parallel costs and revenue rates, the results from conducting an ATA with life cycle costs allows for a solid final decision based on actual figures and predefined economic criteria.

The results from this analysis proved that due to using financial leverage and taking advantage of production tax credits and power purchase agreements, a commercial wind farm is an acceptable and profitable venture. The ATA incorporates pedagogical knowledge conveyed in engineering economics courses such as the time value of money, the modified accelerated cost recovery system (MACRS) of accelerated depreciation factor and associated depreciation values, the debt/equity ratio, cash flow, net present value and breakeven point, internal rate of return and minimum acceptable rate of return.

Case Study

An ATA model developed by Dr. Merino of Stevens Institute of Technology was utilized to assess engineering economics figures of merit and determine project feasibility and acceptance depending on the IRR and Net Present Value (NPV) of the project. Figure 2 depicts the assumptions made for the case study; values were identified by conducting research on comparable projects. The IRR is the evaluation factor for this project, therefore, as long as the IRR is greater than the Minimum Acceptable Return Rate (MARR) the project is considered acceptable. Since a great deal of research was conducted to make generalized assumptions, the model may not accurately portray a real life situation, thus a sensitivity analysis must be conducted, and this is further explained later.

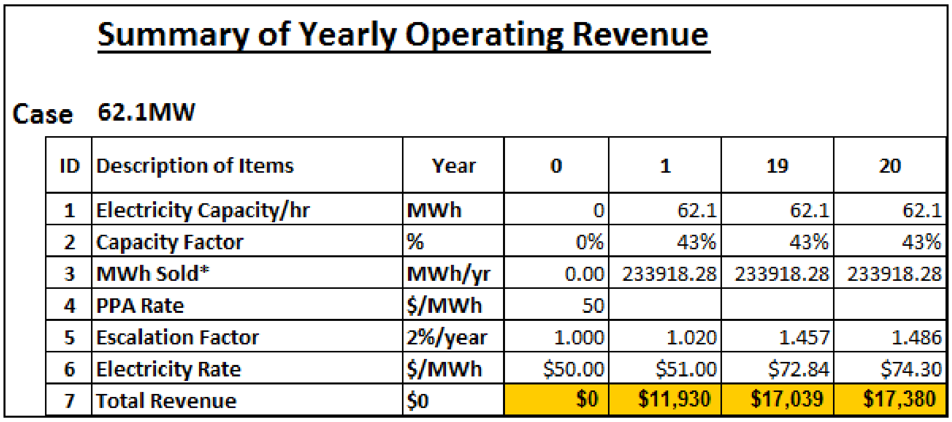
Figure 2 – Assumptions Financial Inputs



Assumption		Units	Value
Loan		%	40.00%
Loan Interest Rate		%/year	6.5%
Loan Amount		K$	$41,428
Equity		%	60.00%
Project Life		Years	20
MARR/Hurdle Rate/Cost of Capital		%/Year	9.5%
Income Tax Rate		%/Year	39.06%
Escalation Rate-Revenue		%/Year	2.00%
Inflation Rate		%/Year	2.00%
Number of Turbine/WTG		Units	27
Property Tax Rate*	Years	Units	
	1-5 years	%/Year	1.50%
	6-15 years	%/Year	1.60%
	16-20 years	%/Year	1.75%
Production Tax Credit		$/MWh	21
PPA Rate		$/MWh	50
PPA Terms			20
O & M Warranty		$K/Turbine	25

This wind farm consists of twenty-seven, 2.3 MWh electricity capacity turbines. The total capacity of the wind farm is 62.1 MW. The turbines are assumed to be operational 24 hours per day for 365 days per year and the project life is 20 years. The large capital investment associated with this project has led to an assumption of a 40% loan from a bank at a 6.5% interest rate. The electricity will be sold via a power purchase agreement (PPA) rate of $50/MWh for the entire 20 year operation. During the first 10 years, production tax credits will be provided from government incentives for this project at $21/MWh. Modified Accelerated Cost Recovery System (MACRS) depreciation rates are used to calculate depreciation and an income tax rate of 39% is applied in the model.

Figure 3



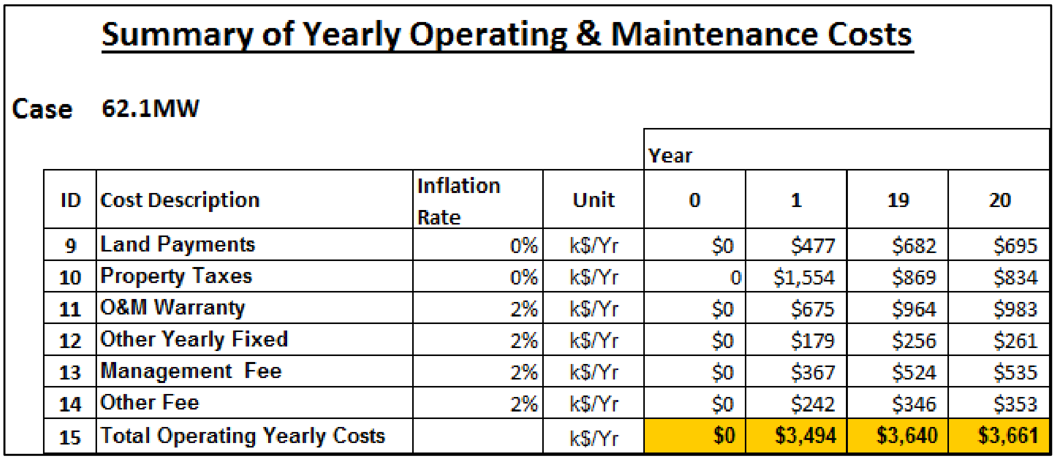
Summary of Yearly Operating Revenue

Case 62.1MW

ID	Description of Items	Year	0	1	19	20
1	Electricity Capacity/hr	MWh	0	62.1	62.1	62.1
2	Capacity Factor	%	0%	43%	43%	43%
3	MWh Sold*	MWh/yr	0.00	233918.28	233918.28	233918.28
4	PPA Rate	$/MWh	50			
5	Escalation Factor	2%/year	1.000	1.020	1.457	1.486
6	Electricity Rate	$/MWh	$50.00	$51.00	$72.84	$74.30
7	Total Revenue	$0	$0	$11,930	$17,039	$17,380

The first component in the model is the Revenue. Figure 3 shows the years 0, 1, 19, and 20 of the project life, because of space considerations years 2-18 have been hidden. In figure 3, you can see that for the year 0, no revenue is collected because during this time, the wind farm is being constructed. In year 1, revenue generation begins. The entire 62.1 MW will not be available at all times, thus a capacity factor of 43% was assumed for revenue calculations. The energy sold is calculated by multiplying the electricity capacity/hr and the capacity factor. The escalation factor was assumed from the financial input to increase at a rate of 2% per year. The electricity rate is determined by multiplying the PPA rate and the escalation factor. At year 20, $17,380 of revenue is generated. Throughout the entire project life, a total of $289,864 of revenue is generated.

Figure 4



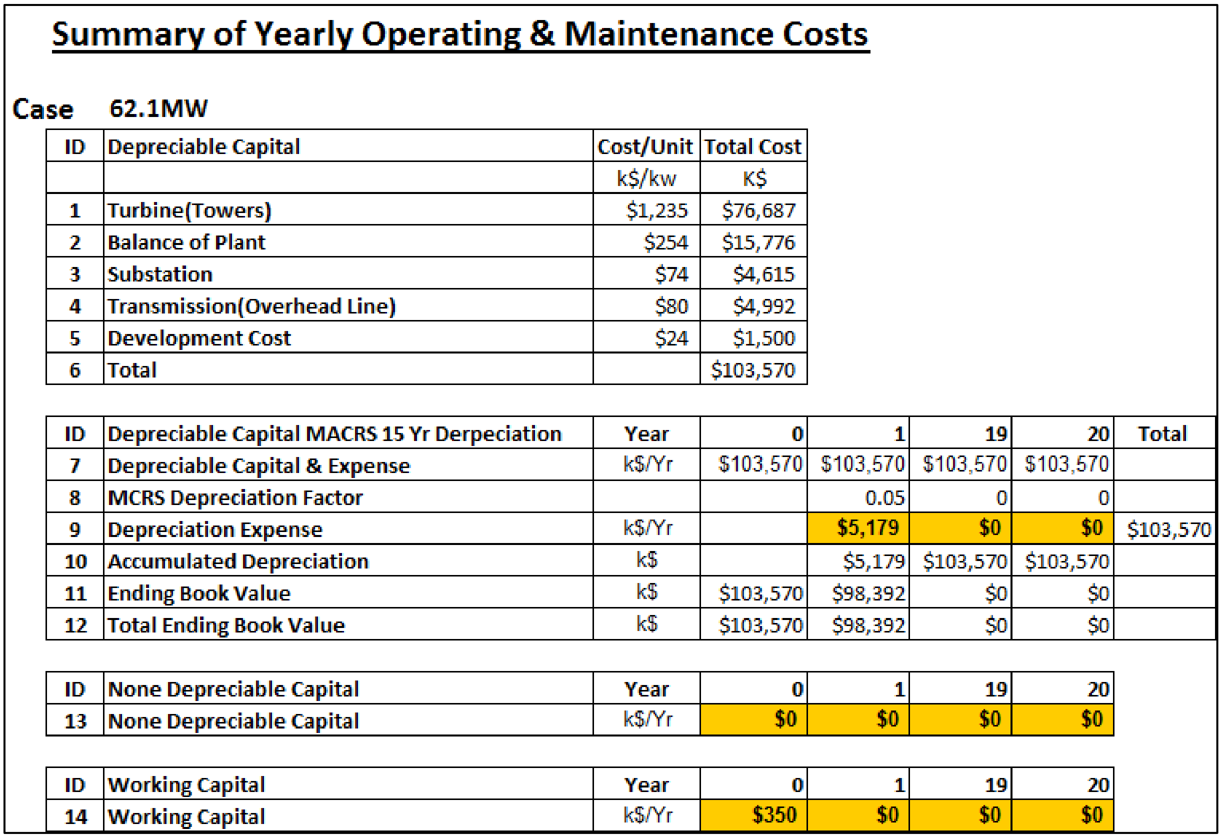
Summary of Yearly Operating & Maintenance Costs

Case **62.1MW**

				Year			
ID	Cost Description	Inflation Rate	Unit	0	1	19	20
9	Land Payments	0%	k$/Yr	$0	$477	$682	$695
10	Property Taxes	0%	k$/Yr	0	$1,554	$869	$834
11	O&M Warranty	2%	k$/Yr	$0	$675	$964	$983
12	Other Yearly Fixed	2%	k$/Yr	$0	$179	$256	$261
13	Management Fee	2%	k$/Yr	$0	$367	$524	$535
14	Other Fee	2%	k$/Yr	$0	$242	$346	$353
15	Total Operating Yearly Costs		k$/Yr	$0	$3,494	$3,640	$3,661

Figure 4 shows the operating and maintenance (O&M) costs for the project. These figures were assessed based on research of comparable projects. Costs are included for the land and property taxes, for the O&M costs of the turbines, management costs, and a buffer for other costs associated with this project that may come up. Figure 5 indicates depreciation rates for depreciable capital.

Figure 5



Summary of Yearly Operating & Maintenance Costs

Case **62.1MW**

ID	Depreciable Capital	Cost/Unit	Total Cost
		k$/kw	K$
1	Turbine(Towers)	$1,235	$76,687
2	Balance of Plant	$254	$15,776
3	Substation	$74	$4,615
4	Transmission(Overhead Line)	$80	$4,992
5	Development Cost	$24	$1,500
6	Total		$103,570

ID	Depreciable Capital MACRS 15 Yr Derpeciation	Year	0	1	19	20	Total
7	Depreciable Capital & Expense	k$/Yr	$103,570	$103,570	$103,570	$103,570	
8	MCRS Depreciation Factor			0.05	0	0	
9	Depreciation Expense	k$/Yr		$5,179	$0	$0	$103,570
10	Accumulated Depreciation	k$		$5,179	$103,570	$103,570	
11	Ending Book Value	k$	$103,570	$98,392	$0	$0	
12	Total Ending Book Value	k$	$103,570	$98,392	$0	$0	

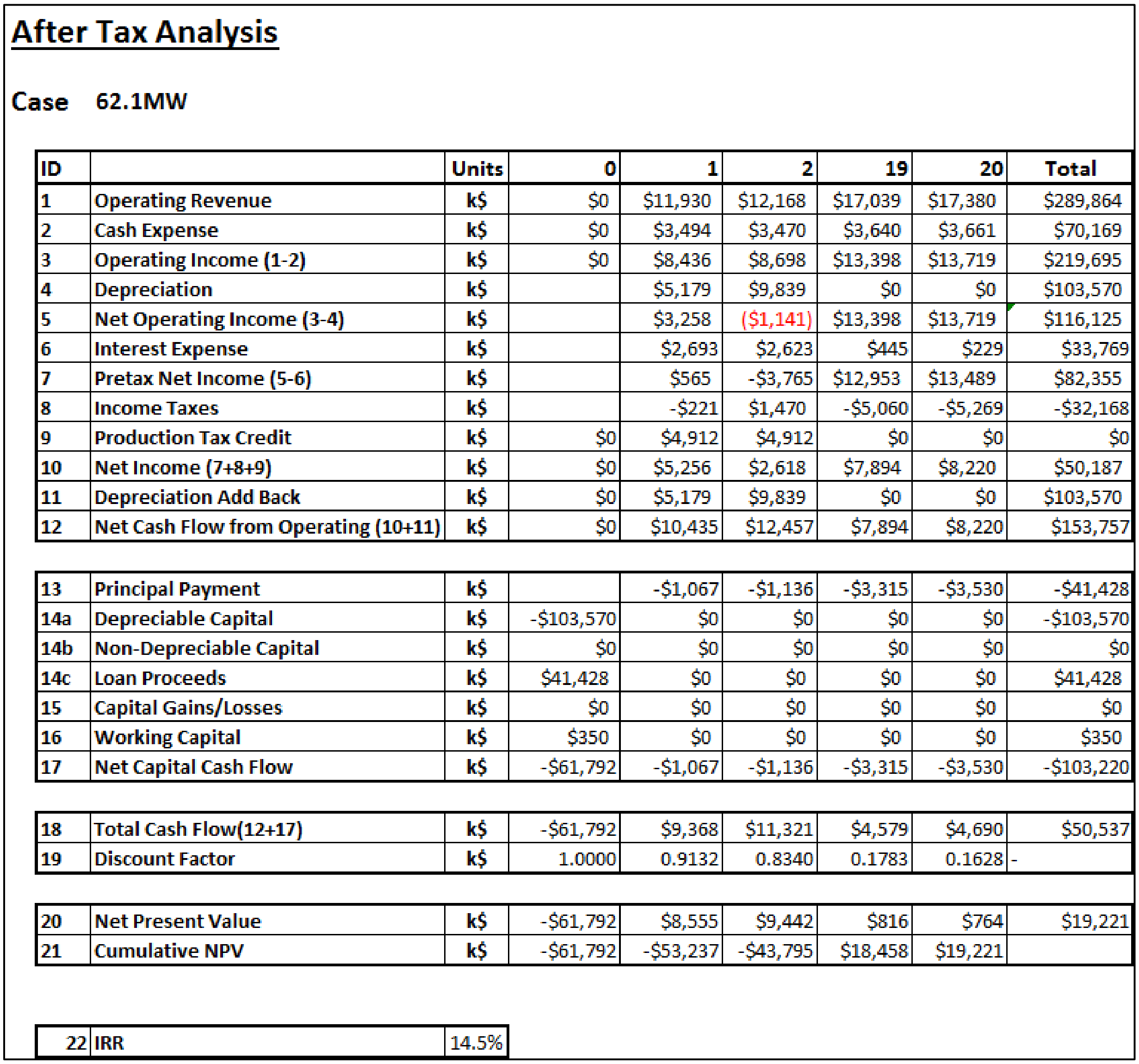
ID	None Depreciable Capital	Year	0	1	19	20
13	None Depreciable Capital	k$/Yr	$0	$0	$0	$0

ID	Working Capital	Year	0	1	19	20
14	Working Capital	k$/Yr	$350	$0	$0	$0

Depreciable capital includes the turbine components and the foundation, the development cost (used to prepare equipment for operation). The non-depreciable capital is negligible since the equipment cost will account for most of the total cost. The working capital is assumed during construction to be $350K, this figure is returned to the project at Year 1.

The complete ATA is shown in figure 6, please note only years 0, 1, 2, 19, 20 and the total figures are portrayed due to space constraints. The values from the previous figures have been inserted here to identify the IRR and Net Present Value (NPV) of the total project. Breakeven occurs in year 10 when the NPV becomes a positive figure. The total NPV of this project is $19,221 at the end of year 20. The IRR is calculated to be 14.5%, this figure is higher than the MARR of 9.5%, and therefore, the project is acceptable.

Figure 6



After Tax Analysis

Case **62.1MW**

ID		Units	0	1	2	19	20	Total
1	Operating Revenue	k$	$0	$11,930	$12,168	$17,039	$17,380	$289,864
2	Cash Expense	k$	$0	$3,494	$3,470	$3,640	$3,661	$70,169
3	Operating Income (1-2)	k$	$0	$8,436	$8,698	$13,398	$13,719	$219,695
4	Depreciation	k$		$5,179	$9,839	$0	$0	$103,570
5	Net Operating Income (3-4)	k$		$3,258	($1,141)	$13,398	$13,719	$116,125
6	Interest Expense	k$		$2,693	$2,623	$445	$229	$33,769
7	Pretax Net Income (5-6)	k$		$565	-$3,765	$12,953	$13,489	$82,355
8	Income Taxes	k$		-$221	$1,470	-$5,060	-$5,269	-$32,168
9	Production Tax Credit	k$	$0	$4,912	$4,912	$0	$0	$0
10	Net Income (7+8+9)	k$	$0	$5,256	$2,618	$7,894	$8,220	$50,187
11	Depreciation Add Back	k$	$0	$5,179	$9,839	$0	$0	$103,570
12	Net Cash Flow from Operating (10+11)	k$	$0	$10,435	$12,457	$7,894	$8,220	$153,757
13	Principal Payment	k$		-$1,067	-$1,136	-$3,315	-$3,530	-$41,428
14a	Depreciable Capital	k$	-$103,570	$0	$0	$0	$0	-$103,570
14b	Non-Depreciable Capital	k$	$0	$0	$0	$0	$0	$0
14c	Loan Proceeds	k$	$41,428	$0	$0	$0	$0	$41,428
15	Capital Gains/Losses	k$	$0	$0	$0	$0	$0	$0
16	Working Capital	k$	$350	$0	$0	$0	$0	$350
17	Net Capital Cash Flow	k$	-$61,792	-$1,067	-$1,136	-$3,315	-$3,530	-$103,220
18	Total Cash Flow(12+17)	k$	-$61,792	$9,368	$11,321	$4,579	$4,690	$50,537
19	Discount Factor	k$	1.0000	0.9132	0.8340	0.1783	0.1628	-
20	Net Present Value	k$	-$61,792	$8,555	$9,442	$816	$764	$19,221
21	Cumulative NPV	k$	-$61,792	-$53,237	-$43,795	$18,458	$19,221	

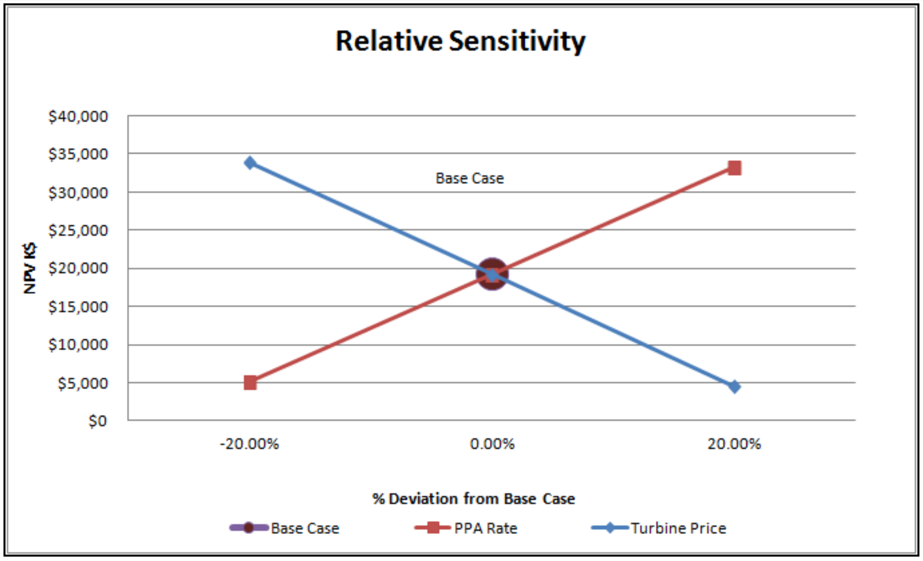
22	IRR	14.5%

A sensitivity analysis is shown in figure 7. The model inputs were varied to identify which variables have the greatest effect on the IRR and the NPV. By carefully controlling these factors, or assessing maximum costs that can be incurred for these variables during the decision making phase, purchases can be made accordingly in order to maximize profitability. The identified variables analyzed were Power Purchase Agreement (PPA) Rate, Turbine Price, and loan rate.

In figure 7, the PPA Rate and Turbine Price are analyzed and the results are graphed. Varying the figures by ±20% yields a change in the NPV. Results show that these values have a significant effect on the NPV, however, in all cases, the NPV remains positive, therefore the project remains profitable. The amount of profitability of the project is also very dependent on the loan percentage, depicted in figure 8. The best case and most profitable scenario would be to increase the PPA rate by 20% to $60 and decrease the Turbine Price by 20% to $82,856. However, even if they were both changed to the worst case scenario (decrease PPA Rate to $40 and increase Turbine Price to $124,284), the NPV would still be positive and the IRR would make it an acceptable project. In conclusion, if these conditions are met, this project should be taken on due to the positive figures of merit and the investment in renewable technology and cleaner electricity generation.

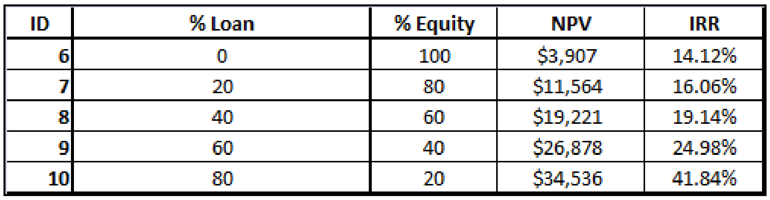
Figure 7

ID	Attribute	Parameter Change			FOM Change (NPV in K$)	
		Before	After	% change in parameter	Before	After
		A	B	C=(B-A)/A	D	E
1	Base Case			0%	$19,221	
2	PPA Rate -20%	$50	$40	-20%	$19,221	$5,113
3	PPA Rate +20%	$50	$60	20%	$19,221	$33,330
4	Turbine Price -20%	$103,570	$82,856	-20%	$19,221	$33,922
5	Turbine Price +20%	$103,570	$124,284	20%	$19,221	$4,521

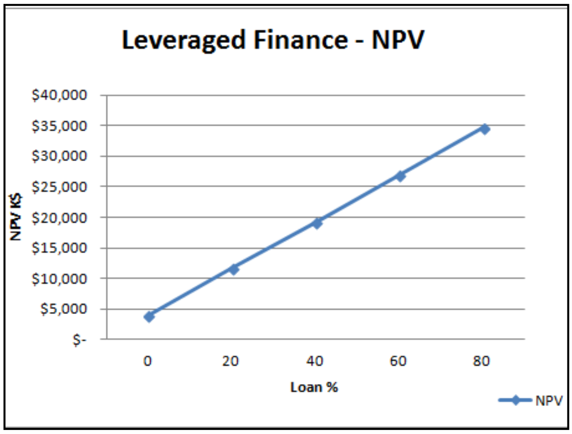


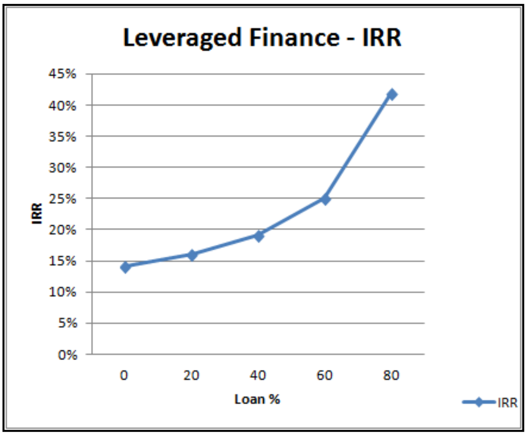
Finance is leveraged when the owner of the project seeks a loan for the capital investment. The loan percentage greatly affects the IRR and NPV of the project. Also, the greater the loan amount and less equity invested in the project, the less risky the investment is for the owner of the project[12]. Figure 8 shows this analysis; note the increasing NPV and IRR with the increasing loan percentage.

Figure 8



ID	% Loan	% Equity	NPV	IRR
6	0	100	$3,907	14.12%
7	20	80	$11,564	16.06%
8	40	60	$19,221	19.14%
9	60	40	$26,878	24.98%
10	80	20	$34,536	41.84%





Case Study Application in the classroom

By applying this case study, students will understand the financial variables that must be considered for renewable energy projects, and specifically for a commercial wind farm. They will learn how to conduct the research to identify the financial components and during this research they will understand how a commercial wind farm yields profits and generates revenue; they will learn about and understand the technical components and capital investments of a wind farm and financial components of renewable energy generation, in this case, the power purchase agreement rate. The ATA will show the students how to vary the figures to achieve the goal of an IRR that is greater than the MARR.

Finally, the students will learn how to identify the figures that have the greatest impact on the IRR and NPV by varying the parameters in the model. They will learn how to apply a sensitivity analysis based on the figures that have the greatest impact on the IRR and NPV. Through application of the sensitivity analysis, students can vary the parameters to understand how an increase or decrease in the most sensitive factors will affect the acceptability of the project. Conversely, by varying the figures, such as the loan, interest rate, PPA rate, assumptions can be made on project profitability via the change in IRR and NPV. Application of this case study will generate an understanding of renewable energy terminology as well as a deeper understanding of how the figures of merit are interrelated and how they are affected by the variables of renewable energy projects.

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