IAH- 304, Energy resources, Economics and Sustainability

Financial Analysis of Wind Projects in South Korea and India

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1. Yeonggwang Onshore Wind Project, Korea

Introduction

Yeonggwang Onshore Wind Project is a 45.1MW onshore wind power project. It is located in South Jeolla, South Korea. The project is currently active. It has been developed in multiple phases. Post completion of construction, the project got commissioned in January 2019.

We will do modelling on Yeonggwang Onshore Wind Project (Yeonggwang Onshore Wind Project Phase I) which consisits consists of 3 Unison U93 turbines with 2MW nameplate capacity making a total capacity of **6MW**.

Assumptions for setting up Yeonggwang Wind Project

Inital Cost of Setting Wind Power Plant

Asuuming Total Capacity of 6MW of power plant for modelling, and from relevent data, we get the cost of setting wind turbine as **$1300 per KW**, we get the initial investment of setting a 6MW Power Plant which comes out to be **$7,800,000.**

Depreciation

As by time, value of plant will depreciate, So we assume straight line depreciation for plant over **20 years** making **$390,000 per year** as depreciation of plant.

Capacity Factor

From relevant data, we get to know the capacity factor of Wind power plants in South Korea which come out to be about **23%** and so we assume the capacity factor of this plnat as **23%** for modelling.

Availability of Wind Power Plant

We also assume the availabilty of plant to be **98%** for **first 5 years** and after that a **de-escalation of 1% from year 5 to year 20**.

Expenses

As from relevant data, we assume the **operational cost to be around $45,000 anually, production cost to be $0.02/KWh of electricity production** and **$20,000 of warranty expense anually** (for first 5 years only) with assuming **annual escalation of 2%** over 20 years (accounting inflation of South Korea which is 2.21% for year 2021).

Assumptions for setting up Yeonggwang Wind Project (contd.)

Tax Rate

From **Damodaran Database**, we get tax rate of South Korea to be **17.18%** which will be applied on net profits of plant.

Discount Factor (Cost of Capital)

In order to find discount factor for **power industry of South Korea**, we get specific data parameters of South Korea to find cost of capital (disocunt factor) of power sector of South Korea for **year 2021** and we will assume this as constant for modelling.

We took these parameters from **Damodaran Database**. These parameters are-

- Country Risk Premium
- 10 year Govt Bond Yield
- Risk Free Rate = 10 year Govt Bond Yield - Country Risk Premium
- Implied Equity Risk Premium
- Debt/Equity Ratio
- Unlevered Beta
- Default Spread

Using this data, we find **cost of equity (Ke)** and **cost of debt (Kd)** which combined with **equity and debt ratio** to find **cost of capital (Kc)** which is our required discount factor which came out to be around **3.25%** fo **year 2021** for power sector of South Korea.

Power Purchasing Agreement Rate (PPA)

PPA rate is the rate at which power plant will sell the electricity at the specific decided rate for revenue generation. As from **electricity database of countries**, we found out that the rate of electricity price in South Korea is **$0.103 per kWh** which we will take as PPA rate of plant with **annual escalation of 2%** over 20 years (accounting inflation of South Korea which is 2.21% for year 2021).

2. Wind Project in India

Introduction

In order to set up wind power plant in India and do modelling on it, we will assume the same characteristics of plant as of Yeonggwang wind project.

So, we will assume a wind project which consists of which consists of 3 Unison U93 turbines with 2MW nameplate capacity making a total capacity of **6MW and we will assume same initial cost as that of Yeonggwang wind project.**

Assumptions for setting up Wind Project in India

Inital Cost of Setting Wind Power Plant

Asuuming Total Capacity of 6MW of power plant for modelling, and from relevent data, we get the cost of setting wind turbine as **$1300 per KW**, we get the initial investment of setting a 6MW Power Plant which comes out to be **$7,800,000.**

Depreciation

As by time, value of plant will depreciate, So we assume straight line depreciation for plant over **20 years** making **$390,000 per year** as depreciation of plant.

Capacity Factor

From relevant data, we get to know the capacity factor of Wind power plants in India which come out to be about **19.33%** and so we assume the capacity factor of this plant as **19.33%** for modelling.

Availability of Wind Power Plant

We also assume the availabilty of plant to be **98%** for **first 5 years** and after that a de-escalation of 1% from year 5 to year 20.

Expenses

As from relevant data, we assume the **operational cost to be around $45,000 anually, production cost to be $0.02/KWh of electricity production** and **$20,000 of warranty expense anually** (for first 5 years only) with assuming **annual escalation of 5%** over 20 years (accounting inflation of India which is 5.56% for year 2021).

Assumptions for setting up Wind Project in India (contd.)

Tax Rate

From Damodaran Database, we get tax rate of India to be **30%** which will be applied on net profits of plant.

Discount Factor (Cost of Capital)

In order to find discount factor for power industry of India, we get specific data parameters of India to find cost of capital (disocunt factor) of power sector of South Korea for **year 2021** and we will assume this as constant for modelling.

We took these parameters from Damodaran Database. These parameters are-

- Country Risk Premium
- 10 year Govt Bond Yield
- Risk Free Rate = 10 year Govt Bond Yield - Country Risk Premium
- Implied Equity Risk Premium
- Debt/Equity Ratio
- Unlevered Beta
- Default Spread

Using this data, we find cost of equity (Ke) and cost of debt (Kd) which combined with equity and debt ratio to find cost of capital (Kc) which is our required discount factor which came out to be around **8.11%** fo **year 2021** for power sector of India.

Power Purchasing Agreement Rate (PPA)

PPA rate is the rate at which power plant will sell the electricity at the specific decided rate for revenue generation. As from electricity database of countries, we found out that the rate of electricity price in India is **$0.075 per kWh** which we will take as PPA rate of plant with **annual escalation of 5%** over 20 years (accounting inflation of India which is 5.56% for year 2021).

3. Calculations

Yeonggwang Wind Project, Korea

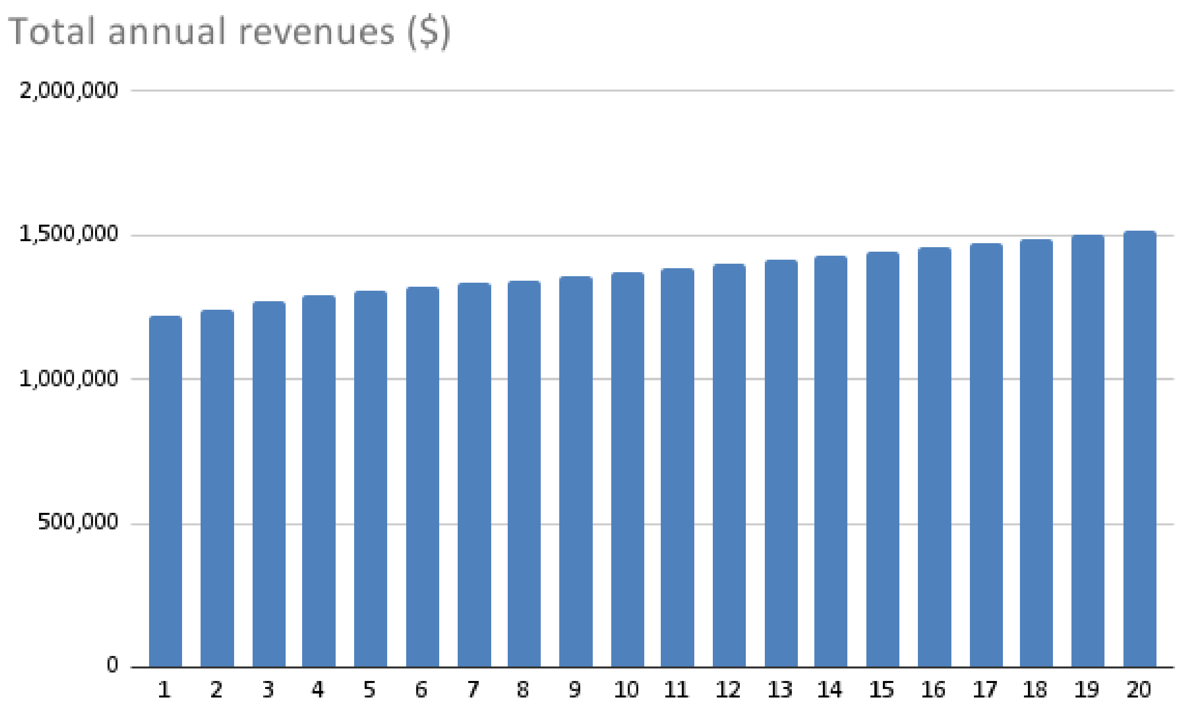
Total Annual Revenues

Firstly, we generated the net production of electricty from year 1 to year 20 by using the required formula-

Electricity produced (kWh/yr) = (Project Size (kW))*(Net capacity factor)*(Anuual hours)*(Availability)

Then we find the net revenue by multiplying electricity produced by PPA rate of that year

Annual Revenue = (Electricity produced)*(PPA rate)



*Column chart showing annual revenues from year 1 to year 20 of Yeonggwang Wind Project, Korea

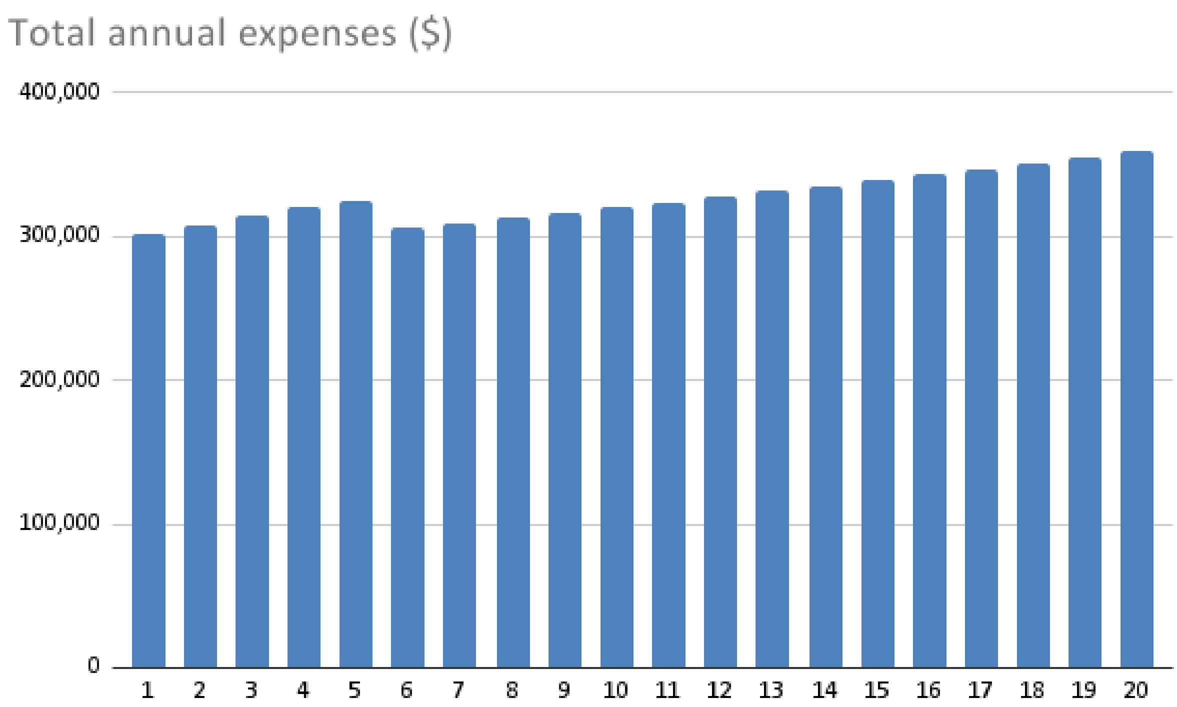
Total Annual Expenses

We find total annual expenses of plant from year 1 to year 20 by using the required formula-

Annual Expenses = (Operations and Maintainance) + (Warranty Expense) + (Total Production Cost)

Where Total production cost is product of electricity produced & Production cost/kWh

Total Production Cost = (Electricity produced)*(Production Cost ($/kWh))



*Column chart showing annual expenses from year 1 to year 20 of Yeonggwang Wind Project, Korea

*Summary of revenues and expenses alongside depreciation of Yeonggwang Wind Project, Korea over 20 Years

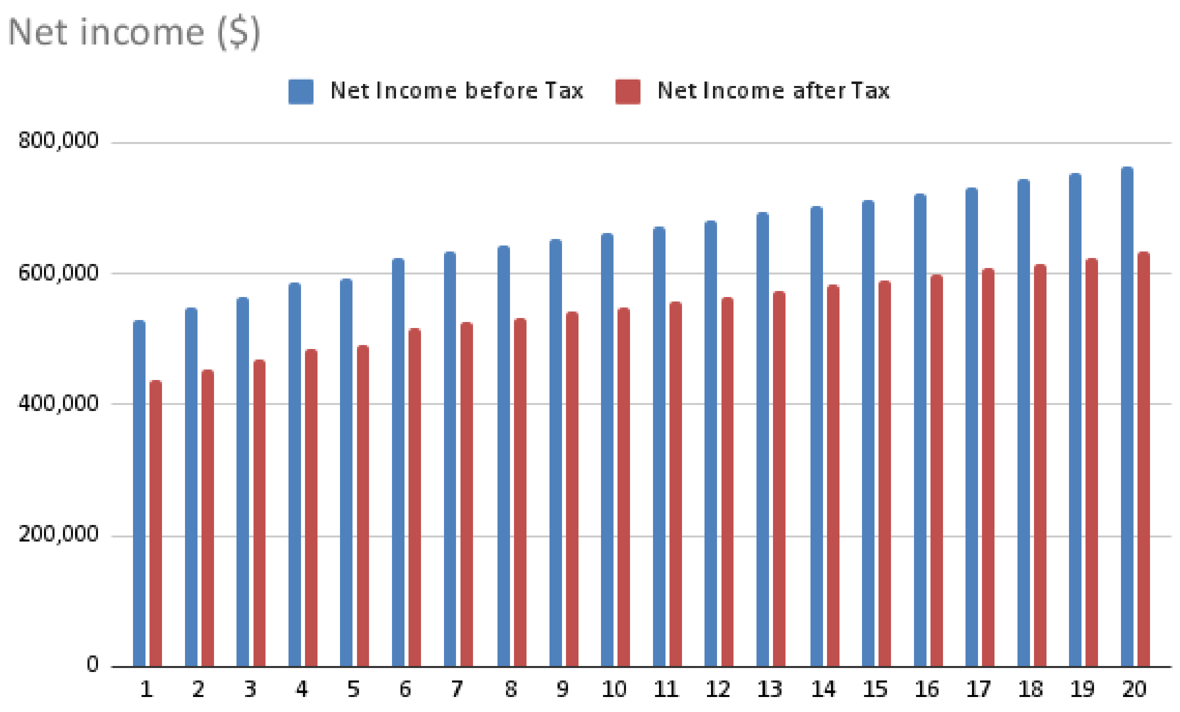
Net Income

As we have found both revenues and expenses of plant, and by considering the depreciation of plant, we find out the net income of plant before tax by following formula-

Net income before Tax = (Revenue) - (Expenses) - (Depreciation)

Now we find out the net income by taking tax rate of South Korea (ie 17.18%) by

Net Income after Tax = (Net Income before tax)*(1-Tax rate(%))



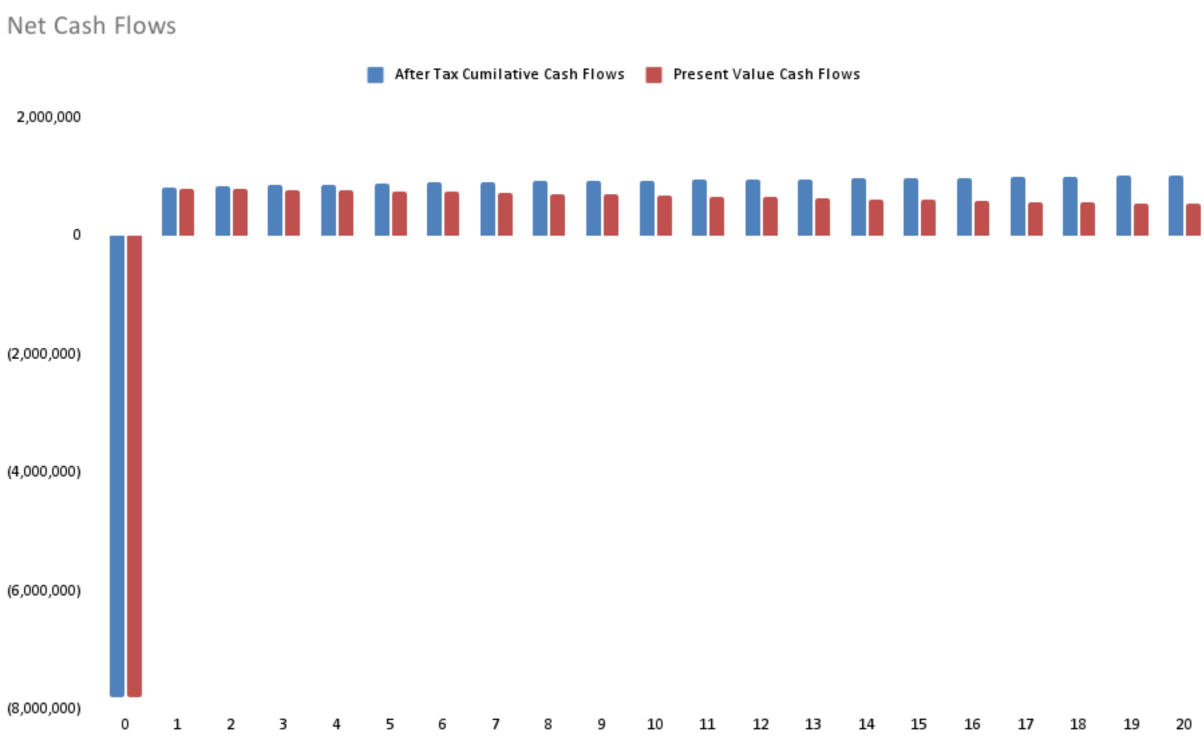
*Column chart showing net income from year 1 to year 20 of Yeonggwang Wind Project, Korea

Net Project Cash Flows

After finding out the net income after tax, we find the **net after tax cumillative cash flows** of plant from **Year 0 to Year 20** by adding baking Depreciation (as Depreciation is non taxable) in net income after tax as-

Net After ATx Cumilative Project Cash Flow = (Net Income after Tax) + (Depreciation)

After this, we find the present value of cashflows using discount factor calculated which is **3.25%** for **South Korea** to get present value Project Cashflows of Plant which will be used to find various financial parametrs of Plant.



*Column chart showing Net Project Cashflows from year 0 to year 20 of Wind Project in India

Wind Project in Inida

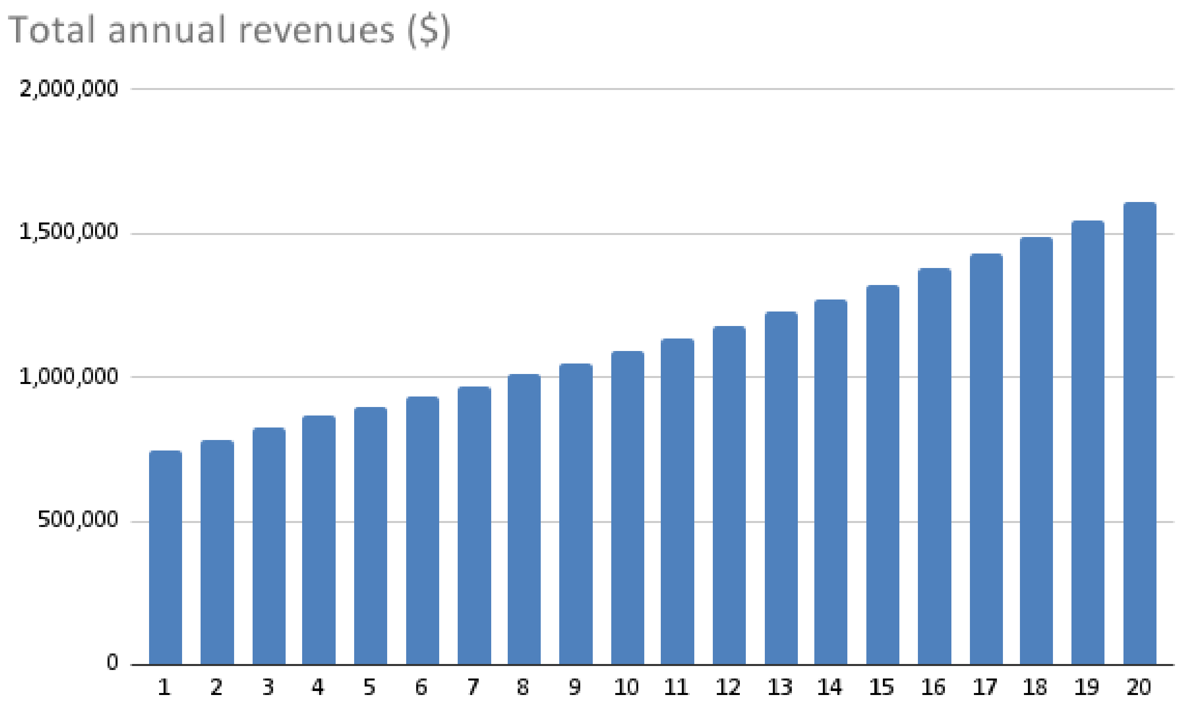
Total Annual Revenues

Firstly, we generated the net production of electricty from year 1 to year 20 by using the required formula.

Electricity produced (kWh/yr) = (Project Size (kW))*(Net capacity factor)*(Anuual hours)*(Availability)

Then we find the net revenue by multiplying electricity produced by PPA rate of that year

Annual Revenue = (Electricity produced)*(PPA rate)



*Column chart showing annual revenues from year 1 to year 20 of Wind Project in India

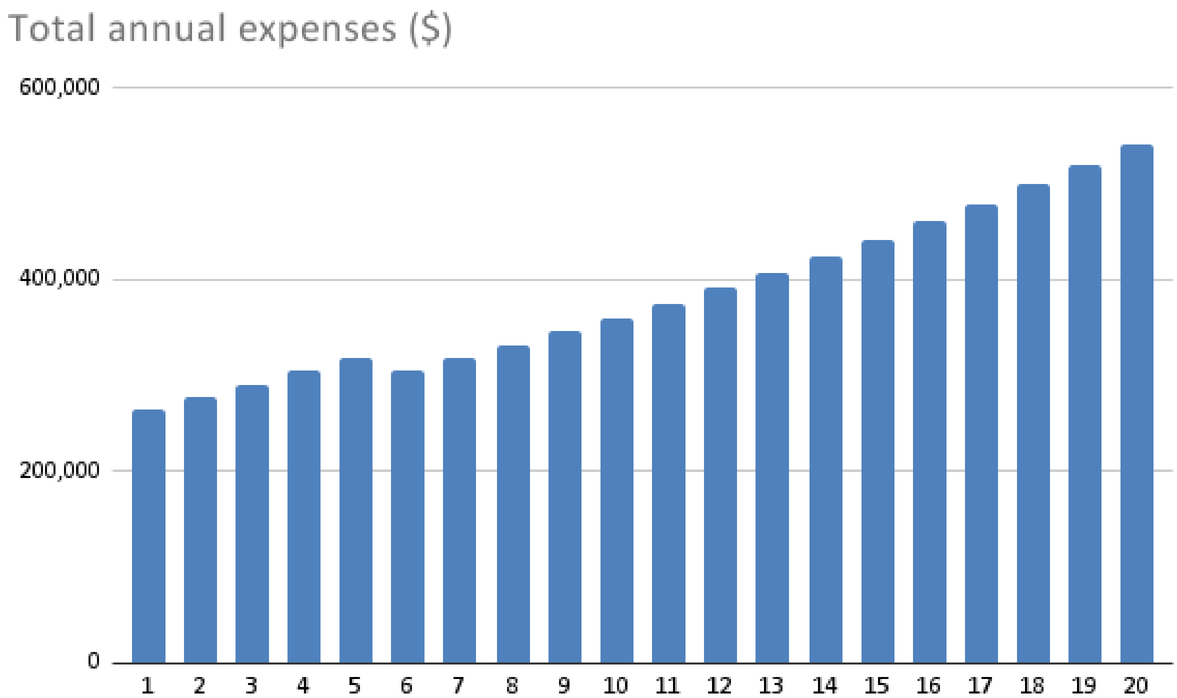
Total Annual Expenses

We find total annual expenses of plant from year 1 to year 20 by using the required formula-

Annual Expenses = (Operations and Maintainance) + (Warranty Expense) + (Total Production Cost)

Where Total production cost is product of electricity produced & Production cost/kWh

Total Production Cost = (Electricity produced)*(Production Cost ($/kWh))



*Column chart showing annual expenses from year 1 to year 20 of Wind Project in India

*Summary of revenues and expenses alongside depreciation of Wind Project in India over 20 Years

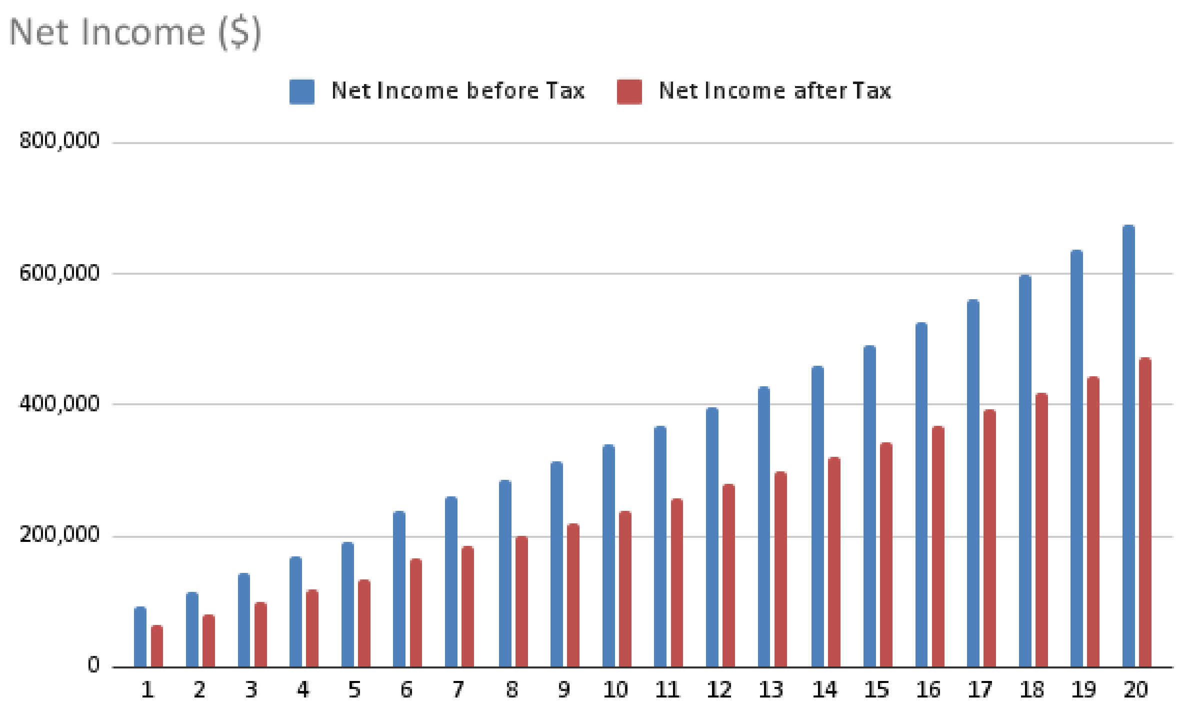
Net Income

As we have found both revenues and expenses of plant, and by considering the depreciation of plant, we find out the net income of plant before tax by following formula-

Net income before Tax = (Revenue) - (Expenses) - (Depreciation)

Now we find out the net income by taking tax rate of India (ie 30%) by

Net Income after Tax = (Net Income before tax)*(1-Tax rate(%))



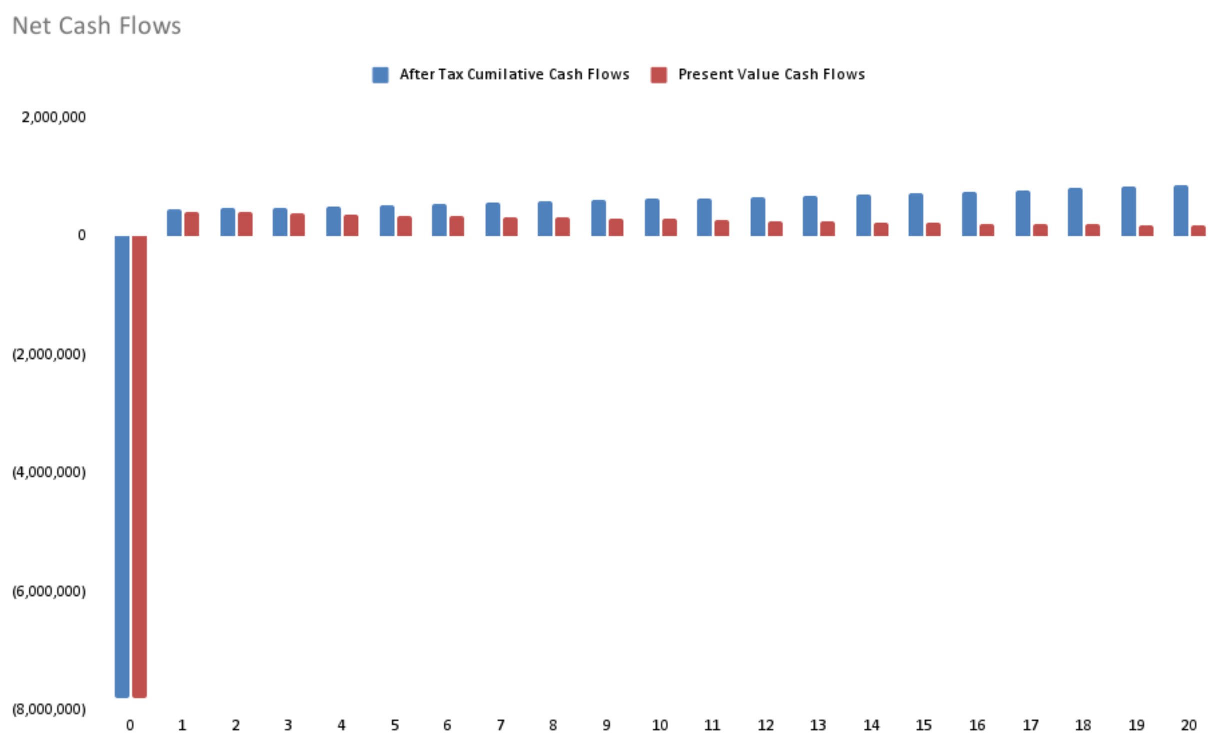
*Column chart showing net income from year 1 to year 20 of Wind Project in India

Net Project Cash Flows

After finding out the net income after tax, we find the **net after tax cumilative cash flows** of plant from **Year 0 to Year 20** by adding baking Depreciation (as Depreciation is non taxable) in net income after tax as-

Net After ATx Cumilative Project Cash Flow = (Net Income after Tax) + (Depreciation)

After this, we find the **present value of cashflows** using discount factor calculated which is **8.11%** for **India** to get present value Project Cashflows of Plant which will be used to find various financial parametrs of Plant.



*Column chart showing Net Project Cashflows from year 0 to year 20 of Wind Project in India

4. Financial Metrics of Plant

Yeonggwang Wind Project, Korea

Net Present Value (NPV)

Net present value (NPV) is a method used to determine the current value of all future cash flows generated by a project, including the initial capital investment.

As we have find out the Cumilative and Present value cashflows of plant, we now come to find the Net Present value of Plant over 20 Years by using following formula as-

$$NPV = \sum_{i=1}^{n} \frac{Cash\ Flow_i}{(1+r)^i} - Initial\ Investment$$

Here n = 20, r = 3.25%, Initail Investment = $7,800,000,
Cash Flow(i) = Cumilative Cash Flow at Year i

We finf out that NPV of Yeonggwang Wind Project, Korea comes out to be **$5,677,652**

Internal Rate of Return (IRR)

Internal rate of return (IRR) is a metric used to estimate the profitability of potential investments. I**RR is a discount rate** that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis.

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} - I_0 = 0$$

Here n = 20, Initail Investment (I) = $7,800,000,
Cash Flow(i) = Cumilative Cash Flow at Year i

We finf out that IRR of Yeonggwang Wind Project, Korea comes out to be **10%**

Payback Period

Payback Period refers to the amount of time it takes to recover the cost of an investment.

$$PaybackPeriod = \frac{Initial\ Investment}{Yearly\ Cash\ Flow}$$

We finf out that Payback Period of Yeonggwang Wind Project, Korea comes out to be **8.83 Years.**

Profitibality Index (PI)

Profitability Index (PI) describes an index that represents the relationship between the costs and benefits of a proposed project.

It is calculated as the ratio between the present value of future expected cash flows and the initial amount invested in the project

$$\text{Profitability Index Formula} = \frac{\text{PV of Future Cash Flows}}{\text{Initial Investment}}$$

We finf out that PI of Yeonggwang Wind Project, Korea comes out to be **1.73.**

Operating Expense Ratio (OER)

Operating expense ratio (OER) is a measurement of the cost to operate a piece of property, compared to the income brought in by the property.

$$\text{Operating Expense Ratio} = \frac{\text{Operating Expenses}}{\text{Revenues}}$$

We finf out that OER of Yeonggwang Wind Project, Korea comes out to be **0.24.**

Wind Project in India

Net Present Value (NPV)

Net present value (NPV) is a method used to determine the current value of all future cash flows generated by a project, including the initial capital investment.

As we have find out the Cumilative and Present value cashflows of plant, we now come to find the Net Present value of Plant over 20 Years by using following formula as-

$$NPV = \sum_{i=1}^{n} \frac{Cash\ Flow_i}{(1+r)^i} - Initial\ Investment$$

Here n = 20, r = 8.11%, Initail Investment = $7,800,000,
Cash Flow(i) = Cumilative Cash Flow at Year i

We finf out that NPV of Wind Project in India comes out to be **-$2,025,688**

Internal Rate of Return (IRR)

Internal rate of return (IRR) is a metric used to estimate the profitability of potential investments. **IRR is a discount rate** that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis.

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} - I_0 = 0$$

Here n = 20, Initail Investment (I) = $7,800,000,
Cash Flow(i) = Cumilative Cash Flow at Year i

We finf out that IRR of Wind Project in India comes out to be **5%**

Payback Period

Payback Period refers to the amount of time it takes to recover the cost of an investment.

$$PaybackPeriod = \frac{Initial\ Investment}{Yearly\ Cash\ Flow}$$

We finf out that Payback Period of Wind Project in India comes out to be **13.55 Years.**

Profitibality Index (PI)

Profitability Index (PI) describes an index that represents the relationship between the costs and benefits of a proposed project.

It is calculated as the ratio between the present value of future expected cash flows and the initial amount invested in the project

$$\text{Profitability Index Formula} = \frac{\text{PV of Future Cash Flows}}{\text{Initial Investment}}$$

We finf out that PI of Wind Project in India comes out to be **0.74.**

Operating Expense Ratio (OER)

Operating expense ratio (OER) is a measurement of the cost to operate a piece of property, compared to the income brought in by the property.

$$\text{Operating Expense Ratio} = \frac{\text{Operating Expenses}}{\text{Revenues}}$$

We finf out that OER of Wind Project in India comes out to be **0.34.**

5. Financial Analysis of Yeonggwang Wind Project

Net Present Value (NPV)

As NPV of Yeonggwang Wind Project came out to be **$5,677,652** which is greater than 0, this implies that plant is at net overall profit for first 20 years thanks to low tax rate, inflation, high capacity factor and high PPP rate of India.

Internal Rate of Return (IRR)

As IRR of Yeonggwang Wind Project came out to be **10%**, which is way more than discount rate of power sector of Korea (ie, 3.25%), this has lead to higher cash flows of plant which is seen in NPV of plant thus continuing the project for 20 years has lead to higher profit of plant.

Payback Period

As Payback Period of Yeonggwang Wind Project came out to be **8.83 Years**, this implies that plant has covered its initial cost within 8.83 years and after that its net cashflow is positive which is a good sign that plant has covered its cost within such a short span of time.

Profitibality Index (PI)

As PI of Yeonggwang Wind Project came out to be **1.73**, it indicates that that present value of future cash inflows from the investment is more than the initial investment, indicationg that plant will earn profits which can be seen in NPV of plant.

Operating Expense Ratio (OER)

As OER of Yeonggwang Wind Project came out to be **0.24** ,it indicates that plant spend 24% of what we earn from revenues thanks to less inflation.

6. Financial Analysis of Wind Project in India

Net Present Value (NPV)

As NPV of Wind Project in India came out to be **-$2,025,688**, which is less than 0, this implies that plant is at net overall loss for first 20 years thanks to high tax rate, inflation, low capacity factor and low PPP rate of India.

Internal Rate of Return (IRR)

As IRR of Wind Project in India came out to be **5%**, which is a little less than discount rate of power sector of India (ie, 8.11%), this has lead to lower cash flows of plant which is seen in NPV of plant thus continuing the project for 20 years has lead to loss of plant.

Payback Period

As Payback Period of Wind Project in India came out to be **13.55 Years**, this implies that plant has covered its initial cost within 13.55 Years and after that its net cashflow is positive which is a indicator that plant has covered its cost within such a long span of time thus plant is just covering losses in this span of time.

Profitibality Index (PI)

As PI of Wind Project in India came out to be **0.74**, it indicates that that present value of future cash inflows from the investment is less than the initial investment, indicationg that plant will earn loss which can be seen in NPV of plant.

Operating Expense Ratio (OER)

As OER of Wind Project in India came out to be **0.34**,, it indicates that plant spend 34% of what we earn from revenues thanks to high inflation.

7. Conclusions

Yeonggwang Wind Project, Korea

As we can see, plant has generated high revenues within 20 Years which is a good sign for South Korea that Wind Project is viable here thanks to low inflation, more developed technology of turbines (high capacity factor), less tax rate, low discoun rate, high PPP rate due to more GDP per capita of South Korea.

Hence we can say that by forecasting, setting up a wind project in South Korea is a profitable investment for span of 20 Years.

Wind Project in India

As we can see, plant has generated low revenues within 20 Years which is not a good sign for India that Wind Project is viable here thanks to high inflation, less developed technology of turbines (low capacity factor), high tax rate, high discounti rate, low PPP rate due to low GDP per capita of India.

Hence we can say that by forecasting, setting up a wind project in India is not a profitable investment for span of 20 Years but in future it may be.

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