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Financial Evaluation of Photovoltaic Energy Projects in Colombia

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ABSTRACT

The use of renewable sources, especially photovoltaics, has become a viable alternative as a supply of this vital element without destroying the environmental environment. In this sense, the main objective of the study is to propose a methodology of economic/financial evaluation of photovoltaic energy projects in Colombia, through the application of the real options valuation, the above supported by a mixed method that combines the review of qualitative information or documentary in conjunction with a quantitative sample based on numerical data and official figures, in order to address the issue with rigorous livelihoods. The results indicate that the photovoltaic energy has a high potential in the country, according to the real options valuation the total investment cost of the installation and commissioning for a 5000 Kw plant would be $ 18,930,000 USD, taking advantage of 1825 h of work thus generating about 9,125,000 Kw/h. It is concluded that the energy matrix in Colombia must be diversified, supported by a government management that facilitates access to credit lines that leverage the initial investment in capital, additionally, taking advantage of the geographical characteristics of Guajira, Magdalena and the Atlantic is crucial for Implement these types of projects.

Keywords: Renewable Energies, Photovoltaic Energy, Real Options Valuation, Feasibility
JEL Classifications: Q42, Q48, G171

1. INTRODUCTION

Sustainable development is the responsibility of all on the planet and therefore the current reality of the environment must be made aware; thus, it is essential to implement measures that promote favorable changes in consumption patterns, in the production of goods and services, and in the use of natural resources that allow favorable economic growth without causing adverse effects on environmental and social environments (Bravo, 2015). In this sense Trujillo et al. (2018) stated that the concept of administration in terms of sustainability is perceived as a new approach that has developed an exponential boom globally in recent years. It is recorded in the economic sphere, as a strategy of enormous benefits, since it integrates the variables that affect the normal development of a sector or guild.

Energy is a particularly important aspect in the daily life of the human being, so great efforts are devoted to generating it, often with a high environmental price, for this reason, within these policies for the achievement of sustainable development, the use of alternative energy sources occupies the first places of interest (Bravo, 2015). Among the most common generation methods there is solar photovoltaic, solar thermal, hydraulic, wind, or bioenergy energy; the first two use sunlight either through radiation or by the heating it produces; the third option uses water movement as the main element; the fourth resorts to wind strength; while the latter is derived from the management of organic matter of plant or animal origin; (Bravo, 2015).

In adopting a system of energy generation using renewable sources, it is essential to analyse the conditions and impact of these in the long term; such as the potential of available resources, solar irradiation levels and effects on the ground are some of the topics to consider (Bhandari et al., 2014). Global energy demand and environmental concerns are the driving force for the use of alternative, sustainable and clean energy sources (Hosenuzzaman et al., 2015); this is why hydropower, wind and photovoltaic power are used as main sources of renewable energy depending on the capacity installed on the planet (Bhandari et al., 2015).

Solar energy is regarded as an inexhaustible and emission-free source of CO_2; Earth's surface receives from the sun a power of 1.4 × 105 TW, of which approximately 3.6 × 104 TW is useful (Hosenuzzaman et al., 2015); therefore, photovoltaic systems have experienced strong growth in the market over the past decade (Yu et al., 2016). It is important when analyzing and implementing projects of this nature, not only to measure economic projections but also the impact they can generate on the ecosystem.

An example of this is reflected by Capel (2015), who proposes to deepen the effect that this type of systems generates in the landscape, stopping in its typological singularity and the effects on the intensity of the visual incidence; at the same time the location, extent, orientation and distribution of the elements. On the other hand, Pasqualino and Cabrera (2015), propose that the environmental impact should be measured in relation to abiotic factors (air; soil), biotics (ecosystems; vegetation; fauna) and socioeconomic (local economy; education, science, technology and innovation; social and cultural aspects).

In this sense, it is possible to establish the large number of opportunities for the use of these systems, which have also led to research of all kinds ranging from the analysis of the impact of photovoltaic energy penetration in electrical energy distribution systems (Correa et al., 2016), going through the economic impacts on society (Simpson y Clifton, 2016), or even studies for optimizing these generation techniques from hybridization with other renewable sources (Sinha and Chandel, 2015). Because of this, the development of this research is presented in order to propose a method of economic – financial assessment, using the Real Options Valuation, which not only contemplates the technical aspects of the project, but also analyses its sustainability in the future.

2. MATERIALS AND METHODS

The methodology is descriptive because it describes the net present value, reflecting the reality of the project from the real options valuation, it is also non-experimental, documentary with bibliographic cut, since the documents and briefs were reviewed that reflect the data that were used to make the estimates. To collect these results, a content analysis was made by taking under consideration the element for calculating the Net Present Value (NPV), which states the following formula:

$$NPV = \sum_{t=1}^{n} \frac{FCt}{(1+k)^t} \tag{1}$$

Where Lopez (2006) defines "*FCt*" as the cash flow in a specific period "*t*", and "*k*" as the established interest rate.

3. RESULTS

During the execution of the study, an electrical power plant with photovoltaic solar panels of 2000 kW was selected; to analyze the working capacity of the solar power plant, a capacity factor of 21% was used. This value was deduced from the average solar radiation to the day generated at its maximum power (net), equivalent to 5, of 24 h, in cities such as Barranquilla - Colombia, which mostly has sunny days and tropical environment (Hosenuzzaman et al., 2015).

The net present value is calculated for forecasting the value of the investment to recover in the long term and check if the project is profitable for the investor. In the results obtained it was noted that in the operating path of the plant (about 25 years of service life), COP $23,611,221,091 gross increased than the total investment cost of the installation and commissioning of the 2000 kW plant COP $23,473,200,000, which means that the plant would only pay itself and adding very little return according to all the time and work invested on it, making this option very unattractive.

The real options valuation (ROV) uses inflation as a livelihood, considering that this long-term forecast is executed. When applying a model where cash flow behaviors, investment cost and operating time vary, their final value will depend on how high those annual cash flows vary and how low the interest rate applied. The latter plays an important role and only depends on the facilities that the market offers to develop its projects, so the lower this is the bigger profitability the generation project has. For this reason, it is insisted that the government support the renewable sector to provide the initial capital.

On the other hand, in the formula of net present value, which is commonly used for evaluating and comparing financial products or capital projects with cash flows spread over time. The divisor of the formula for NPV $(1+k)^t$, represents the cash depreciation after a specific time. When applying NPV with inflation adjustments in the sale price and the most current market values, a more realistic component was added to the financial method applied with real options.

According to the review, there are three options or decision alternatives to be applied according to the results obtained, we assume that the last option to be made would be the most drastic one because it is previously analyzed what would happen when deciding the other two alternatives, this option is to differ the project if none of the evaluated plants fulfils the profit margin expectations. Evaluating the 5000kW plant its detailed in Table 1 its profits yearly and at the end of the 25 years of productive life.

With the estimated generation price for 2019, the total investment cost of installation and commissioning for a 5000-kW plant would be USD $18,930,000. The total cost of investment of the installation and commissioning for a 5000-kW plant would be passed to $58.683.000.000 Colombian pesos. Considering that the hours a day that make the most of solar radiation are between 10 am and 3 am, 365 days, 1825 h of work would be taken advantage of, which applied to 5000 kW would result in 9,125,000 Kw/h generated at the plant during 1 year of operation.

Table 1: Yearly NPV calculations

Year	Depreciation factor result $(1+i)^t$	Annual sales (COP$)	Annual cash flow (income-outcome)	Annual cash flow (income-outcome)/$(1+i)^t$
2019	1.08	$3.650.000.000	$2.609.750.000	$2.416.435.185
2020	1.17	$3.897.105.000	$2.856.855.000	$2.441.756.410
2021	1.26	$4.160.939.009	$3.120.689.009	$2.476.737.308
2022	1.36	$4.442.634.579	$3.402.384.579	$2.501.753.367
2023	1.47	$4.743.400.940	$3.703.150.940	$2.519.150.300
2024	1.59	$5.064.529.184	$4.024.279.184	$2.530.993.198
2025	1.71	$5.407.397.810	$4.367.147.810	$2.553.887.608
2026	1.85	$5.773.478.642	$4.733.228.642	$2.558.501.968
2027	2	$6.164.343.146	$5.124.093.146	$2.562.046.573
2028	2.16	$6.581.669.177	$5.541.419.177	$2.565.471.841
2029	2.33	$7.027.248.180	$5.986.998.180	$2.569.527.116
2030	2.72	$7.502.992.882	$6.462.742.882	$2.376.008.412
2031	2.94	$8.010.945.500	$6.970.695.500	$2.370.984.864
2032	3.17	$8.553.286.510	$7.513.036.510	$2.370.043.063
2033	3.43	$9.132.344.007	$8.092.094.007	$2.359.211.081
2034	3.7	$9.750.603.696	$8.710.353.696	$2.354.149.648
2035	4	$10.410.719.566	$9.370.469.566	$2.342.617.392
2036	4.32	$11.115.525.281	$10.075.275.281	$2.332.239.648
2037	4.66	$11.868.046.342	$10.827.796.342	$2.323.561.447
2038	5.03	$12.671.513.080	$11.631.263.080	$2.312.378.346
2039	5.44	$13.529.374.515	$12.489.124.515	$2.295.794.948
2040	5.87	$14.445.313.170	$13.405.063.170	$2.283.656.417
2041	6.34	$15.423.260.871	$14.383.010.871	$2.268.613.702
2042	6.85	$16.467.415.632	$15.427.165.632	$2.252.140.968
2043	7.4	$17.582.259.671	$16.542.009.671	$2.235.406.712
				$60.173.067.522

For the calculation of the total operating cost of the plant was taken as the basis, the operating cost whose value corresponds to $COP 114/kW-h, to take the estimate of the operating time in the study will be done according to the 25 years of service life being for this study COP$416,100,000 per year in operating costs. Values in the formula are replaced and the NPV value resulted with a positive value of COP$1,490.067,522 as a return, apart from the recovery of the value initially invested with the respective depreciation of the money in the operative time (25 years) with an interest rate of 8%.

According to the results for a 5000kW plant, profits are made in greater proportion of money compared to stipulations for the 2000kw plant, however, by comparing this value with the initial investment of the project it is still a minor value, so differing would be the best of the options, to expect changes and better conditions both price and market flexibility, through government regulations and statutes. By applying photovoltaic energy project evaluation techniques with high degree of uncertainty for 2000kW and 5000kW plants, it follows that the return on investment is long-term.

4. CONCLUSIONS

The real options valuation has become a valuable tool for the evaluation of investment projects, with a high degree of uncertainty. It can be applied to various sectors, in this case, in the solar photovoltaic energy generation sector, which belongs to the energy sector, one of the most variable in price and by the intermittency in the information of resources. By using methodologies to simulate reality in the face of uncertainty scenarios, you can project the profitability and losses generated by the consumer price index and the determination of other investment costs, market prices, among others. In this context, the real options valuation is used as a decision alternative, which seeks economic quantification, streamlining decisions, considering flexibility, abandonment, expansion or waiting.

Pilot testing, factory design, conceptual engineering are key examples, where the option to expand a business can be determined. The option to differ can certainly be applied when the NPV is negative, feasibility studies determine whether cash flows are not as expected, so the waiting option is very valuable for inclusion of projects at another time with better opportunities. These valuations made certainly avoid future risks and losses.

The results of low economic feasibility make the government's presence necessary, as a regulatory body that flexes the market and guarantees economic subsidies, tax incentives and opportunities for SMEs and interested companies for the incorporation and development of renewable energy projects in the Colombian territory. The matrix must be diversified, avoiding the purchase of electricity to neighboring countries by promoting self-generation with clean alternatives that support the environment.

It is necessary to expand the percentage of participation in Colombia's energy matrix of innovative projects that eliminate the high costs of consumption of fossil fuels in the operation of plants, and excessive pollution of the environment, this will certainly end the resources, remembering that they are not renewed or can be re-established. Colombia, has cities with high potential for solar power generation as a tropical country with a prestigious geographical location and still has a large field of exploration for the creation of opportunities in the renewable sector, where solar energy promotes the development of projects with short installation time of approximately 6 months to a year, compared to other power generation plants. The Guajira, Magdalena, Atlántico and other sectors of the Northern Region, are attractive destinations for such projects.

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