ASSESSMENT OF PV INVESTMENTS IN NORTHERN CYPRUS

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ABSTRACT

Energy is one of the most important merchandises in the whole world as it is considered as the engine for the economic growth and development of the countries. The investment in renewable energy systems became one of the successful investments as the demand on energy is increasing significantly. However, the profitability of renewable energy systems highly depends on the geographical location. Northern Cyprus is poor in traditional energy resources and the power generation system depends on imported fossil fuel. On the other hand, Northern Cyprus has high potential of solar energy which makes it a suitable place for PV projects. Therefore, this study aims to specify the best regions in Northern Cyprus to install PV power plants where the best regions are selected based on the highest profitability of the project. The simulation results indicate that the investment in PV projects in all the regions is profitable if the feed in tariff was the same as Southern Cyprus, i.e. 0.294 USD/kWh. Guzelyurt is the best region for PV investments in Northern Cyprus with NPV of 3256.1 USD/kWp, LCOE of 0.1035 USD/kWh, IRR of 31.77% and a PBP of 6.1 years.

1. INTRODUCTION

Energy is one of the essential factors for the development of societies through life quality enhancement. However, the conditions in energy sectors are changing as the demand is rapidly increasing. This stress on energy demand has induced a big burden on conventional energy resources. With the recent attention to climate change and environmental issues with fossil-fuel based energy production, governments and utilities are becoming motivated to increase renewable energy penetration into electric grids [1]. Photovoltaic (PV) power is an important sustainable energy resource. Projections show that the usage of PV technology is expected to be the highest among all other types of renewable energy resources by 2030 [2] due to the extreme decline in its installation prices [3] .Therefore, countries characterized with high potential of solar irradiation commenced PV projects all around the globe to enhance the sustainable development of energy sectors. Despite the fact that Northern Cyprus heavily depends on imported fossil fuel based energy resources [4], the island is well known for its high potential of solar irradiation availability [5] where it is characterized to have 300 sunny days in a year [6]. Hence, it is a major motivation for utilities and government to increase the investment in PV projects in the island in order to fasten the movement towards clean energy usage and higher profitability gains to investors.

Various studies in literature discuss the installation of PV plants in Northern Cyprus. For instance, authors in [6] found that having 6.81 MW off-grid PV power plant with batteries would meet the demand of the university; however, the cost of electricity generated was 0.24 USD/kWh where the grid tariff was 0.22 USD/kWh, while having a 5.875 MW grid-tied PV plant with feed in tariff of 0.22 USD/kWh would reduce the cost of electricity to 0.14 USD/kWh. Furthermore, authors in study [7] determined the feasibility of different sizes of grid-tied PV power plants in Middle East Technical University Northern Cyprus Campus with energy storage system; having a 4.5 MW PV plant with 15 MWh PHS would meet the demand 83% of the time and have LCOE of 0.24 USD/kWh; where the

minimum LCOE, 0.2 USD/kWh, could be achieved with 0.5 MW power plant and no storage system. Unlike reference [8] where authors compared two solar energy technologies, namely Photovoltaic (PV) and Parabolic trough (PT) technologies, having the same installation capacity of 40 MW in two cities of Northern Cyprus, Nicosia and Famagusta. They concluded that the PT technology promises more energy production relative to PV. Finally, authors in [9] proposed an iterative approach to design an optimal large scale PV plant in Cyprus International University relying on payback period.

To the best of our knowledge, none of the studies presented in literature assessed the PV investments in different locations of the island considering profitability. Therefore, this study aims to specify the best regions in Northern Cyprus to install PV power plants where the best regions are selected based on the highest profitability of the project. The profitability of the PV power plants will be assessed using net present value, simple payback period and internal rate of return where the energy production from the PV power plants will be estimated using PVGIS online software.

2. THEORY AND METHODOLOGY

2.1 Energy Production

The Global Horizontal Irradiation (GHI) of the selected regions and the electrical energy produced by the PV systems in different regions in Northern Cyprus were obtained from Photovoltaic Geographical Information System (PVGIS) online software [10]. The software estimates the electrical energy production taking into consideration the optimal geometry of the PV panels and all the electrical losses namely wiring, inverter and temperature losses. The economic and technical assessments of the PV projects were done for 19 regions in Northern Cyprus. Table 1 shows the geographical information and the GHI for the 19 regions in Northern Cyprus.

2.2 Economic Assessment of PV System

The profitability of any investments in any sector- including energy sector- is the main aim for any investor; several economic parameters can be used as measures for the economic profitability such as net present value (NPV), payback period (PBP) and internal rate of return (IRR). From an investor prospective, the project with higher IRR, higher NPV and lower PBP is the most attractive. NPV and PBP can be calculated using Eq. (1) and Eq. (2) while IRR is equals to discount rate at which the NPV of the project equals to zero [11].

$$NPV = \sum_{t=1}^{l} \frac{R_t}{(1+d)^t} - C \quad (1)$$

where NPV is the net present value of the PV project [USD/kWp], R_t is the annual revenues of the PV project [USD/kWp] and C the capital cost of the PV project [USD/kWp].

$$PBP = \frac{C}{R_1} \quad (2)$$

where PBP is the payback period of the PV project [years] and $R_1$is the revenues of the PV project in the first year [USD/kWp].

Moreover, the levelized cost of electricity (LCOE) is one of the economic parameters used in the energy sector to evaluate the projects where it is the cost of electricity produced by the energy system. The LCOE can be used to compare the cost of energy produced from a certain energy system with the local grid tariff and with alternative energy projects. The project with LCOE lower than the price of electricity is considered as an attractive one and the lower the LCOE the more attractive the project is. The LCOE can be calculated as,

$$LCOE = \frac{C + \sum_{t=1}^{l} \frac{M}{(1+d)^t}}{\sum_{t=1}^{l} \frac{E}{(1+d)^t}} \quad (3)$$

where $LCOE$ is the levelized cost of electricity [USD/kWh], M is the annual maintenance cost [USD/kWp], d is the annual discount rate [%] and E is the annual energy production from the PV power plant [kWh/kWp].

Table 1. The geographical information of the selected regions in Northern Cyprus as well as the average daily GHI.

Region	Altitude (m)	Latitude (degree)	Longitude (degree)	GHI ($kWh.m^{-2}$)
Alsancak	65	35.33	31.20	6.19
Bafra	12	35.35	34.05	6.30
Camlibel	277	35.30	33.05	6.41
Catalkoy	123	35.30	33.40	6.14
Dipkarpaz	172	35.62	34.40	6.16
Esentepe	172	35.33	33.57	5.97
Gazimagusa	11	35.10	33.92	6.36
Gecitkale	80	35.27	33.73	6.11
Girne	107	35.32	33.30	6.14
Guzelyurt	21	35.20	32.97	6.38
Lapta	253	35.33	33.15	6.11
Lefka	214	35.08	32.83	6.14
Nicosia	130	35.18	33.37	6.16
Sadrazamkoy	83	35.37	32.93	6.25
Tatlisu	172	35.37	33.75	5.95
Vadili	45	35.13	33.65	6.19
Yeni Erenkoy	117	35.53	34.18	6.19
Yeni Iskele	39	35.28	33.88	6.25
Yesilirmak	24	35.15	32.73	6.25

Northern Cyprus started to encourage the deployment of renewable energy systems by legislating supporti large scale renewable energy systems such as feed in tariff. In this study it is assumed that the future feed in tariff of grid-tied PV plants in Northern Cyprus will be equal to the feed in tariff in the Southern Cyprus [12]. All the economic parameters used in this study are listed in Table 2.

Table 2. The economic parameters of the PV systems in Northern Cyprus.

Parameter	Value	Reference
PV System Capital Cost (USD/kW)	1533	[13]
PV System Annual Maintenance Cost ($/kW)	24	[14]
Feed in Tariff (USD/kWh)	0.294	[12]
Annual Discount Rate (%)	8	[15]
System's Lifespan (years)	25	[15]

3. RESULTS AND DISCUSSION

The geographical location of the PV projects affects significantly the profitability of it due to the variation in the solar radiation and the ambient temperature since they affect the energy production. Obviously, projects with the highest profitability is more attractive to the investors. Therefore, the technical performance and the economics of PV projects in different regions in Northern Cyprus are analysed in order to specify the best regions for such investment. Table 3 shows the economic parameters of the PV investments in 19 regions in Northern Cyprus in addition to their annual capacity factor.

Table 3. The economic and technical parameters of the PV power plant in different regions in Northern Cyprus in addition to the annual electricity production from the PV power plant.

Region	E (kWh/kWp)	LCOE (USD/kWh)	NPV (USD/kWp)	PBP (years)	IRR (%)	CF (%)
Alsancak	1670	0.1078	3053.9	6.4	30.42	19.06
Bafra	1700	0.1059	3140.6	6.3	31.00	19.41
Camlibel	1710	0.1053	3169.5	6.3	31.19	19.52
Catalkoy	1650	0.1091	2996.2	6.5	30.04	18.84
Dipkarpaz	1660	0.1085	3025.1	6.5	30.23	18.95
Esentepe	1580	0.1140	2794	6.8	28.68	18.04
Gazimagusa	1720	0.1047	3198.3	6.2	31.39	19.63
Gecitkale	1630	0.1105	2938.4	6.6	29.65	18.61
Girne	1640	0.1098	2967.3	6.6	29.84	18.72
Guzelyurt	1740	0.1035	3256.1	6.1	31.77	19.86
Lapta	1620	0.1112	2909.6	6.6	29.46	18.49
Lefka	1660	0.1085	3025.1	6.5	30.23	18.95
Nicosia	1660	0.1085	3025.1	6.5	30.23	18.95
Sadrazamkoy	1670	0.1078	3053.9	6.4	30.42	19.06
Tatlisu	1570	0.1147	2765.2	6.9	28.49	17.92
Vadili	1660	0.1085	3025.1	6.5	30.23	18.95
Yeni Erenkoy	1670	0.1078	3053.9	6.4	30.42	19.06
Yeni Iskele	1670	0.1078	3053.9	6.4	30.42	19.06
Yesilirmak	1690	0.1065	3111.7	6.3	30.81	19.29

It can be clearly seen from Table 3 that Guzelyurt is the best place for PV investments in Northern Cyprus followed by Gazimagusa with LCOE of 0.1035 and 0.1047 USD/kWh respectively and NPV of 3256.1 and 3198.3 USD/kWp respectively. Moreover, all the PV investments in Northern Cyprus can be profitable and attractive since their LCOE lower than the local grid tariff and their NPV higher than zero. In addition to their economic profitability the PV projects will contribute in the mitigation of greenhouse gases by reducing the dependency on fossil fuel. Figure 1 shows the annual reduction rate in the CO_2 emissions by the PV projects in the selected regions in Northern Cyprus.

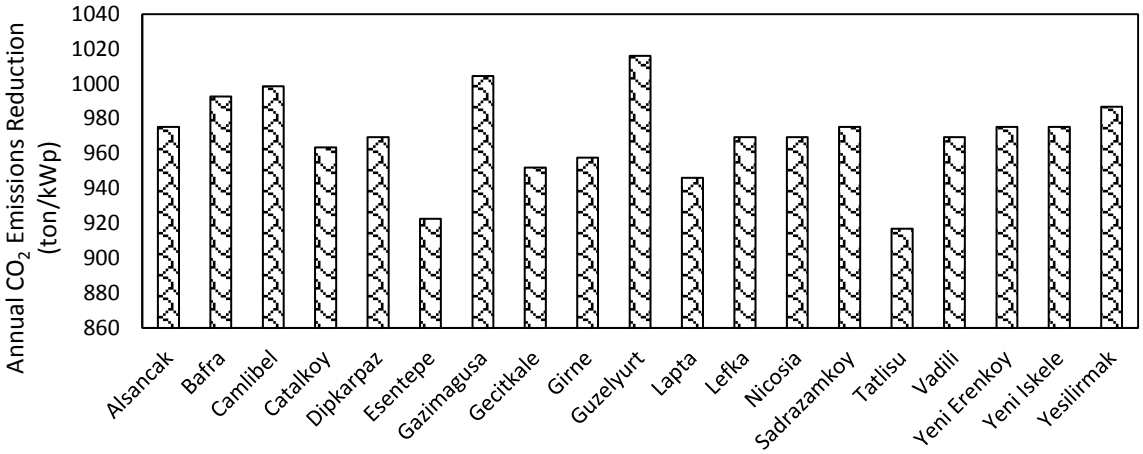

Figure 1. The annual reduction rate in the CO_2 emission in different regions in Northern Cyprus by the PV projects.

As it can be seen from Figure 1, that Guzelyurt has the highest environmental benefits- represented by the CO_2 reduction rate- followed by Gazimagusa with 1016 and 1004 ton/kWp respectively which mean these regions ensures the highest environmental and economic benefits at the same time.

4. CONCLUSION

Investors start to pay more attention toward the investment in renewable energy projects due the high possibility of achieving high profits. The investments in solar projects in Northern Cyprus is attractive since it is characterized by high solar radiation during

the year as it is located within the solar belt region. This study aims to assess the economics of PV power plant in 19 regions in Northern Cyprus where the energy production from the PV systems was estimated using PVGIS online software. The simulation results indicate that the investment in PV projects in all the regions is profitable if the feed in tariff is 0.294 USD/kWh like Southern Cyprus where Guzelyurt is the best region for PV investments in Northern Cyprus with NPV of 3256.1 USD/kWp, LCOE of 0.1035 USD/kWh, IRR of 31.77% and a PBP of 6.1 years.

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