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Improving Return on Investment for Photovoltaic Plants by Deploying Customized Load

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***Abstract*—The deployment of grid connected photovoltaic (PV) power plants is increasing dramatically recently. Due to the intermittent nature of the PV power plant, a battery and/or a power curtailment controller has to be installed to maintain the stability of the distribution network. The battery is an additional cost in the system so the return on investment (ROI) analysis has to be conducted. An alternative to the battery, a customized load can be used to consume the surplus energy. This load has to make an additional income to be profitable for the plant's owner. Such load can be crypto-currency mining rig that does calculation to validate the transaction in the Blockchain network. This study compared the ROI of the battery and the mining rig. The study shows that mining rig has higher ROI of 7.7% compared to 4.5% for battery.**

Keywords-Photovoltaic power plants; return on investment; batteries; blockchain; mining rig

I. INTRODUCTION

During the last decade the price of the photovoltaic (PV) systems decreased dramatically [1], this led to a huge deployment for PV power plants as a private investments [2]. Supported by governments' incentives many private investors have been invested in the PV power plants. This made a rapid growing for the sector all over the world with many different types of incentives' mechanisms. However the main challenge for deploying the PV plants is still there, how to mitigate the intermittent issue of the PV power plants. The well-known solution is to install batteries to store the surplus energy. Installing battery is good rigid solution; however, this is increasing the cost of the power plant. And since the investors are always looking for a solution with the best return on investment, choosing the batteries as a solution is not preferred. Batteries can absorb that extra energy and store it then injected it back to the grid at the time when the solar radiation is low. The other solution for the investors is to apply power curtailment but in this case the power will be lost. The other way to solve that exceeded power issue is to have a customized load that can consume the extra power. However, this load has to be profitable for the investor with reasonable return on investment in order to decide to invest on it. A load with this capability is such as mining rig that doing calculation to support the Blockchain network.

Blockchain technology is growing worldwide, which is revolutionary changing many sectors in our life. Blockchain is peer-to-peer technology so no need for Central authority to approve each and every transaction [3].

However, for each and every transaction to be approved everyone connected to the Blockchain network have to do some calculation, to check the validity of the transaction. In order to do so the people who are connected to the network are providing their machines to do the calculation and approve the processes, and in return they are getting reward from the network. This reward is the crypto-currencies, which is well-known nowadays [4]. Therefore, the concept here that everyone is contributing his machine and using his electricity to validate the transactions and get reward. This reward is the crypto-currencies such as Bitcoin, Ethereum.

In this study the return on investment for the PV power plant is investigated in two different cases; the first one by deploying the battery as energy storage device while the second one by using mining rig as a customized load. This study calculates the required capital cost for each case, the running cost and the expected income out of each case.

II. CALCULATION FOR BATTERY SIZE AND ROI

In this study, a PV power plant with the capacity of 1 MW dc has been considered. For such installed capacity in Gaziantep, Turkey, 1,570 MWh can be generated yearly. The assumptions of this calculation are shown in Table I.

The daily average generated energy is 5,500 kWh from April to September, and by considering that we have 4% of surplus energy daily then a battery with 225 kWh capacity has to be installed. For this purpose BYD battery model: OSNP100B225ER1 can be used. This model has Nominal power of 100 kVA and energy capacity of 225 kWh. In Turkey the current government incentive for PV power plants is about 0.1$/kWh after deducting the distribution network usage fees. Therefore, by utilizing the full capacity of the battery during the above mentioned months, the total amount of income, I_{com} can be calculated as,

$$I_{com} = S_c G_{com} D \quad (1)$$

where income is the income from the investment, daily stored capacity, S_c in [kWh], number of days, D with surplus energy [days] and the government incentives, G_{inc} in [$/kWh], which equals 4,050 $ yearly income; and by knowing that the capital cost of BYD OSNP100B225ER1 is about 90,000 $ so the ROI can be calculated as,

$$ROI = \frac{Y_{com}}{G_{com}} 100\% \tag{2}$$

Therefore, the yearly ROI is 4.5%.

TABLE I: DATA USED TO CALCULATE THE GENERATED ENERGY IN THE SELECTED LOCATION.

Item	Value
Location (Lat/Lon)	37.131, 37.450
PV installed (kWp)	1000
System loss (%)	14
Slope angle (°)	31
Yearly PV energy production (kWh)	1570179.45
Yearly in-plane irradiation (kWh/m2)	2048.72
Year-to-year variability (kWh)	43113.94

III. CALCULATION FOR MINING RIGS AND ROI

The aim here is to handle daily the same amount of surplus energy which is 4% of 5,500 kWh (the 225 kW). This amount of energy has to be consumed within two hours (the peak hours). Therefore, a mining rig with consumption capability of 112 kW is required to have a fair comparison with the battery. One of the most famous manufacturers of mining rigs is Bitmain. The most recent product produced by Bitmain is Antminer S19 with hash power capability of 95T H/s. The features of the products are shown in [5]. This product is consuming 3.25 kW per hour, so the total number of required devices, N_{rd} can be calculated as,

$$N_{rd} = \frac{S_e}{P_c} \tag{3}$$

where the surplus energy, S_e is the total amount of surplus energy per hour, and the power consumption, P_c is for each device. Therefore, the number of required devices equals 34.4; therefore, let's consider 35 devices. Total hash power, T_{hp} for these 35 devices can be calculated as,

$$T_{hp} = H_p N_d \tag{4}$$

where H_p is the individual hash power and N_d is the number of the devices. Therefore, the total amount of hash power equals 3,325 TH/s. And based on many open resources such as; whattomine.com and cryptocompare.com the hash power of 3,325 TH/s can generate 13.4 $/h based on the assumptions shown in Table II

TABLE II: ASSUMED VALUES FOR MINING POWER CALCULATION

Item	Value
Algorithm	SHA-256
Date	21.05.2020
BTC difficulty	15.138T
BTC block reward	6.25
Current price for 1 BTC	9,765 USD
Current daily for 100 TH/s	0.001 BTC

This device is going to be operating for 2 hours a day and the capital cost as announced in the website of Bitmain 1785.00 $ per device. Therefore, the total capital cost, C_{cost} can be calculated as,

$$C_{cost} = C_{ind} N_d \tag{5}$$

where N_d is the number of devices and C_{ind} is the per unit cost. Therefore, the total capital cost equals 62,475 $ and the total yearly income, Y_{inc} is calculated as,

$$Y_{inc} = H_{OI} N_h \mathrm{N}_D \tag{6}$$

where H_{OI} is the hourly operation income, N_h is the number of hours per day, and N_D is the number of days. Therefore, the yearly income from the investment equals 4,824 $, and by knowing that the capital cost of this mining rig 62,475 $; therefore, 7.7% ROI is calculated for the case.

IV. RESULTS AND DISCUSSION

In Table III, a comparison between mining rig and batteries is explained which showing the advantages and dis advantages of each solution. It is clear that the capital cost for mining rig is less than for the battery. Moreover, the ROI of the mining rig is higher than the battery which makes the mining rig a preferred investment choice.

TABLE III: A COMPARISON BETWEEN USING MINING RIG VS BATTERIES, ADVANTAGES AND DISADVANTAGES

Item	Battery	Mining rig
Total energy storage/ consumption (kWh/day)	225	227
Power (kW)	100	113
Capital cost	90,000	65,380
ROI (%)	4.5	7.7

V. CONCLUSIONS

In this study, an analysis for ROI of PV power plant has been conducted. In order to avoid power curtailment either battery or mining rig can be used. Both alternatives have a considerable capital cost. The battery generates income from the government incentives while the mining rig generates income from the reward comes from verifying the transactions in the Blockchain network. This study showed that the ROI of the battery is 4.5% while for the mining rig is 7.7%. This results proof that using mining rigs for PV power plants are more profitable choice for the owners' of the plants.

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