Economical Analysis of Huawei MA5622 External Active Access Device Charged by Photovoltaic Panel

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Abstract- In the communication sector, in order to provide broadband internet and fixed telephone services to customers, systems called external active access devices are installed inside the building. These devices, which are usually installed in buildings in the city centers, are supplied by energy from city grid. In this study, economic analysis of HUAWEI MA5622 external active access device have been explored which is installed in 185 buildings in Karabük province is provided by grid connected solar energy system. Karabük province has been taken as a role model for the other regional applications that would be applied later, and after this stage it will be called as "pilot province". First of all, 300 Wp installed solar power system was designed to meet the greatest amount of energy needs of system and to meet the missing energy requirements from grid. In this way, minimum material cost and depreciation period at low installed power were calculated. Afterwards, beyond the entire power demand of the system was met, the excess power produced was planned to be sold to rid and installed power was increased. In this way, 5 different installed power system design in 600Wp, 1.5kWp, 3kWp, 5kWp, 10kWp was also made by calculating depreciation period for each system designed. The design and simulations of solar energy systems were realized by program named as PVSYST. According to the data obtained from the simulation results, the depreciation periods of the systems designed with 300Wp, 600Wp, 1.5Wp, 3kWp, 5kWp, 10kWp installed power are calculated respectively 37.8 years, 22.1 years, 16.3 years, 13.1 years, 12.2 and 9.9 years. As a result, it has been seen that depreciation period decreases as the installed power increases and the most economical system design is found to be 10kWp installed power system.

Key words: Energy, renewable, solar, external active access, photovoltaic, power, on-grid, off-grid, electricity.

1. Introduction

Rapid developments in the field of science and technology have made it necessary for the communication sector to follow innovations closely under ever-increasing competition conditions. While the need for people to access information faster and easier have been increasing day by day, the quality of service infrastructure provided to customers becomes equally important in communication. In fixed telephone and internet service, higher quality and speed of the service provided as how closer the customers are to the systems. At this point, in order to bring the systems closer to the customers, fixed telephones and broadband internet devices are installed in the areas and buildings where people are densely demanded and called as external active access system. The increase in number of devices and the increasing energy costs require a variety of saving policies. In this sense, the use of renewable energy sources which is becoming more and more important, can be considered as a good alternative for the communication sector [1]. Studies related to the use of renewable energy sources in communication sector have been carried out in order to meet electricity needs of mobile base stations in rural areas far from the city center and in places where there is no electricity network.

In a study, the long-term minimum cost solution of photovoltaic based hybrid power systems for remote telecommunication stations was investigated. Since it is not possible to provide electricity to the communication systems installed in rural and remote areas or because it is expensive, diesel generator is generally installed in the related places and energy needs are met. These diesel generators also cause problems such as excessive air pollution, consumption of oil, high maintenance and repair costs, the need to go to that location periodically for refueling and transportation difficulties due to rural land. In order to alleviate some of the problems mentioned, a research has been carried out on photovoltaic based diesel hybrid power systems. Not only the initial investment cost, but also a comprehensive economic analysis such as diesel consumption, oil consumption, battery, maintenance costs of electronic devices has been made in study. Minimum total costs for 10, 20 and 30 years operating time compared [2].

Photovoltaic based hybrid diesel generator set up for telecommunication systems in rural and remote areas was analyzed in another study. According to the results of the study, the angle of inclination of the photovoltaic panel is very important for the proposed hybrid diesel power system and it is one of the best solutions for providing low maintenance needs [3].

In another study, the design analysis and control strategy for isolated GSM base stations is presented in order to operate the hybrid green energy system (photovoltaic-wind) efficiently and reliably. The meteorological data of Abuja, Benin city and Sokota, which are three centers in Nigeria with varying climatic conditions, were used to simulate the process. In the proposed model, 12 kWh energy costs 1 US dollar, while it shows excellent performance compared to a US $ 3.29 kWh grid and 2 kWh diesel generator [4].

Micro hybrid system consisting of solar panel and wind turbine for telecommunication equipment in remote areas in a study conducted in Sudan, where petroleum is one of the main electricity sources was examined. The basis of the study is the optimal size and design of a hybrid power system to provide power to remote base station sites. 3 different system configurations were evaluated and compared according to energy cost and environmental emissions. This analysis was performed with HOMER software. The proposed hybrid system has proven 100% reliability, high performance, long life (20 years) and more cost-effective than conventional power supplies on a 24-hour basis [5].

MTN-C has evaluated the most suitable power options for base stations in a study conducted in Cameroon. MTN-C mobile operator, a leader in Cameroon that has market share of 52%, requested a proposal for the supply, installation and commissioning of a solar hybrid system in 2008 to reduce environmental pollution and reduce carbon dioxide emissions and power consumption to improve the quality of life of local residents. have prepared. The aim of the company is to apply the solar hybrid system in 27 facilities for 3 years. For this purpose ZTE applies the solution proposed by the company, thereby reducing diesel consumption and limiting air and noise pollution from the generator 24/7. The company adopts a modular and reliable solar system design to realize green BTS areas, reducing site costs, by the way, company effectively reduces operating costs and increases its competitiveness [6].

In a study conducted in the Punjab region of India, power generation and economic analysis of different hybrid combinations in Amritsan, Ludhiana, Patiala and Chandigarh cities in this region were conducted. Telecommunication load is used in HOMER simulations. According to the results, combination of PV-wind-diesel-battery is the most suitable combination for maximum power generation in the city compared to PV-diesel-battery, PV-wind-diesel, wind-diesel-battery, wind-diesel, PV-diesel systems [7].

In a similar study conducted in rural areas of the Democratic Republic of Congo, one of the developing countries, the use of hybrid photovoltaic & wind systems as the primary power source was investigated. For this purpose, Mbuji-Mayi and Kamina regions were selected as pilot sites in the cabin where there is no network and solar and wind resources. According to the results of this study using HOMER software simulations, it is understood that hybrid power system is the most economical system compared to pure photovoltaic, wind and diesel generator options during the 20-year project period in the specified pilot sites [8].

Photovoltaic solar panel proposes an algorithm that finds the minimum cost solution over a period of 10 years to supply power to LTE base station using a number of batteries and optionally secondary power (energy cell or small diesel generator), in a study that was conducted in a location with two different solar power generation models, a southern European city like Torino, Italy and a tropical city such as Aswan, Egypt. The results show that hybrid systems are much more effective than pure solar energy. Hybrid system in Torino reduces costs compared to electricity grid and diesel generator. In Aswan, electricity and diesel prices are very low, which is equivalent to a diesel generator, a bit more expensive than the current connection to the electricity grid [9].

Another study is to investigate the operability of grid-independent telecommunications base stations as a hybrid system powered by fuel cells and renewable energy sources. Fuel cells, a photovoltaic system and a diesel power generator were used for this study. At the same time, surely, batteries are used for energy storage. These studies were evaluated for 6 sites. Data were collected for one year. As a result of study, it has been seen that this fuel cell supported hybrid system helps to reduce fossil fuel consumption and it is concluded that it is competitive in terms of efficiency. It was concluded that the fuel cell does not cause any problems in terms of control systems as it provides current to the battery or load immediately in case of sudden cloudy weather [10].

The energy saving potential of the hybrid cooling system with a model prediction control (MPC) was investigated in a study on hybrid cooling in telecommunication base stations. Simulations were performed for one week to evaluate the performance of MPC, and as a result, although good performance was obtained for the hybrid cooling system, the cost was found to be high [11].

Another study examined the management of the base station of a mobile network using a photovoltaic system. Analyzing the results, maximum power point monitoring technology known as MPPT controller is used to increase the efficiency of photovoltaic power system and this system is found to be the best solution for maximum power transmission [12].

As seen in the majority of the studies, the studies related to the use of solar energy in the communication sector have been carried out in the form of off-grid system design for areas far from the city center, in other words, where there is no electricity grid.

In this study, it is designed to supply the Huawei MA5622 external active access communication device, which is installed inside the buildings in city center and fed from the electricity grid, with solar energy in connection with the grid [13, 14].

Two important issues are aimed to realize the design of grid connected system. First of all, the device is able to receive energy from the grid when it is necessary in order to avoid any energy interruption due to providing telephone and internet service to the customers. Secondly, since there are 185 devices in the pilot province and there is enough space for solar panels on the roofs of the buildings, the surplus energy is sold to the grid, thus saving both the energy consumed by the device and generating revenue from the energy sold to the grid. Based on this idea, solar panels were designed on the roofs of the buildings where the devices were located with an inverter in its cabinets. On the other hand, system designs of different powers have been realized in order to examine whether a low installed power system design or a high installed power system design to the field permitted by the roof area is more economical. PVSYST simulation software is used to design the system and perform an economic analysis according to the data obtained from the simulation results [15, 16]. Depreciation periods of the systems with different powers are calculated with the economic analysis.

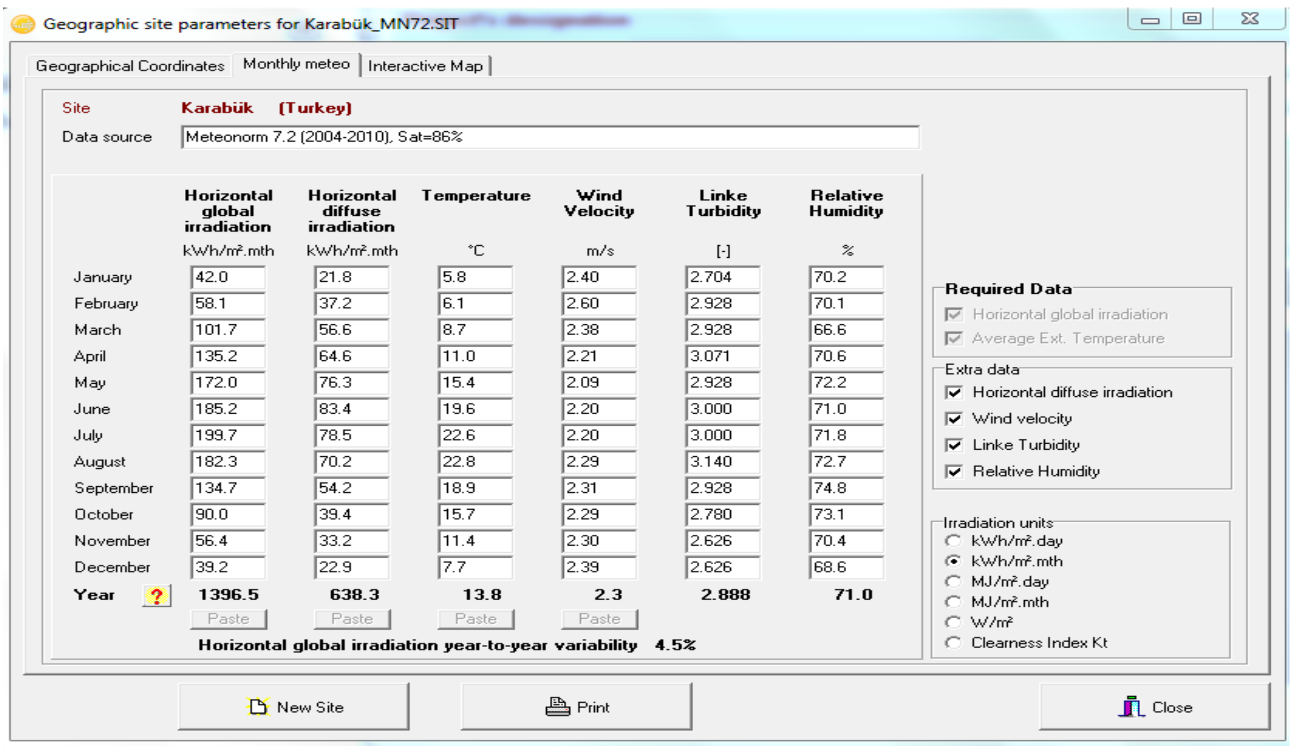
3 main elements of which are explained in economical analysis and results section are used in the calculation of depreciation periods.These are;

- İnitial investment cost.
- The gain by meeting the energy need of the device.
- The gain on surplus energy sold to the electricity grid

Finally, it has been determined which installed power system is a more economical investment.

2. Materials And Methods

The meteorological data of pilot province shown in figure 1 required for the design of solar power systems in this study is taken from the METEONORM 7.2 database using the PVSYST simulation program. PVSYST is a software developed to simulate photovoltaic systems by the University of Geneva in Switzerland. PVSYST is on of the PV simulation softwares that is widely used and has effective tools because of its ability to carry out multiple analyses which makes it easier and faster to evaluate different system configurations [17, 18]. In the simulations, the azimuth angle is assumed to be 0 ° and no shadow effect is assumed. Panel tilt angle is 30 degrees.



	Horizontal global irradiation kWh/m².mth	Horizontal diffuse irradiation kWh/m².mth	Temperature °C	Wind Velocity m/s	Linke Turbidity [-]	Relative Humidity %
January	42.0	21.8	5.8	2.40	2.704	70.2
February	58.1	37.2	6.1	2.60	2.928	70.1
March	101.7	56.6	8.7	2.38	2.928	66.6
April	135.2	64.6	11.0	2.21	3.071	70.6
May	172.0	76.3	15.4	2.09	2.928	72.2
June	185.2	83.4	19.6	2.20	3.000	71.0
July	199.7	78.5	22.6	2.20	3.000	71.8
August	182.3	70.2	22.8	2.29	3.140	72.7
September	134.7	54.2	18.9	2.31	2.928	74.8
October	90.0	39.4	15.7	2.29	2.780	73.1
November	56.4	33.2	11.4	2.30	2.626	70.4
December	39.2	22.9	7.7	2.39	2.626	68.6
Year	1396.5	638.3	13.8	2.3	2.888	71.0

Fig. 1. Monthly meteorological data for pilot province in PVSYST.

The HUA MA5622 device is shown in Figure 2, with a total annual energy consumption of 578 kWh. Firstly, system has been designed with 300 Wp installed power to meet a large part of the annual energy requirement of the device and minimum material and cost have been aimed. Since there is no surplus energy generation in this design, it is not possible to sell the energy to the grid.

Fig. 2. HUA MA5622 External active access device.

All of energy generated is consumed by the device. Then, installed power was increased togenerate more energy than energy required by the device, and it was aimed to sell surplus energy to grid. In this way, solar energy systems with 600 Wp, 1.5 kWp, 3 kWp, 5kWp, 10 kWp installed power were designed and simulations were realized by PVSYST program. Annual yields of these systems are calculated by evaluating the amount of energy generated by systems designed according to the simulation results. Finally, the depreciation period of each system designed is calculated to determine which system is economical. The diagram for roof applied power generation system is shown in Figure 3.

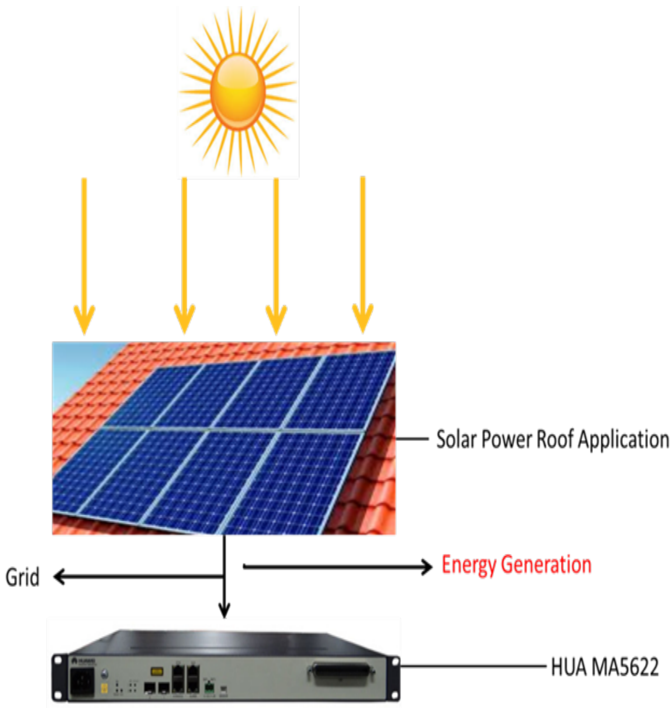


Fig. 3. Roof applied power generation system design.

Specifications of the components which defined in Figure 3 are shown in Table 1 and 2.

Table 1. Specifications of solar modules.

Module 1 (used for 300 Wp system)	REC 320 TP2M
Technology	Si Monocrystal
Maximum module power	320 Wp
Module dimensions	1.675 m × 0.997 m
Open circuit voltage	40 V
Maximum power point voltage	33.90 V
Module efficiency	19.26%
Module 2 (used for 600Wp,1.5kWp,3kWp,5kWp,10k Wp systems)	REC 285 TP2
Technology	Si policrystal
Maximum module power	285 W
Module dimensions	1.675 m × 0.997 m
Open circuit voltage	38,60 V
Maximum power point voltage	31.90 V
Module efficiency	17.2%

Table 2. Spacifications of the inverters.

Inverter 1 (used for 300Wp system)	Enphase IQ7PLUS-72-x-INT
Nominal AC power	0.290 kVA
Maximum input voltage	60 V
MPP voltage range	16- 48 V
Maxsimum efficiency	97.52
Inverter 2 (used or 600Wp system)	Ginlong Technologies Solis 700 mini
Nominal AC power	0.7 kW
Maximum input voltage	450 V
MPP voltage range	50- 400V
Maximum efficiency	96.7 %
Inverter 3 (used for 1.5 kWp,3kWp,5kWp,10kWp systems)	Ginlong Technologies Solis 1500 mini
Nominal AC power	1.5 kW
Maximum input voltage	500 V
MPP voltage range	50- 400V
Maximum efficiency	96.7 %

3. PVSYST System Simulations

REC 320 TP2M module and 0.29 kW Enphase IQ7PLUS-72-x-INT inverter are selected for 300 Wp Installed Power System. According to the data obtained from the simulation results, annual energy production of system is 427 kWh. This generation corresponds to 74% of annual energy required by the MA5622. The energy generation as a result of simulation is shown in Figure 4.

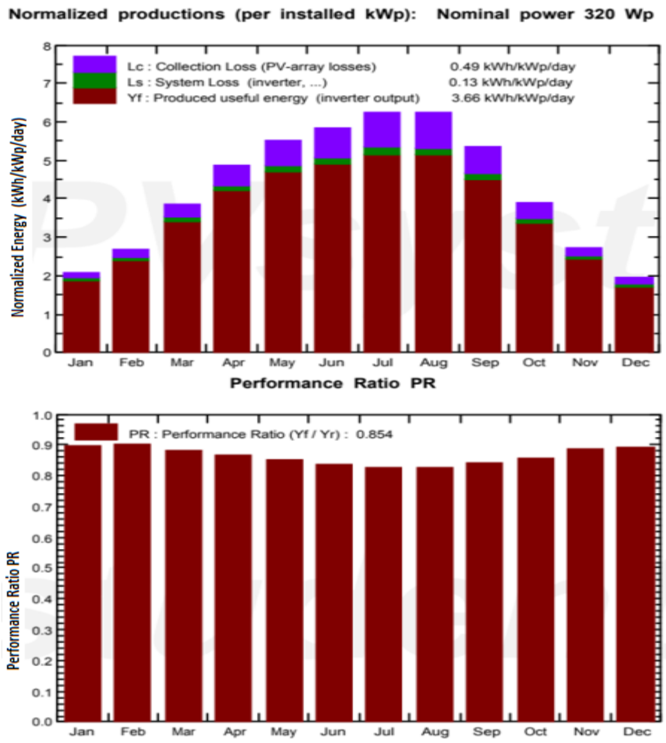


Fig. 4. Simulation Results.

3 REC 285 TP2 modules and 0.7 Kw Ginlong Technologies Solis 700 mini inverters are selected for system with 600 Wp installed power. The annual power generation of the system is 1130 kWh. 552 kWh of energy can be sold to the grid by meeting all energy needs of the device. The energy generation as a result of simulation is shown in Figure 5.

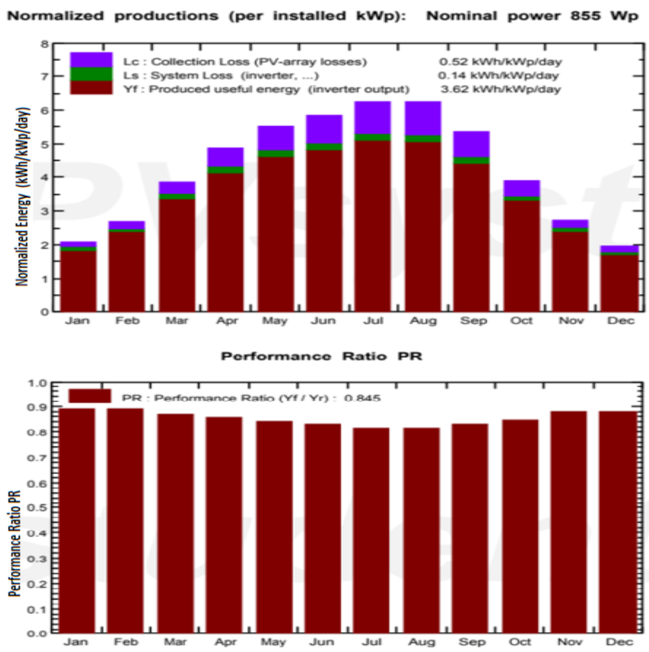


Fig. 5. Simulation Results.

6 REC 285 TP2 modules and 1.5 kw Ginlong Technologies Solis 1500 mini inverter are selected for the system with 1.5 kWp installed power. The annual power generation of system is 2263 kWh and 1685 kWh of energy can be sold to grid. The energy generation as a result of simulation is shown in figure 6.

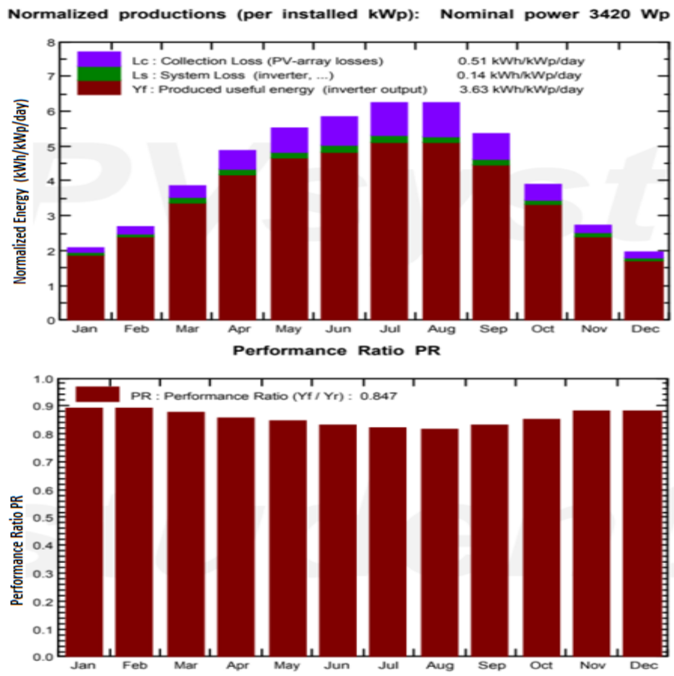


Fig. 6. Simulation Results.

12 REC 285 TP2 modules and 2 Ginlong Technologies Solis 1500 mini inverters are selected for the system with 3 kWp installed power. The annual energy generation of system is 4527 kWh and 3949 kWh energy generated from this system can be sold to the grid. The energy generation as a result of simulation is shown in figure 7.

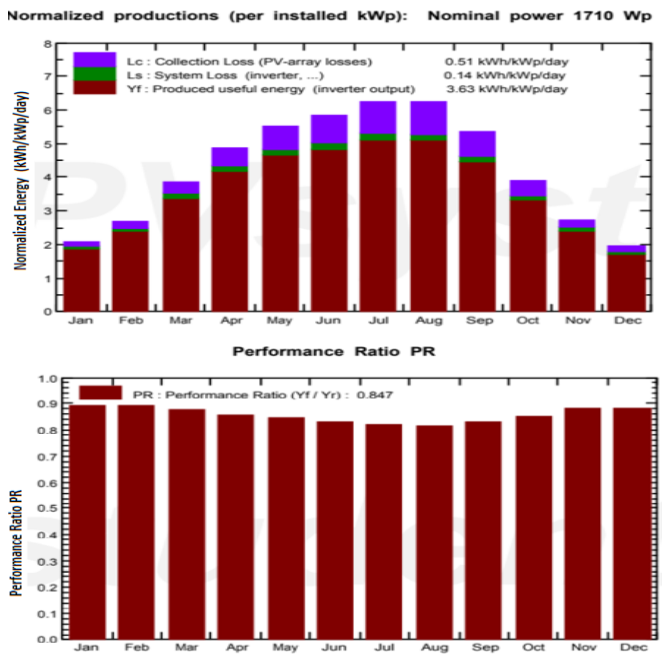


Fig. 7. Simulation Results.

18 REC 285 TP2 modules and 3 Ginlong Technologies Solis 1500 mini inverters are selected for system with 5 kWp installed power. The annual power generation of system is 6.79 MWh and 6212 kWh of energy can be sold to the grid. This result has been calculated for installed power by the way it is possible that it may change by difference between natural conditions and other effects The energy generation as a result of simulation is shown in figure 8.

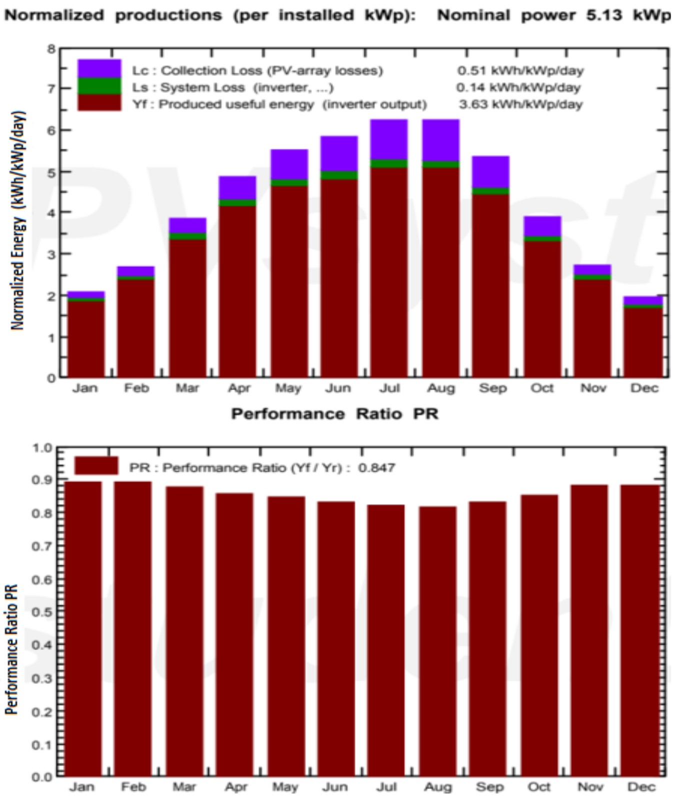


Fig. 8. Simulation Results.

13 REC 285 TP2 modules and 6 Ginlong Technologies Solis 1500 mini inverters are selected for the 10 kWp installed power system as it is designed. The annual energy generation of system is 13.58 MWh and 13002 kWh energy generated from this system can be sold to grid. As it has been seen all technology of equipments are the same however installed powers are different. The energy geenration as a result of simulation is shown in Figure 9.

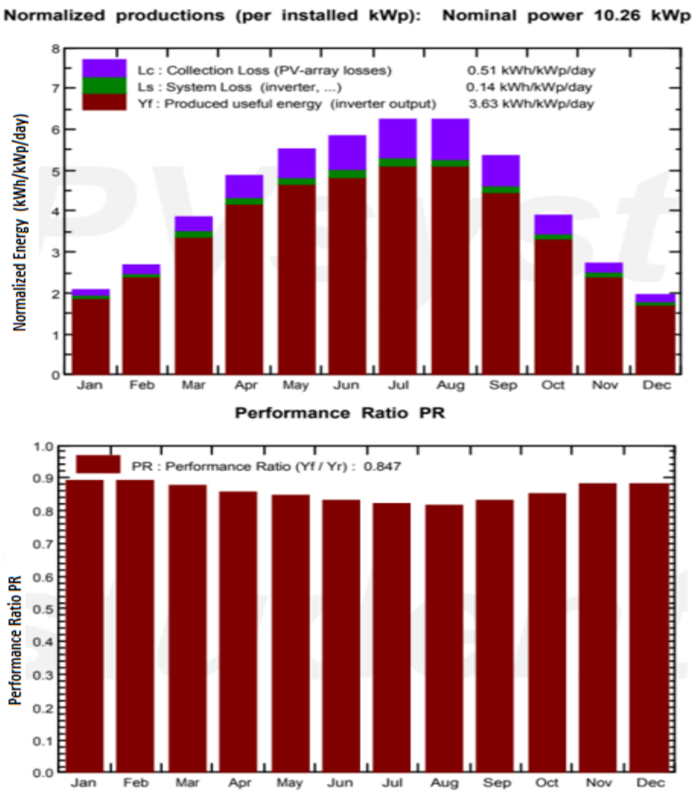


Fig. 9. Simulation Results.

The performance ratio of the systems obtained from the simulation results is shown in Table 3. The performance ratio of all designed systems is above 84% and this value is expected to be high since it is a measure of the quality of PV systems [19]. The daily useful energy output per watt is 3.66, 3.62, 3.63, 3.63, 3.63, 3.63, respectively. Accordingly, the total annual energy produced by the systems is shown in Table 1. Since the annual power consumption of the Huawei MA5622 device is 578 kWh, the total amount of energy sold to the network is obtained by subtracting this value from the total annual energy amount produced by the system. Since the energy produced by the system with 300Wp installed power is sufficient only to meet some of the need of the device, there is no surpass energy to sell to the grid for this system. The surpass energy amounts produced for sale to the grid from other systems are indicated in Table 3 and these values are used in the economic analysis of the systems.

Table 3. Results Table for Simulations.

	300 Wp	600Wp	1.5kWp	3kWp	5kWp	10kWp
Solar Module	1 * REC 320 TP2M	3 * REC 285 TP2	6 * REC 285 TP2	12 * REC 285 TP2	18 * REC 285 TP2	36 * REC 285 TP2
Inventors	1 * Enphase IQ7PLUS-72-x-INT	1 * Ginlong Technologies Solis 700 mini	1 * Ginlong Technologies Solis 1500 mini	2 * Ginlong Technologies Solis 1500 mini	3 * Ginlong Technologies Solis 1500 mini	6 * Ginlong Technologies Solis 1500 mini
Rated Inverter Power	0.290 kW	0.7 kW	1.5 kW	1.5 kW	1.5 kW	1.5 kW

Maximum Power Of Module	320 Wp	285 Wp	285 Wp	285 Wp	285 Wp	285 Wp
Collection Loss (PV-array losses)	0.49 kWh/kWp/day	0.52 kWh/kWp/day	0.51 kWh/kWp/day	0.51 kWh/kWp/day	0.51 kWh/kWp/day	0.51 kWh/kWp/day
System Loss (inverter)	0.13 kWh/kWp/day	0.14 kWh/kWp/day	0.14 kWh/kWp/day	0.14 kWh/kWp/day	0.14 kWh/kWp/day	0.14 kWh/kWp/day
Produces useful energy (inverter output)	3.66 kWh/kWp/day	3.62 kWh/kWp/day	3.63 kWh/kWp/day	3.63 kWh/kWp/day	3.63 kWh/kWp/day	3.63 kWh/kWp/day
Performance Ratio	0.854	0.845	0.847	0.847	0.847	0.847
Annual Total Energy Amount Generated By System	427kWh	1130kWh	2263kWh	4527kWh	6.79mWh	13.58mWh
Annual Total Energy Sold To Grid	-	552kWh	1685kWh	3949kWh	6212kWh	13002kWh

4.Economical Analysis and Results

Economic analysis of solar energy systems is evaluated by calculating depreciation periods of the systems.

Depreciation Period = Initial Investment Cost / Total Annual Profit From Solar System

Initial investment cost is the sum of the following costs;

- Module cost
- Inverter cost
- Aluminum mounting material set
- Solar cable cost
- Turnkey installation service price
- Follow-up of state procedures, electrical and static projects, provisional and final acceptance.

The following services are provided within the scope of turnkey installation service;

- Electrical & mechanical installation
- AC-DC wiring operations
- AC panel
- Plant grounding operations
- Connection to existing collection board
- OHS responsibility
- Personel supply

The Central Bank's exchange rate values dated 20.08.2019 are used in calculations. According to that;

1 € = 1.1078 $

1 £ = 1.2091 $

1 $ = 5.71 TL

The unit price of electricity to the grid is $ 0.083 [11].

The unit price of electricity consumed by the system is billed from $ 0.144.

The price of the aluminum mounting kit for installation on a pitched roof is $ 28.32 per panel.

Turnkey installation service Installation cost for per Watt is $ 0.31.

Follow-up of state procedures for each roof up to 10 kW, electrical and static projects turnkey price is $ 1,888.00.

REC 320 TP2M solar module unit price is $ 154.92.

The unit price of the REC 285 TP2 solar module is $ 110.72.

The unit price of the Enphase IQ7PLUS-72-x-INT inverter is 127. 49 $.

Ginlong Technologies Solis 700 mini inverter unit price is $ 259.1.

Ginlong Technologies Solis 1500 mini inverter unit price is $ 269.51.

Total investment cost is calculated according to the total number of modules and inverters used for systems. Total investment cost is sum of the module and inverter costs together with cost of aluminum assembly material set, cost of solar cable, turnkey installation service cost, and costs paid for design and acceptance services, as well as cost of the project and acceptance services. Total annual revenue from systems consists of total annual invoice amount of MA5622 device and annual revenue generated by selling excess energy to the grid. Annual amount of energy produced by systems, total costs, annual income of systems and depreciation periods calculated in accordance with this information are shown in Table 4.

Depreciation periods obtained as a result of economic analysis for 300 Wp, 600Wp, 1.5Wp, 3kWp, 5kWp, 10kWp installed power systems, respectively calculated as 37.8 years, 22.1 years, 16.3 years, 13.1 years, 12.2 years and 9.9 years. The results are shown in figure 10 on the graph.

Table 4. Total Costs, Annual Revenues and Depreciation Times of Solar Energy Systems.

	300 Wp	600Wp	1.5kWp	3kWp	5kWp	10kWp
Solar Module	1 * REC 320 TP2M	3 * REC 285 TP2	6 * REC 285 TP2	12 * REC 285 TP2	18 * REC 285 TP2	36 * REC 285 TP2
Maximum Power Of Module	320 Wp	285 Wp	285 Wp	285 Wp	285 Wp	285 Wp
Annual Total Energy Amount Generated By System	427kWh	1130kWh	2263kWh	4527kWh	6.79mWh	13.58mWh
Annual Total Energy Sold To Grid	-	552kWh	1685kWh	3949kWh	6212kWh	13002kWh
Total Module Cost	$ 154.92	$ 332.17	$ 664.34	$ 1,328.68	$ 1,993.02	$ 3,986.04
Inventors	1 * Enphase IQ7PLUS-72-x-INT	1 * Ginlong Technologies Solis 700 mini	1 * Ginlong Technologies Solis 1500 mini	2 * Ginlong Technologies Solis 1500 mini	3 * Ginlong Technologies Solis 1500 mini	6 * Ginlong Technologies Solis 1500 mini
Rated Inverter Power	0.290 kW	0.7 kW	1.5 kW	1.5 kW	1.5 kW	1.5 kW
Total Inverter Cost	$ 127. 49	$ 259.1	$ 269.51	$ 539.02	$ 808.53	$ 1,617.06
Aluminum Mounting Material Set	$ 28.32	$ 84.96	$ 169.92	$ 339.84	$ 509.76	$ 1,019.52
Solar Cable Cost (20 meters)	$ 32.22	$ 96.66	$ 193.32	$ 386.64	$ 579.96	$ 1,159.92
Turnkey Installation Service Price	$ 93.00	$ 186.00	$ 465.00	$ 930.00	$ 1,550.00	$ 3,100.00
Follow-up Of Government Procedures & Electrical And Static Projects And Assumptions	$ 1,888.00	$ 1,888.00	$ 1,888.00	$ 1,888.00	$ 1,888.00	$ 1,888.00
Initial Investment Cost	$ 2,323.95	$ 2,846.89	$ 3,650.09	$ 5,412.18	$ 7,329.27	$ 11,610.62
Annual Profit From Electricity Sold To The Network	-	$ 45.82	$ 139.86	$ 327.76	$ 515.6	$ 1,079.25
Annual Profit From Invoice Of MA005620 Device	$ 61.49	$ 83.23	$ 83.23	$ 83.23	$ 83.23	$ 83.23
Total Annual Profit From The Solar System	$ 61.49	$ 129.05	$ 223.09	$ 411.00	$ 598.83	$ 1,162.48
Depreciation Period	37.8 year	22.1 year	16.3 year	13.1 year	12.2 year	9.9 year

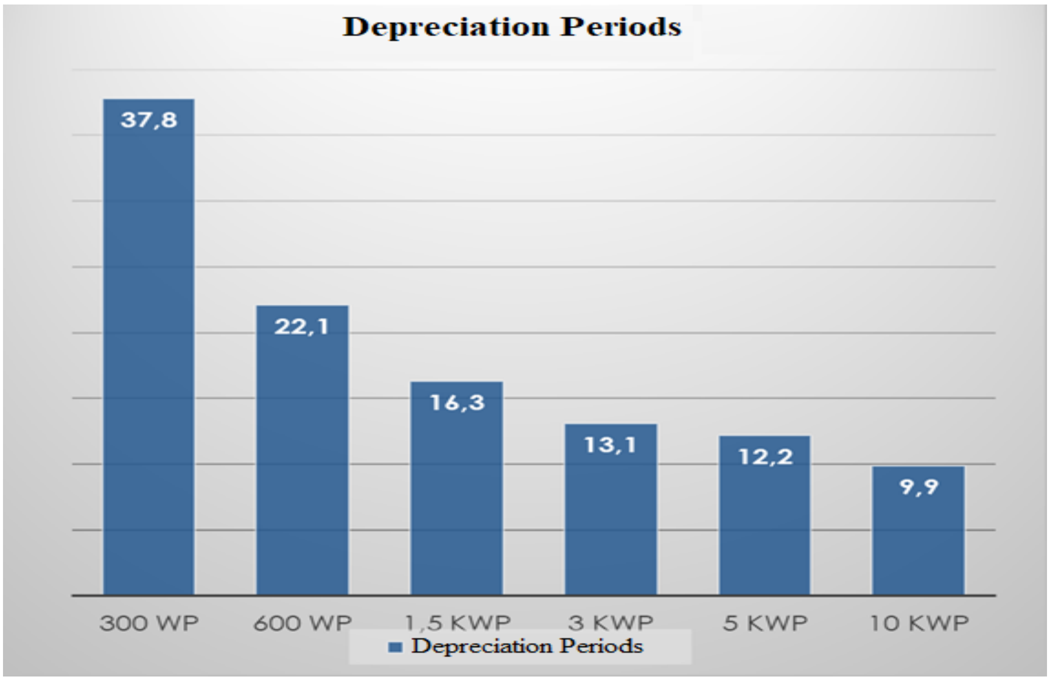


Fig. 10. Depreciation Periods of Solar Energy Systems

5. Conclusion

In this study, solar energy system was installed on roofs of buildings where HUA MA5622 external active access device used in communication sector was installed and an economic analysis was performed for system to be supplied by solar energy. According to PVSYST simulation results obtained from pilot province meteorological data obtained from meteonorm 7.2 database for 300Wp, 600Wp, 1.5kWp, 3kWp, 5kWp, 10kWp installed power respectively, the following results were obtained;

1. Depreciation period of system with 300 Wp installed power has been found as 37.8 years, whereas depreciation period of system with 600W installed power is 22.1 years, depreciation period of the system with 1.5kWp installed power is 16.3 years. According to this result, it has been seen that these systems are not an economic investment.

2. Depreciation periods for 3kWp, 5kWp and 10kWp installed systems have been found 13.1, 12.2 and 9.9 years respectively. It has been seen that these systems are more economical than other systems as taking into account that the economic life of solar investment is around 25 years maintenance-free.

3. As installed power increases, the depreciation period of the system decreases. The biggest factor here is the follow-up of government procedures, the same charge for electricity and static projects regardless of installed power up to 10kW. This shows that it is an unattractive investment for roof and facade solar energy systems investments only for investors who will meet their own energy needs or have the opportunity to invest in small power. However, in areas where the size of roof area to be installed increases, it makes it attractive to install with great power.

4. When we think that 10 KWp installed system, which is the most economical option for all buildings where HUA MA5622 device is installed in the pilot province, 36 * 185 = 6660 solar panels and 6 * 185 = 1110 inverters are required and companies can apply purchase for panels and inverters that have various prices. This will help to lower investment costs and shorten the amortization period.

5. Increasing unit price of electricity sold to grid within the scope of government incentives or reducing initial investment costs will play a major role in increasing use of solar energy by spreading investments in these systems.

References

[1] Kirmani, S., Jamil, M., Akhtar, I., “Effective low cost Grid-Connected Solar Photovoltaic System to Electrify the Small Scale industry/Commercial Building”, International Journal of Renewable Energy Research-IJRER, 7(2): 797-806 (2017).

[2] Kaldellis, J., K., Ninou, I. & Zafirakis, D., “Minimum long-term cost solution for remote telecommunication stations on the basis of photovoltaic-based hybrid power systems”, Energy Policy, 39(5): 2512-2527 (2011).

[3] Kaldellis, J., K., “Optimum hybrid photovoltaic-based solution for remote telecommunication

stations", Renewable Energy, 35(10): 2307-2315 (2010).

[4] Okundamiya, M., S., Emagbetere, J., O. & Ogujor, E., A., "Design and control strategy for a hybrid green energy system for mobile telecommunication sites", Journal of Power Sources, 257, 335-343 (2014).

[5] Salih, T., Wang, Y. & Adam, M., A., A., "Renewable micro hybrid system of solar panel and wind turbine for telecommunication equipment in remote areas in Sudan", Energy Procedia, 61, 80-83 (2014).

[6] Nfah, E., M. & Ngundam, J., M., "Evaluation of optimal power options for base transceiver stations of Mobile Telephone Networks Cameroon", Solar Energy, 86(10): 2935-2949 (2012).

[7] Khan, M., J., Yadav, A., K. & Mathew, L., "Techno economic feasibility analysis of different combinations of PV-Wind-Diesel-Battery hybrid system for telecommunication applications in different cities of Punjab, India", Renewable and Sustainable Energy Reviews, 76, 577-607 (2017).

[8] Tur, M., R. and Bayindir, R., "Project Surveys for Determining and Defining Key Performance Indicators in the Development of Smart Grids in Energy Systems", International Journal of Smart Grid, 3(2): 103-107 (2019).

[9] Zhang, Y., Meo, M., Gerboni, R. & Marsan, M., A., "Minimum cost solar power systems for LTE macro base stations", Computer Networks, 112, 12-23 (2017).

[10] Cordiner, S., Mulone, V., Giordani, A., Savino, M., Tomarchio, G., Malkow, T. & Jensen, J., "Fuel cell based Hybrid Renewable Energy Systems for off-grid telecom stations: Data analysis from on field demonstration tests", Applied Energy, 192, 508-518 (2017).

[11] Wang, J., Zhang, Q. & Yu, Y., "An advanced control of hybrid cooling technology for telecommunication base stations", Energy and Buildings, 133, 172-184, (2016).

[12] Akgün, A., Yılmaz, S., C. and Cebeci, M., E., "A Study on Undesired Case of Unlicensed PV Power Plants in Turkey With Regard to DSO", International Conference on Renewable Energy Research and Application (ICRERA), Birmingham, 330-334 (2016).

[13] Sharma, D., K., Verma, V., Singh, A., P., "Review and analysis of solar photovoltaic softwares", International Journal of Current Engineering and Technology, 4(2): 725-731 (2014).

[14] Buqiong, X. and Yan, L., "Study on the Impact of PV Connection to Grid on Power Flow Based on Time Series Output Characteristics", International Conference on Renewable Energy Research and Application (ICRERA), Paris, 275-281 (2018).

[15] Umar, N., Bora, B., Banerjee, C., Panwar, B., S., "Comparison of different PV power simulation softwares: case study on performance analysis of 1 MW grid-connected PV solar power plant", International Journal of Engineering Science Invention (IJESI), 7(7): 11-24 (2018).

[16] Mizuno, Y., Baba., T., Yoshito, T., Kurokawa, F. and Matsui, N., "A New Apoproach of Load Rejection in Fault of PV Output in Smart Grid", International Conference on Renewable Energy Research and Application (ICRERA), Paris, 452-454 (2018).

[17] Al Shafeey, M. & Harb, A., M., "Photovoltaic As A Promising Solution For Peak Demands And Energy Cost Reduction İn Jordan", 9th International Renewable Energy Congress (IREC), 1-4, (2018).