EASTERN PARTNERSHIP Civil Society Forum
ԱՐԵՎԵԼՅԱՆ ԳՈՐԾԸՆԿԵՐՈՒԹՅԱՆ Քաղաքացիական հասարակության ֆորում ՀԱՅԱՍՏԱՆԻ ԱԶԳԱՅԻՆ ՊԼԱՏՖՈՐՄ
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The research of one PV station in Armenia was implemented as one component (activity 2) within project "Prospects of solar energy use in Armenia in the context of CEPA and other international commitments and opportunities".

150kW Solar PV station in Yenokavan, Tavush Marz, Armenia

Introduction

Criteria for PV station selection were: effectiveness, feasibility, availability, modern equipment, cost/effectiveness, use of local materials.

Natural climatic conditions in Armenia for solar energy use are favorable. Annual average value of sunshine hours is 2500 hours. Average annual flow of solar radiation on horizontal surface is 1720 kWh/m2. For comparing purposes, in Central Europe this average value is 1000kWh/m2, particularly, in Poland, Czech Republic, and Slovakia 950-1050kWh/m2, in Hungary – 1200 kWh/m2, in Bulgaria – 2000 kWh/m2 [1]. From site to site on the territory of Armenia, actual annual average hours of sunshine vary from 1800 to 2800hours/year [1]. This value constitutes more than 50% of possible sunshine hours. Actual sunshine hours for Yerevan are 2700, for Martuni -2750, for Idjevan - 1827 hours. For the territory of Armenia actual annual average hours of sunshine are equal to 2500 hours. The solar intensity in Tavush region is estimated over 1500 kWh/m2, which is 1.5 times more than in Europe (data from Solaron LLC). Solar Energy Resources Map for Armenia is presented on the Fig. 1

Data collection/activity

In December 2017, 147 kW solar PV station has been installed in v.Yenokavan (Tavush marz, Armenia). The village is a few kilometers north of the regional capital of Ijevan (Ijevan is located 142 km from Yerevan), close to the main highway (see Fig. 2-3). The canyon behind the village is lush with forest, river and has caves with interesting carvings (see Wikipedia). There are different touristic routs near it (Yell Park, Lastiver Resort, Apaga Resort hotels etc). Many tourist buses and tourists are usually around. Current capacity of the PV station is 150 kW. The design works, manufacturing of the panels, and the installation works were carried out by Armenian company Profpanel LLC with the trademark Solaron.

The PV station was visited and selected in September, 2020 after making preliminary researches on PV stations in urban and rural areas in Armenia. PV station is owned by Apaga Resort hotel, is connected to electricity network and can also provide with electricity the hotel located nearby (see photos on Fig. 5, 6). Data on solar energy resources were taken from R2E2 agency.

In July 2020, during the researches the author made two visits to the office of Profpanel LLC (Solaron) in Yerevan and met with Dr. Vahe Sharafian (technical director and co-founder) and Arthur Alaverdyan (co-founder). The manufacturing facilities to produce solar panels with capacity of around 50 MW/year were shown to me. The special questionnaire was developed to collect data on PV station. Data on station operation for researches were provided by Solaron and are presented in Tables 1-3.

Fig. 1. Solar Energy Resources Map for Armenia (Source www.r2e2.am)

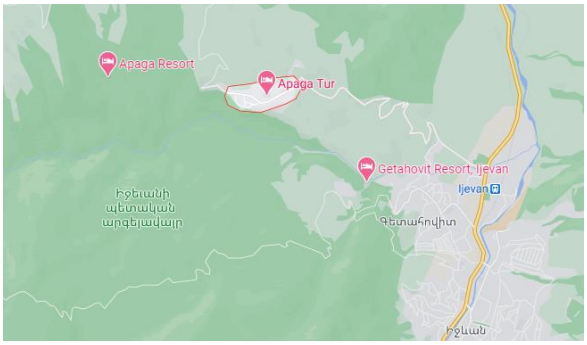

Fig. 2. Yenokavan location, view from Google maps view

Fig. 3. Yenokan 150kW PV station, satellite view

Fig. 4. PV panels of 150 kW PV station in Yenokavan

Fig. 5. 150 kW PV station in Yenokavan

Fig. 6. Hotel Apaga Resort

Table 1

SNL-60 բազմաբյուրեղային ֆոտովոլտային պանել/ SNL-60 poly crystal PV panel **Էլեկտրական ցուցանիշները/Electrical parameters**	
Անվանական հզորություն, Վտ Nominal power, W	255
Պարապ ընթացքի լարում, Վ Open circuit voltage, V	38.75
Կարճ միակցման հոսանք, Ա Short circuit current, A	8.75
Լարման արժեքը անվանական հզորության դեպքում, Վ Voltage at nominal power, V	31.2
Հոսանքի արժեքը անվանական հզորության դեպքում, Ա Current at nominal power, A	8.2

Table 2. Solar Invertor KSTAR KSG-50K Data

KSTAR KSG-50K Արևային ինվերտորի տվյալները

Solar invertor rated output power, kW Արևային ինվերտորի անվանական ելքային հզորություն, կՎտ	50
Rated output current, A, Անվանական ելքային հոսանք, Ա	72
Rated alternating voltage, V Անվանական ելքային լարում, Վ	400
Frequency, Hz, Հաճախականություն, Հց	50+/- 2
	

Table 3

Technical and economic parameters of PV station **Ֆոտովոլտային կայանի տեխնիկական և տնտեսական ցուցանիշները**	
Estimated annual electrical energy production, kWh Ելեկտրական էներգիայի գնահատված տարեկան արտադրություն, կՎտժ	208,000
Estimated average monthly savings, AMD Գնահատված ամսական խնայողություններ, միջին արժեքը	745,000
Estimated monthly green gases savings, tons Ջերմոցային գազերի գնահատված ամսական խնայողություններմ միջին արժեքը, տոննա	7.2
Actual annual electrical energy production in 2019, kWh 2019թ. էլեկտրական էներգիայի փաստացի արտադրություն, կՎտժ	187 000
The price of 1kW of installed capacity, USD Կայանի տեղադրված հզորության 1 կՎտ արժեքը, ԱՄՆ դոլար	950
Estimated pay back period, years Ներդրումների հետ բերման ժամանակահատված, տարի	8-10

Discussion

SNL-60 poly crystal PV panels with nominal capacity of each 255W and dimensions of 1.640x0.992m^2 were used. Parameters of solar panel are brought in Table 1. Group of 196 panels were connected to Solar Invertor KSTAR KSG-50K (made in China) with rated output power of 50W and rated AC voltage of 400V. So 3 solar invertors of these type were used to provide output power of 150 kW. The total number of panels was 588 in 2019 with total power to 150 kW (in 2017 power totaled 147 kW).

The funding of the station was made through ACBA Leasing based on Green Leasing scheme. Net metering mechanisms has been used while PV station supply electricity to Electricity Network of Armenia (ENA). For this purpose, the reverse multi-tariff electronic meter was installed in accordance with state regulations (see Attachment 1). Excess electrical energy above the needs of the hotel is sold to ENA. If the amount of electricity provided by the autonomous energy producer is positive as a result of the annual calculation, the autonomous energy producer shall be reimbursed at the rate of 50% of the tariff set by the Commission (around 24 AMD/kWh without VAT) according to Armenian regulations established through Public Services Regulatory Commission (PSRC, see Attachment 1).

There is no license required to operate PV station with capacity less than 500kW for legal person and with capacity less than 150 kW for individuals.

Information on actual annual electrical energy production in 2019 for Yenokavan power plant are based on data that are generated through invertor and that are available on Internet.

Electrical energy produced by years	
2017 (since 10 December)	9500 kWh
2018	153 000kWh
2019	187 000 kWh
Total (by September 2020)	501 000 kWh

Data on estimated (208, 000 kWh) and actual (187,000 kWh) annual electrical energy production in 2019 are enough close. In 2018, annual electrical energy production totaled 153,000kWh. Total amount of electrical energy by September 2020 was 501 000 kWh. Definite outage periods for previous years are explained by necessity to replace some components of PV station. More years of registration of annual electrical energy production are desirable to have more detailed analysis. Some data on production for 2018 were lost due to invertor manufacturer.

Estimated average monthly savings totals 745000 AMD and estimated monthly green gases savings – 7.2tons (see Table 3).

From point of effectiveness, feasibility, availability, modern equipment, cost/effectiveness, use of local materials PS station shows good results. PV panels were manufactured in Armenia using laminator, but solar cells are still imported. invertor is also imported. Panels are competitive and can be sold abroad. In press there was information that there exist local company that is involved in cell manufacturing.

According to data from PSRC as of end of December 2019 13.1 mln kWh/year was produced from grid connected solar PV stations, and 10.1 mln kWh/year was produced by autonomous producers.

With current prices on components of PV station pay-back period would be reduced to 6-8 years for these climatic conditions.

Conclusions

1. Three years of operation has proved the effectiveness and reliability of PV station in v. Yenokavan, in spite of some breaks. More time period and more available data are required for detailed analysis.
2. Even under less than average for Armenia solar intensity values operation of PV station in v. Yenokavan is feasible and pay-back period for PV stations with current prices on its components can be reduced to 6-8 years.
3. Introduction of more efficient panels such as bifacial and etc. can increase efficiency of PV station but due to higher prices rarely would further reduce pay-back period.
4. From point of effectiveness, feasibility, availability, modern equipment, cost/effectiveness, use of local materials PS station shows good results, with that not all the components of station are manufactured in Armenia.
5. Operation of station is good example of use of sustainable energy sources to reduce green gases emission and combat climate change.

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Literature and citations

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Attachment 1. Guidelines for building autonomous power stations and connecting to the network (source: www.minenergy.am)

1. An autonomous power generator (APG), an individual or a legal entity, may construct a solar power installation with a capacity of up to 150 kW without a license to meet its own needs (EMO Article 23). For legal entities, this limit was increased to 500 kW, and for individuals it remained at 150 kW.
2. The technological connection of the consumer to the electric network is made according to his application. It is necessary to apply to local Supplier site of "Electric Networks of Armenia" CJSC (Distributor) according to the territorial affiliation of the connected electrical installation. A contract is signed for the connection of the new consumer or the reconstructed consumption system to the electricity network. According to the contract, the Supplier connects the consumption system of the new consumer or developer or the consumer reconstructing the consumption system (Customer) to ENA, and the Customer undertakes to pay for the connection to ENA.
3. Then, the reverse multi-tariff electronic meters are installed, the issues related to the acquisition and maintenance of which are regulated by the rules of electricity supply and use approved by the RA PSRC (Commission Decision No. 358-N of December 27, 2006).
4. Calculation of amounts payable for electricity supplied to the APG by the Distributor and Payment by the APG to the Distributor is made on monthly basis, and the calculation of the amounts to be paid for the electricity supplied to the Distributor by the APG, the final calculation and the payment by the Distributor to the APG are made annually. If, as a result of the annual calculation, the amount of electricity supplied by the APG is negative, the Distributor shall refund that amount. If the amount of electricity provided by the APG is positive as a result of the annual calculation, the autonomous energy producer shall be reimbursed at the rate of 50% of the tariff set by the Commission (RA Law on Energy Saving and Renewable Energy adopted on November 9, 2004).
5. Tax regulations on parallel work with the power system of autonomous energy producers are made in accordance with the Tax Code of the RA of October 4, 2016.

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