A FEASIBILITY STUDY OF SOLAR ENERGY-TECHNO ECONOMIC ANALYSIS FROM AKSARAY CITY, TURKEY

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ABSTRACT
This study posed a feasibility study of solar energy-techo economic analysis that was investigated for 20,000 m² area of Aksaray city from Turkey. The result of a solar energy radiation production was found to be 1.65 million [kWh/m² year]. The profit of solar energy plant was determined about 501,825 [$/y]. A simple payback period was found to be 4.5 [y]. The aim of the study is to indicate building solar energy plant that can be efficiently for Aksaray city. Since a solar energy plant can be a feasible plant for Yapilcan village, Aksaray city that is near the power line local area network. These results figure out very efficient result for building solar energy plant to Yapilcan village, Aksaray city from Turkey.

Keywords: Renewable Energy, Solar Energy, Techno Economic Analysis, Energy

INTRODUCTION
Over the years, most of countries need to product energy for their life and development. Thus, enhancement of sustainable energy works should be revealed by all countries. Hence, many countries try to progress renewable energy sources such as solar energy, wind energy, biomass, wave energy, fuel cell, hydrogen energy etc. Solar energy becomes an alternative energy that can be useful for all field of energy.

In literature, there are many previous studies. These literatures emphasize and describe a significant of solar energy.

Cetin and Egrican [1], who posed solar energy as future key roles for Turkey’s energy, researched the employment effects of solar energy industry in Turkey.

Toklu [2] determined that solar energy could be used for biomass energy or auxiliary energy. Beside, apart from renewable energy, biomass is huge one that can be effectively stored solar energy.

Melikoglu [3] carried out the role of renewables and nuclear energy in Turkey’s Vision 2023 energy targets for an economic and a technical research.

The combination of PV (photovoltaic) solar energy, a wind power plant and a PEM (Proton Exchange Membrane) fuel cell hybrid system were investigated for electrical power production by Devrim and Bilir [4].

Eksi and Karaosmanoglu [5] indicated about available heat sources of biomass involve solar for generation renewable energy.

Many previous studies also include solar energy with other renewable energy. Ozden and Tari [6], who studied other energy systems, researched a solar–hydrogen based hybrid renewable.

Badea et al [7] figured out a case study concerning a plant for hydrogen production using solar energy and technical analysis. Morcillo-Herrera et al [8] calculated the electricity generated by a photovoltaic cell.

In this study, we figure out solar energy plant that can be installed on a fertile land. Therefore, this plant can be appropriate to build a solar energy plant for Yapilcan Village on which solar radiation is a very high ratio and efficiently. Furthermore, this land is near the power line of local area network.

FEASIBILITY OF SOLAR ENERGY PLANT’S PLACE
Before the calculation of solar energy, the feasible of solar energy plant’s place has to explain in a detailed way. Aksaray is located in Central Anatolia Region of Turkey.

Aksaray is the crossroads of Turkey as a location as well as history and culture. Not only Aksaray is located importance place but also its place includes energy and transportation issues.
Besides, Yapilcan Village, which is a district of Aksaray, is very suitable for building solar energy power plant due to the efficient of solar radiation. Thus, Yapilcan Village was chosen according to these reasons. These data and information of figures were taken from The Ministry of Energy and Natural Resources, General Directorate of Renewable Energy [9].

In Fig. 3, daily solar duration of Aksaray and PV type area – production of energy can be seen for a year. In this study, 20 decare of unproductive land was conducted for the solar power plant feasibility study. Solar energy panels of 20,000 m² can be installed to benefit from unlicensed electricity generation legislation. 1 [MW] power can reach to 14,000 [m²] of this area, the result of which solar energy facility can be installed by using photovoltaic solar panel.

It is determined according to solar energy maps and other information from the town of Yapilcan where is a region with a solar radiation potential of 1650 [kWh / m²-y]. Furthermore, this region is close to the power distribution network. According to the Law No. 5346 of Renewable Energy Sources for Electricity Generation Production is presented in Table 1 below [9].
The production of an electricity sales price is 13.3 [¢/kWh] and construction of solar energy is 0.8 [¢/kWh] (A native construction). A native PV module that can be used, price is 1.3 [¢/kWh]. Accordingly, the total sales price of 15.4 [¢/kWh] is realized in the form.

Table 1. Incentives of General Directorate of Renewable Energy

| Support (Incentives) | [¢/kWh] |
|----------------------|---------|
| Based on Solar Energy Production Facility Production | 13.3 |
| Construction (native) | 0.8 |
| PV Modules (native) | 1.3 |
| Cells that make up the PV Module (native) | 3.5 |
| Inverter (native) | 0.6 |
| PV solar ray focusing device on Module (native) | 0.5 |

Table 2. Facility investment cost of solar energy

| Facility investment cost of solar energy | [€/W] |
|-----------------------------------------|-------|
| Solar panel | 0.56 |
| Inverter | 0.20 |
| Construct | 0.08 |
| Wiring DC-AC | 0.06 |
| Protect Equipment | 0.03 |
| Transformer | 0.02 |
| Other * | 0.06 |
| Labor + Shipping | 0.07 |
| **Total Cost (Except Vat)** | **1.08 [€/W]** |
| Total Cost (Vat Included, 18%) | **1.27 [€/W]** |
| **GENERAL TOTAL COST (Including Tax)** | **1.34 [$/W]** |

Note: *Remote Monitoring, Counter, Transformer Cabinet, Panels, Wire Mesh, Concrete etc.

According to the study, it can be estimated the facility investment cost of solar energy plant from Table 2, respectively. Besides, some assumptions is approved and costs of the solar energy plant is determined considering the market conditions. Data of table is suitable for solar PV thin film that is taken from 1,300 [$/kW] to 1,450 [$/kW] [9, 10, 11, 12]. Total facility investment cost of solar energy was found around 1.34 [$/W] equals to $1.34×10^6 [$/MW].

In this study, solar energy and techno-economic was calculated respectively. An area of solar energy radiation can be calculated from Eq. 1 as follows [7, 8]:

![Figure 3. Solar duration of Aksaray city [9]](image-url)
\[ A_r [m^2] = A_T [m^2] \times R_c [%] \]  

where \( A_r \) is an area of solar energy radiation, \( A_T \) is a total area and \( R_c \) is efficiency of solar radiation.

An annual production of solar energy radiation can be found from Eq. 2 as follows [7, 8, 13]:

\[ E_s [kWh/y] = Q_r [kWh/m^2\text{year}] \times A_r [m^2] \times 1,000 \]  

where \( E_s \) is an annual production of solar energy radiation and \( Q_r \) is a ratio of solar energy radiation.

An operation cost of solar energy plant can be calculated from Eq. 3 as follows:

\[ OC [$] = GTC [$/kW] \times 1,000 [kW] \]  

where \( OC \) is an operation cost of solar energy plant and \( GTC \) is a general total cost of solar energy plant.

A support price can be calculated from Eq. 4 as follows [7, 8, 13]:

\[ SP [$/m] = E_s [kWh/m] \times 1.3 [\cdot] \times PTC [$/kWh] \]  

where \( SP \) is a support price (incentive) from Turkish Government. PTC that is supported by Turkish Government according to 1.3 multiplier PV module native is 0.133 [$/kWh].

Annual of the plant profit can be found from Eq. 5 as follows:

\[ PPA [$/y] = SP [$/m] \times n [m/y] \]  

where \( PPA \) is an annual of plant profit and \( n \) is a year (12 months). Besides, energy consumption of solar energy plant was assumed 150,000 [kWh/m]. The cost of plant exempted tax was calculated 18,000 [$/m] for monthly.

Moreover, depreciation time can be estimated from Eq. 6 as follows:

\[ DT [y] = OC [$] / PPA [$/y] \]  

where \( DT \) is a depreciation time. If the operation of solar energy panel life is 25 years, profit time will be calculated an investment cost from Eq. 7 as follows:

\[ ADT [y] = N_h [y] - DT [y] \]  

where \( ADT \) is a profit time (After investment cost) and \( N_h \) is an operation time of the solar power plant.

A solar energy power plant profit can be calculated a simple method in Eq. 8 as follows:

\[ PADT [$] = PPA [$/y] \times ADT [y] \]  

where \( PADT \) is a profit of solar power plant (After completed investment cost).

RESULTS AND DISCUSSION

The result of the study was posed in the summary of table. It can be seen clearly in Table 3. In terms of Table 3, it was researched for 20,000 [m²] area of Aksaray city from Turkey. The result of a solar energy radiation production annually was found 1.65 million [kWh/m² y]. This solar energy plant profit annual was calculated 501,285 [$/y]. A depreciation time was also found 6.7 year. Solar energy plant profit (PADT) was found around 9.1 million [$].
Table 3. Result of the solar energy plant’s techno economic analysis

| Feasibility of solar energy plant                  | Amount  | Unit  |
|---------------------------------------------------|---------|-------|
| Solar energy production (Es)                      | 1,650,000 | kWh/yr |
| Operating costs (OC)                              | 1,340,000 | $     |
| Plant's cost (exempted) (PCE)                     | 18,000   | $/m   |
| Supported price (SP)                              | 23,773   | $/m   |
| Plant profit (PPA)                                | 501,285  | $/y   |
| Payback period time: Depreciation time (DT)       | 6.7      | year  |
| Profit time after investment cost (ADT)           | 18.3     | year  |
| Solar energy plant profit (PADT)                  | 9,182,125 | $     |

According to the previous studies, payback period time was researched by Koppelaar [14], who determined payback period time as from 2 to 22 years from similar studies. Thakur and Chakraborty [15] found payback period time as from 8-10 years.

In terms of the payback period result, result of our study is proper to similar previous similar studies. In that, we found payback period time (depreciation time) as 6.7 year. When we compared our result of payback period to similar previous studies, our result of the solar energy plant’s payback period time can be seen very proper. Therefore, our study is suitable for building solar energy plant to Yapilcan village.

The cost of energy was compared to previous similar studies. IRENA Agency [11] determined the unit cost of solar energy around 1.4 [$/W] for 7 [m^2] area. IRENA Agency [12] estimated the unit cost of solar energy from 1.35 [$/W] to 1.56 [$/W] for Europe. In our study, total facility investment unit cost of solar energy was found around 1.34 [$/W]. The unit cost of energy can be seen suitable when comparing to the literature.

CONCLUSION

This study shows that a solar energy plant can be built on the land of Yapilcan village, Aksaray city that is near the power line local area network. These results are very proper, so the solar energy power plant can be installed Yapilcan village, Aksaray city from Turkey. According to the sunshine duration and solar radiation values, it is very important to have a value above the average of Turkey and to be in a position to invest solar power plants. Thus, the interest of native and foreign investors and the expectation of this interest can be increased this region in the future. There is a government support for the renewable energy law and for the equipment to be used in renewable energy plants to be produced in Turkey. Foreign and domestic investors can start their analysis work to establish solar energy fields.

The first investment cost of solar energy is being reduced by the enhancement of new works. In the coming period, renewable energy resources will be given importance by reducing the reserves of fossil fuels and increasing their costs. It is an environmental friendly energy and there is no harm to the environment. Solar energy can’t be affected by the economic depression that could be caused by not being dependent on the outside in terms of raw material. This study indicated that Aksaray had to be evaluate for building solar energy plant to this region.

ACKNOWLEDGEMENT

The study that was designed a feasible solar energy plant for Yapilcan village land was requested to build solar energy plant by a firm. The study was also presented as a presentation at the International Conference on Energy and Thermal Engineering 2017, which was organized by Yildiz Technical University and held in Istanbul.

NOMENCLATURE

| Symbol | Description                  | Unit |
|--------|------------------------------|------|
| Ar     | solar energy radiation area  | [m^2]|
Qr  solar radiation ratio, [kWh/m²/year]
OC  operating cost of solar energy plant, [$]
GTC  general total cost of solar energy plant, [$/kW]
SP  supported price (incentive), [$/m]
PCT  supporting amount, [$/kWh]
PPA  plant profit annual, [$/y]
n  month time, [m/y]
DT  depreciation time, [y]
ADT  profit time after investment cost, [y]
Nth  operating time of the solar power plant, [y]
PADT  solar energy power plant profit, [$]
T  total
y  year
m  month
s  solar
r  radiation
W  Watt
$  US dollar
€  Euro
c  cent
k  kilo
M  Mega
PV  photovoltaic

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