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An economic analysis of the applicability of solar power on multi-apartment buildings in Turkey

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Electricity consumption reaches its peak between 19:00 and 22:00 worldwide and this consumption occurs largely in the residential areas. The isolated houses have advantages in terms of applicability of solar panels while the same opportunity does not exist for apartment complexes. Having many flats and not enough space for the installation of solar panels, tenants of such complexes are not able to act independently. However, usage of solar energy has vital importance for energy productivity, consumption control, and supporting the production especially for countries like Turkey where the majority of the population lives in apartment complexes. For instance, while the energy consumption in a complex with 50 flats means 50 times more than the consumption of isolated houses, the ability of the same complexes to produce its own energy means a great gain. The main barriers of the solar panel usage in the apartment complexes are the requirement of the common usage of panels which requires the flat owners act together, and unbalance between the number of flats and roof space. These problems mentioned require not only solution for the technical hardware but also economic solution as well. This study at hand presents a solution to the issue from the economic perspective. It is aimed to minimize the necessity of flat owners acting together by developing a scenario of not reflecting the set up cost to the owners. On the other hand, the set up and its cost are left for the private companies to handle. It is estimated that the set up cost along with a profit equal to the average interest rates to be paid by the flat owners to the companies setting up the system in 20 years which is the average lifetime of the panels. The resulting scenario shows that the amount of monthly payments of the owners to the company throughout the 20 years are nearly 30 % lower that their monthly electricity and gas payments. It is also presented how the State support discussed in the research pays back in various ways along with the economic activity estimated in the solar panel market. An apartment complex with 20 flats in 5 floors is chosen for the illustration purposes in the final section.

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1. Introduction

The fact that solar power is a clean energy source and it does not pollute the environment is obviously the most important reason of this increasing popularity. Furthermore, increasing productivity of the solar panels and their reducing cost due to the technological advances, development of invertor technologies, more stable operation relative to the wind tribunes, and lower maintenance cost since there is no moving parts can be mentioned among the other main reasons.

Although the potential for the solar energy is quite high for Turkey, the fact that solar energy fields are not necessarily attractive commercially and significant investment budget required by this system for the State to take over the whole system by itself prevents the utilization of solar energy potential available.

A microgrid system that will be built for a building is studied in this research along with the usage of solar panels which will be used as the source of energy in this system. A developing concept recently along with the smart grids is microgrids [2]. Microgrids can be a business center, hospital, university campus, military zone, building, street, and even a city. Sorts of structures which can produce its own energy and distribute to the users and utilize an automation system to make this production-distribution work more productively, are considered to be microgrids. The study at hand considers the solar power as the source of energy and studies the applicability of the microgrids in a building from the economic point of view. An economic analysis is provided in the final section.

Recently, by the researches on smart grids it is aimed to reduce the loses on the energy lines and prevent the unnecessary loading of the lines through consumption control [8, 9]. Along with these studies, reseach on microgrids which has a great impact on reducing the load of the energy transmission and distribution lines has gained more importance. In the implementations of microgrids it is aimed for the users of the energy transmission-distribution lines to produce and consume their own energy, thus reducing the load on these lines. On the second stage, the microgrids are expected to support the central network during the periods when the consumption increase excessively. Initially, structures such as hospitals, universities, large shopping malls, military zones and factories with large spaces are considered when it comes to the applications of microgrids. However, the time frame of 19:00 and 22:00 in which the energy consumption reaches its peak is more about the energy consumed at households rather than the industrial consumption. Thus, it is essential to study renewable energy option for households as a way of reducing energy need in overall. Recently, several studies are presented on this issue [1, 5]. A considerable rate of the population in Turkey lives in big cities and in apartment complexes. Thus, considering every apartment complex as a microgrid is supposed to make a major contribution in solving the energy problem of the country. In this research, it is discussed that to what extent these apartment complexes can be treated as microgrids, the spaces that solar panels take up is calculated, comparison of the energy production and consumption of the apartment flats is provided, and the average cost of an energy automation system that can be installed for a 20-flat apartment complex is estimated using the real-time data available. The features of the device which will be designed for such an energy automation is studied in accordance with the criteria determined.

Microgrids are small-scale power-generation systems consisting of local power-generating facilities equipped with alternative power systems. They are the systems that can organize the energy consumption and distribution in itself, transfer energy to the central network when needed, and also receive energy from it when it is necessary. From the central network point of view, a situation is where the microgrids generate their own energy, transfer energy to the central network when needed and request energy from it as small as possible constitutes the ideal scenario. This way, the load of the energy transmission and distribution lines decrease and the loses are also reduced to a great extent. On the other hand, the ideal situation from the microgrids point of view is where the consumers do not have to pay for electricity after the initial investment in the system, moreover, receive revenue from the excessive energy produced by the system. In smart grid systems, control points can reach every user through smart counters, and disable some of the receivers in the house or office depending on the contract prepared [7]. However, if a micro grid system is installed in a university campus, business center, street or city etc., an internal organization becomes an issue of consideration independent from the smart grid.

2. Solar energy usage in Turkey

Turkey is located in a superior place in terms of solar energy potential compared to the other European countries. According to the research of EIE, average annual daylight of Turkey is 2640 hours (7,2 hours/day) and average total solar radiation is 1.311 kWh/m^2-year (daily total 3,6 kWh/ m^2). Turkey has a great solar energy potential of 110 days and in the case of appropriate investments, Turkey can produce 1.110 kWh of solar energy annually per square meter. However, there is not a single plant producing its own energy that is connected to the central energy network. The main reason is the lack of required legislation and high investment figures. The small number of solar energy systems with small capacities established so far are currently working off grid.

3. Apartment complexes in Turkey and Suitability for solar energy usage

Daily energy need of an average household excluding the heating systems can be reduced to 6 kWh in average with an appropriate energy automation. Using a grouping scheme for the electric househould appliances with first, second, and third degree priorities, 2 kWh energy is sufficient for each group. In the first group electronic devices such as lightning, oven/stove, TV-computer are placed and they are used whenever wanted during the day. Refrigrator, air conditioner and water heater which are needed during the day are considered to have second degree priority and can be arranged to be used in certain periods of the day. Appliances such as dish washer, washing machine and iron which can be arranged to be used in certain days are grouped to have third degree priority. Daily need of 6 kWh is considered in the calculations made in this study. Considering the average of 180-200 w energy generation from a 1 m^2 solar panel perpendicular to the sun and assuming the placement of the panels on south-side with a constant 30 degree, 150 w of energy is calculated to be generated from a 1 m^2 panel. In this case, generating 9 kWh energy from 6 panels in sunny and long days along with loses; the daily solar energy generated is determined to be 6 kWh, in parallel with the need.

3.1 Analyzing the structure of apartment complex from the solar panel installation point of view

Studying the current apartment complex structure in Turkey, the most appropriate place for the installation of solar panels are the roofs because the return of investment period in the case of using the sides of the complexes – even the south side- is quite long, thus reduces the attractiveness of the investment. In terms of using the roofs, the part of them facing the South takes up 50 % of the whole roof in the best scenario. Considering the factors such as the structure of the roof, direction of the complex and existence of the balconies etc., the appropriate space for the placement of the panels on the roof reduces down to nearly 30 %. In which case, the number of floors in the complexes that will be using solar energy should not excess five, considering the size of a given flat to be 100 m^2 in average. Even though surface of the roof increases as the number of flats per floor increases, the end result would not be changing as the total number of the flat to consume energy would also be increasing. For the complexes with social areas around, the system seems applicable also for the complexes with more than five floors, since the panels can also be located on areas such as parking lot, administration building, and even solar energy fields. It is possible to obtain more productive results with innovative roof designs for the new generation apartment complexes.

3.2 Economic Analysis of the Solar Energy Usage in the Apartment Complexes

The main expense figures in solar energy systems are the solar panels, panel platforms, invertors, battery charge system, battery storage and smart counter, and apartment automation device to manage the whole energy automation. The expenses other than the ones for invertor, battery charge system and apartment automation system are directly proportional with the number of flats in the complex. Cost of invertor and battery charge system on the other hand, is calculated to increase by 30 % of the base price per every other 5 flats. An estimated price is used in the calculations for the apartment automation device since it is studied theoretically in this research. The capacity of the battery per flat is chosen to be 2 kWh because it is aimed that the energy stored during the day can cover for the energy needed by the first-group home appliances during the period of 19:00 and 22:00 which is the most expensive period of the day. Considering also the loses in the system, a battery of 12V 200Ah (2,4 kWh) is appropriate for every flat.

In accordance with these criteria, the cost estimation for a solar energy system of a 5-floor and 20-flat apartment complex is provided below:

Cost of invertor and battery charge device for 20 flats (200 kw):

5 flats (50 kw)	: 3000 TL
20 flats	: 3000 TL + (900 TL X 3) = 5700 TL

Required panel space(20 x 6 m^2)	: 120 m^2
Panel + Panel platform	: 1000 TL / m^2
Total	: 120.000 TL
12V 200Ah battery	: 800 TL
Total battery cost for 20 flats	: 14.000 TL
Smart counter	: 200 TL
Apartment Energy autom. device	: 5.000 TL
Cabling and labor cost for 20 flats	: 10.000 TL
Total	**: 155.700 TL**
Cost per flat	**: 7.785 TL**

For the illustration purposes, monthly average electricity bill of a household is considered to be 50 TL. Receiving 90% of this bill after a 10% discount to the users, the investing company would end up with 45 TL per month/flat, thus 540 TL/year per flat.

During the calculations, 50% of the total investment is assumed to be sponsored by the State. For the purpose of calculating the opportunity cost, we consider an approximate interest rate offered by commercial banks in Turkey where the potential investors can choose to invest their capital. The lifetime of panels is approximately 22 years, so the investors would compare their investment options after a 22-year period. Since the investor keeps the capital in banks, investment in solar system should also return the investors their capital after 22 years which needs to be included in the calculations. Thus, the investment of 3.892,5 TL should be paid to the investor over the period as well which requires 176,5 TL/year payments. The remaining amount per year that the investor receives is 363,5 TL which constitutes 9,3% profit rate.

4. Conclusion

The peak hours of energy consumption throughout the world is between 19:00 and 22:00 which is apparently cumulating from the residential usage of electricity. Thus, it is vital for the governments to come up with solutions and alternatives for residential use of energy in a more efficient way. Renewable energy resources appear to be one of the most efficient and effective solutions for clean and sustainable energy development in Turkey [10]. Especially for countries relied on energy sources from outside, the issue has great significance for strategic purposes.

The study at hand proposes a profitable and convenient solution for all three parties involved: The State, Investor, and the Users.

Although the State carries a heavy financial burden in the scenarios mentioned in this study, it is in fact reduced to a minimal level by attracting the potential investors. However, the major gains for the State are in long-term nature, rather than short-term financial figures. Aside from the environmental advantages due to the use of renewable energy source, this system will reduce they heavy load on the energy transmission and distribution lines, thus reducing the failures and losses on these lines.

The users will also benefit from the system by ending up with 10% discount on their electricity bills for a 22-year period, in return for letting their roofs be used for panel installation.

Finally, the investors will get into a new and emerging sector by installing the system and handling the billing. As presented in previous section, although this is a new sector the profit rates are quite comparible with alternative investment opportunities. Considering that the installation and material costs are continuously decreasing, expecially the investors going into this sector first will increase their profitability even more as the conditions improve in a close future.

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