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Using Solar Energy in the Cleaning of Swimming Pools in North Cyprus

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Abstract: Currently there are over 5,000 swimming pools in operation in North Cyprus. The paper briefly investigates the solar energy availability in North Cyprus, and proposes the use of solar electricity to operate the pumps used for circulating the water and cleaning swimming pools. The paper concludes that electrical energy can be saved if solar energy is used during the pool cleaning process.

Keywords: Photovoltaic panel, renewable energy pool pump, solar energy, swimming pool.

1. Introduction

Renewable energy sources like wind, solar, biomass, geothermal, hydropower, and tidal offer an alternative to fossil fuels and can help reduce the CO_2 emissions in the environment. In addition, there are financial benefits too. Investing in a renewable energy source now means buying energy at today's prices for a future where energy may cost a lot more. Fuel prices have been fluctuating in recent years and if fuel prices rise, which seems to be the trend in recent decades, then the pay back period of the capital cost of solar energy installation would be shorter.

All forms of energy are expensive, but over time, renewable energy generally becomes cheaper [1], while fossil fuels generally become more expensive. During the five years from 2004 to 2009, worldwide renewable energy capacity grew at a rate of 10-60% annually for many technologies, and the growth accelerated in 2009 relative to the previous years. Wind power has had the most investment of renewable energy sources [2], followed by the grid-connected Photovoltaic (PV) technology.

One of the aims of supporting the generation of electricity from renewable sources is to help reduce CO_2 emissions. Electricity generated from renewables does not result in any CO_2 emissions. In contrast, gas, oil, and coal-fired power generation produces between 0.2 and 0.9 tonnes of CO_2 per MWh, depending on the energy source and the efficiency of the plant.

Solar energy is a renewable energy of particular interest to countries that lie between latitudes 40ºN and 40ºS. This part of the earth receives most of the radiation falling on earth's surface. Many researchers have measured or estimated the amount of solar radiation falling on their countries of interest. In this paper we are only interested in climates which are the same as Cyprus, which include countries in the Mediterranean basin. In general, the average daily solar radiation in this region varies between 5 and 7 kWh/m^2 as shown in the solar radiation maps [3-4]. Countries located in the northern parts of the Mediterranean have lower values. For example, the average daily solar radiation in Greece is quoted [5] as 5.2 kWh/m^2, and in the islands of Crete and Rhodes the radiation levels are estimated to be around 6.57 kWh/m^2. Fortunately, Cyprus enjoys a slightly higher level at around 7 kWh/m^2.

Solar electricity is primarily used in many general purpose electricity generation applications [6-7], such as: rural water pumping [8]; solar refrigeration [9]; navigation buoy lights [10]; solar pool heating [11]; and in the powering of electric pumps used for circulating the water to clean swimming pools, which is the subject of this paper. Currently, the pumps of swimming pools in Northern Cyprus are operated using conventional electricity sources. This paper presents the results of a study carried out in Northern Cyprus to investigate the benefits of operating swimming pool pumps using solar electricity.

Currently electricity in North Cyprus is provided by the government owned Electricity Generating Board [12] where two 60MW gas turbine generators are used as the main source of energy. In addition, a number of smaller generators are used at times of peak loads to meet the demand. Currently, there are no renewable energy sources in use in North Cyprus.

2. Solar Energy in Cyprus

Cyprus is an island situated in the Eastern Mediterranean between the latitudes 34º 33' - 35º 34'N and longitudes 32º 16' - 34º 33'E, and is the largest island in the Mediterranean after Sicily and Sardinia. The island of Cyprus is currently divided into two politically separate parts after the intervention by Turkish forces in 1974. North Cyprus (see Fig. 1) occupies the northern part of the island, with an area of 3,355 km^2. The problems

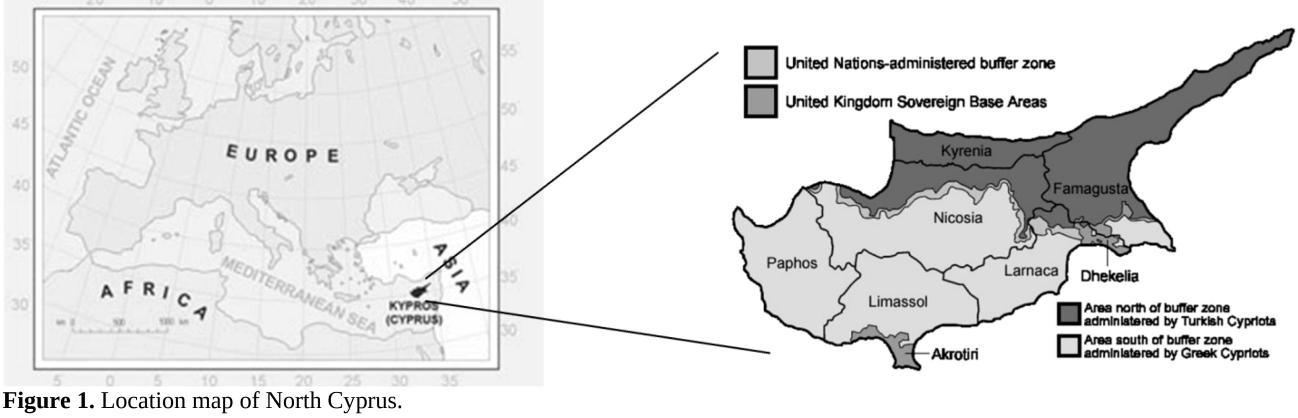

Figure 1. Location map of North Cyprus.

of conventional electrical energy usage to clean swimming pools is common to both parts of the island.

The design and installation of solar energy plants requires a knowledge of the average solar radiation at the place of interest throughout the year. The climate of Cyprus is a typical Mediterranean climate with hot, dry summers, becoming very hot and humid at night. During winter, the weather is warm and rainy, becoming cold at night. The solar radiation received in Cyprus, based on historical data collected by the various meteorological stations on the island, is 7 kWh/m^2 in the summer months and 3 kWh/m^2 in the winter months (see Fig. 2), making Cyprus a potential candidate for using solar energy. Although the North Cyprus authorities have heavily invested in conventional fossil based energy, there is considerable interest in the use of solar energy, especially among the owners of private homes and factories.

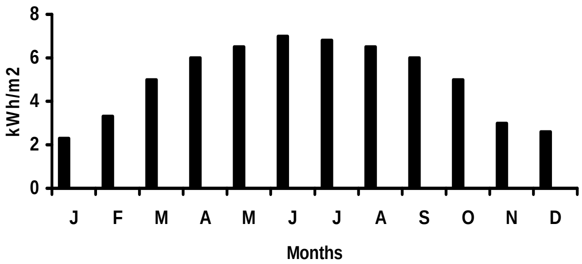

Figure 2. Average daily global solar radiation in Cyprus.

Although currently there is no renewable energy usage in North Cyprus, recently the European Union has announced [13] that it will invest €4 million in a solar energy project in Northern Cyprus in order to promote the use of renewable energy sources and also to increase the public awareness of alternative energy. The pilot power plant will generate a maximum of 1 MW of electricity to the grid and should be up and running within a few years. According to news reports it is expected to produce over 1.5 million kilowatt hours of electricity each year, with this pilot project being the first of several to come.

In Cyprus there are some areas with average wind velocities of 5-6 m/s, and a few areas with 6.5-7 m/s. It is reported that [14] the estimated maximum exploitable wind potential on the island is 150-250 MW. Although some studies are being carried out for the installation of wind turbines on the Southern coast of Cyprus the cost is expected to be high due to the high depth of the sea close to the shore (more than 30 m deep at 300 m from the shore).

3. Why Solar Energy for Swimming Pools?

In recent years there have been huge investments in North Cyprus in the building and construction industry. Many new houses, apartments, and especially villa type properties have been built in all parts of the country. The villas are about 120-250 m^2 in size and consist of two-storey buildings with gardens and private swimming pools. Usually these properties are sold even before they are complete, where the buyer pays the cost in instalments, and the builder completes the property with these payments, transferring the title deed to the buyer at the completion of the payment.

The private swimming pools constructed in North Cyprus are of the overflow type [15], incorporating a balance tank for the return of the overflowing excess pool water. The chlorinated water is kept clean by circulating it through a sand filter from the balance tank to the pool where it is returned back to the balance tank through the grills at the sides of the pool. The swimming pools are rectangular, with dimensions 7 m width × 4.25 m length, having a depth of 30 cm to 2 m. The water content of the pools is approximately 50 m^3 (10,000 gallons).

After talking with all the local pool maintenance companies and the companies selling pool cleaning products, the authors have estimated that currently there are around 4,500 private swimming pools in Northern Cyprus, with a majority having dimensions as given earlier. Fig. 3 shows an example of the swimming pool concentration in a small part of Kyrenia City in the north of the island. If we add to this number the swimming pools at hotels, commercial institutions, and other public pools, the estimated number becomes around 5,000. Based on observations in recent years, we can assume an annual growth rate of 10%, and it can be estimated that 500 new swimming pools will be built every year. Thus, for example, the total number of swimming pools is expected to be more than 6,000 by the year 2013. With such a large number of swimming pools in a small country it is obvious that some measures must be taken to avoid water shortage problems, and also keep the environment clean by using environment friendly cleaning chemicals and renewable energy products wherever possible.

Figure 3. Part of Kyrenia City showing the concentration of swimming pools (shown as small rectangular shapes).

Swimming pools are normally cleaned throughout the year in order to keep the pool water clean and healthy, and in addition to avoid the build-up of algae and dirt inside the pool. The pool is normally cleaned [16] by adding chemicals to adjust the pH level and the chlorine concentrations of the water. In the winter months when the pool is not used the chemicals are added and the pools are cleaned once a week. In summer months where the pool may be used heavily the pool is normally cleaned twice a week. In addition to the chemicals, the pool pump is operated to circulate the water inside the pool to ensure that the water is filtered, and chemicals mix with the water. It is recommended that [15-16] in private pools all the water should circulate 4-6 times a day to ensure that the water is clean. The pool system is designed such that to circulate the water 4 times the pump should be operated about 12 hours a day.

The pumps used to circulate the water in swimming pools currently operate with 240 V AC and have a power rating of 2 kW (1.5 HP AC), and are capable of circulating 22 m^3 of water every hour. Assuming 12 hours of operation, the required energy is 24 kWh. Currently, the cost of local electrical energy is £0.12 per kWh. Therefore, the cost of cleaning the pool is £2.88 per day, or £1,036 per year for each swimming pool. Considering that there are around 5,000 swimming pools in North Cyprus, currently the total annual electrical energy requirement will be as high as 120 MWh. It is the authors' opinion that the use of solar energy to power pool pumps will result in huge savings both to the environment and to the individuals responsible for paying the maintenance of the swimming pools.

4. Using Solar Electricity to Power Swimming Pool Pumps

The efficiency and reliability of solar cells are increasing as the old crystalline silicon cells are being replaced with new thin-film solar cells. The new cells are capable of producing electricity for at least twenty years without a significant decrease in efficiency. The typical warranty given by panel manufacturers is for a period of 25-30 years, wherein the output is guaranteed not to fall below a specified percentage (around 80%) of the rated capacity. Although the efficiency of solar cells is currently around 15%, this figure is expected to double within the next decade [7]. The cost of solar cells is currently around £2 per watt, and this figure is expected to drop below £1 within the next decade, making solar cells more affordable.

The use of solar electricity to power water pumps has been in use for several decades, and the technology and practical applications of PV water pumping systems are well known. Many researchers in the past have reported solar PV water pumping systems, especially for rural development areas. Most such systems are used in remote areas of developing countries where there is no access to piped drinking water, and when the population to be served is not high [17-18].

The use of solar electricity to power the swimming pool pumps is not new but there are very few papers detailing this field and most of the information comes from the PV equipment manufacturers. Several companies around the world offer complete solar energy kits designed specifically for swimming pools. Some of these kits are designed for heating the pool water, while some others are designed to power the equipment used to add chemicals automatically to the pool water. Some solar equipment manufacturers [19] report savings of between \$70 to \$130 a month when solar electricity is used to power pool pumps. In addition, such systems are reported to extend the pump lifetime as much as 10 years, and also reduce the owner's carbon foot print.

In North Cyprus swimming pools are not used in the winter months and thus pool heating is not required. In addition, the pools are cleaned manually by adding chemicals. The main use of energy during the Winter is the daily powering of the pool pumps to circulate the water inside the pool.

In this paper we are interested in using solar electricity to power the pool pumps. The pools that have already been installed and are working can be converted to use solar electricity by one of the following options:

- Using the existing AC pumps and purchasing PV panels and an inverter
- Replacing the existing AC pumps with their DC equivalents and purchasing PV panels and a pump controller
- Purchasing a solar energy pool kit

Option 1 requires the purchase of at least 6 × 180W PV panels and a 2kW inverter. Along with cabling and installation the costs are approximately £2,800. Because the DC pumps are more efficient than the AC ones the pump rating is much lower and option 2 will require a new 750W DC pump, 4 × 180W PV panels, all costing around £3200. Option 3 may be attractive to home owners who may want an easy conversion option to solar electricity. Solar pool kits come in many varieties and prices. Such kits in general consist of one or more photovoltaic panels, DC pump, a pump controller, and the associated cables. The pool pumps are normally operated during the daytime and thus it is not necessary to use batteries to store the energy. A typical swimming pool solar kit is shown in Fig. 4. This kit [20] costs £2,750 including the cost of installation, and consists of the following parts:

- 750W DC pool pump
- 6 × 120W photovoltaic panels
- Pump controller
- Cables

Option 3 seems to provide the cheapest and perhaps the easiest method of purchasing all the required parts to convert an existing pool to operate with solar energy. The DC pool pumps are in general smaller, more efficient and also less noisy than the AC pumps. A 750W DC pump would be sufficient to provide the required daily circulation of the pool water. Considering that the cost of operating a conventional pool pump is £1,036 per year, the payback period of the solar system with option 3 is approximately £2,750 / £1,036 = 2.65 years. The lifetime of the solar panels and the pool pump are estimated to be over 20 years with little or no maintenance costs. The total electricity savings alone during the first 10 years of the installation are estimated to be over £7,600. Fig. 5 shows the estimated annual electricity savings for the first 10 years of the installation, assuming the local unit electricity cost remains at £0.12 per kWh.

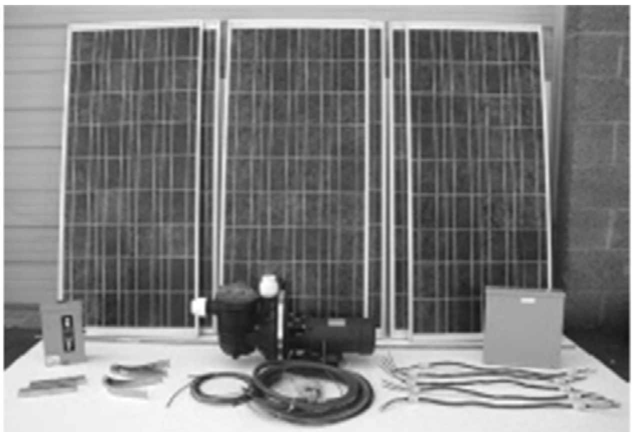

Figure 4. Typical solar energy pool kit.

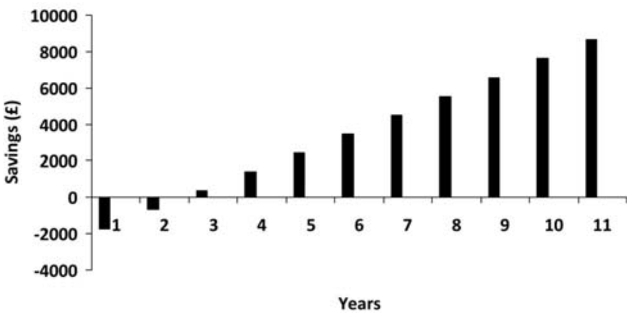

Figure 5. Annual savings over lifetime of the equipment.

5. Conclusion

The solar energy potential of Northern Cyprus is 7 kWh/m^2 per day in the summer and 3 kWh/m^2 per day in the winter. In addition the total amount of energy required to operate all the pumps to clean swimming pools in North Cyprus each year has been estimated to be 120 MWh. A large energy saving is possible if solar electricity is used to power the pumps instead of the currently used conventional fossil based power sources. The payback period after replacing a conventional pump system with a solar kit is estimated to be less than 3 years. Considering the equipment lifetime of around 20 years, the saving in electricity costs for the first 10 years is estimated to be over £7,600. This figure is in agreement with the data provided by the solar pool equipment manufacturers [19].

The analysis carried out in this paper is based on a traditional approach of sizing a solar electricity system. Interested readers can use computer aided methods (e.g. the HOMER software) for extended and more detailed analysis.

The use of solar electricity will be even more attractive on the island if the government educates the people in clean renewable energy, and also encourages the use of renewable energy products by lowering or removing the import duty on such goods.

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