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Installation of Solar PV System as an Alternate Source of Electric Stove and Gas Stove

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Saving energy is one of the major concerns for the increasing future of any nation and electricity is the most useful form of energy. In a development country like Bangladesh is facing acute electricity shortage where most of the power stations are run by natural gas. Also for household cooking we use electric stove and gas stove. Presently, the reservation of gas has fallen to such an alarming level that if no new gas reserves are discovered then this reserve may last for maximum a decade. So we need to find an alternative source for generation of electricity which will mitigate our demand and also reduce the consumption of fossil fuel. Solar energy is identified as the most feasible form, among all the alternative sources for the generation of electricity which can be used to electric stove for cooking. The objective of the paper is to show the effectiveness of solar based electric stove as compared to natural gas or normal electric stove.

Field of Research: Renewable Energy

I. Introduction

Energy is a vital component for economic and social development of a nation. Energy is by far the largest merchandise in the world and daily an enormous amount of energy is extracted, distributed, converted and consumed in our global society. The global energy demand is increasing continuously. Bangladesh is a power starving country where only 62% of the population has access to electricity with a per capita availability of 321 kWh per annum [2]. Being a developing nation, Bangladesh has seen a decent growth in its economy over the past few years. Bangladesh aspires to be a middle-income country by 2021. This will require increasing GDP growth to 7.5 to 8 percent per year based on accelerated export and remittance growth [1]. To achieve the target new industries have to install which require continuous power supply to attract domestic and foreign investor. Each and every year the demand of electricity increase gradually. Statistics shows that, in 2007 maximum generation of electricity was 4130 MW and in 2015 maximum generation of electricity is 8177 MW [4], which indicates that electricity demand is increased 100% by only 8 years duration. So after one decade later we will be needed more than 15000 MW electricity.

Power generation in Bangladesh is heavily dependent on natural gas. The total power generation in Bangladesh is almost entirely dependent on natural gas, which accounts for about 62.59% of the electricity generation of the total installed capacity as on September,2015 is 11877 MW [3]. In Bangladesh, we use electric stove and gas stove for household working where lots of energy and gas consumed. Also, we used compressed natural gas as a fuel of vehicle. At present, the reservation of gas is decreasing which will effect on power if no new gas fields are discovered in future. To mitigate our energy demand

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and to reduce the consumption of gas, solar energy has come out an alternative source for generation of electricity. In this paper we have shown the possibility and effectiveness of solar energy as an alternative supply of electricity for electric stove as compared to natural gas stove or normal electric stove.

II. Motivation and background

Everyone knows renewable energy is the energy for tomorrow. Still it is not affordable to use renewable energy to full fill all our needs. All have to be smart with using renewable energy for different requirements. Cooking is one of the biggest sources where renewable energy can have a significant role. The electric stoves that people use consume a lot of energy and hence cost inefficient. Also the gas stove will no longer be there in future. In this case hybrid stove can be an excellent replacement. In this stove majority of energy will be supplied by PV panels. Weather condition in Bangladesh is also suitable for this project.

III. Climate Study

Apart from the solar radiation availability the climatic (ambient temperature, humidity etc.) and microclimatic parameters (wind speed, dust level etc.) make significant impact on the performance of solar PV system.

A. Average Temperature

Maximum and minimum temperature significantly impact on voltage production in solar panel therefore it is important to consider in design. Figure 1.1 shows the average maximum and minimum temperature of the project site where minimum temperature is 7 degree Celsius in January and maximum temperature is 41.6 during month of Mar.

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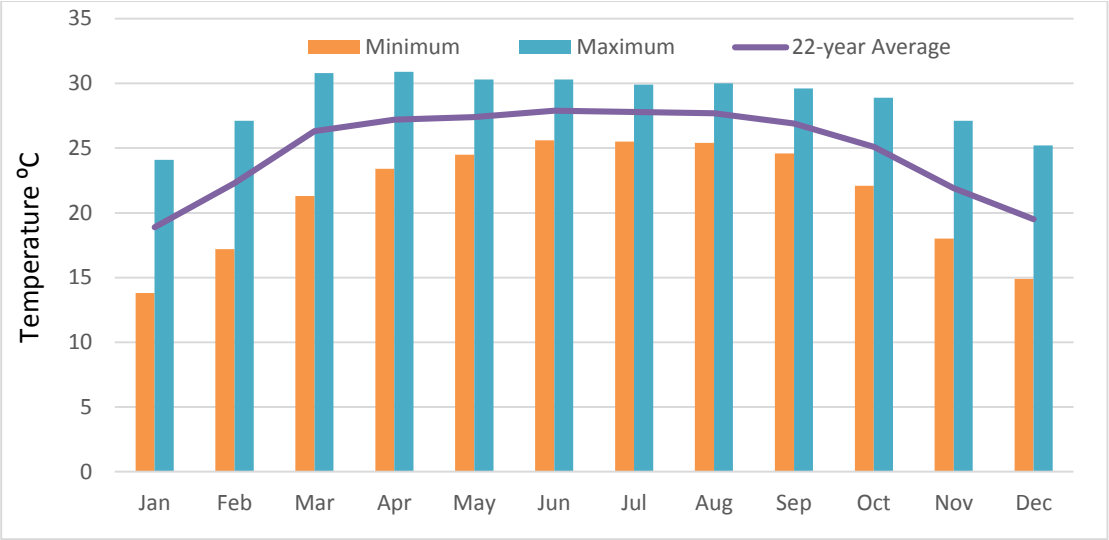
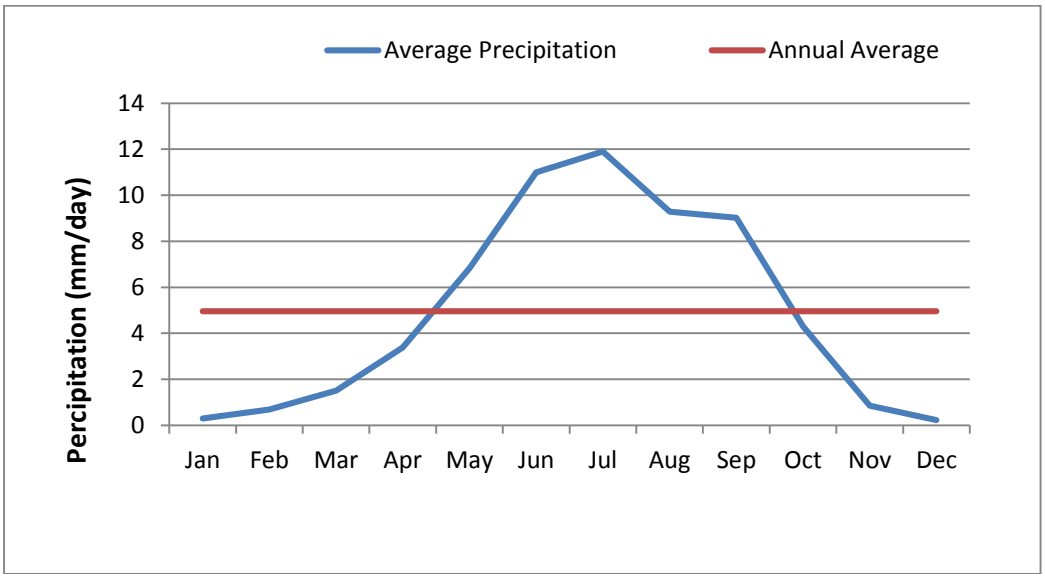
Figure **Error! No text of specified style in document.**.1: Monthly Average Temperature of the Site (NASA Surface Meteorology)



B. Average Precipitation

Figure **Error! No text of specified style in document.**.2: Average Precipitation (NASA Surface Meteorology**)**



C. Humidity

There is an adverse effect of too much humidity in the atmosphere on the PV module performance too. It becomes worse when humidity starts condensing on the panel in night and dust got deposited on the panel, and reduces the amount of solar radiation reaching on the solar cells. This will reduce the power output from the plant. Hence special consideration

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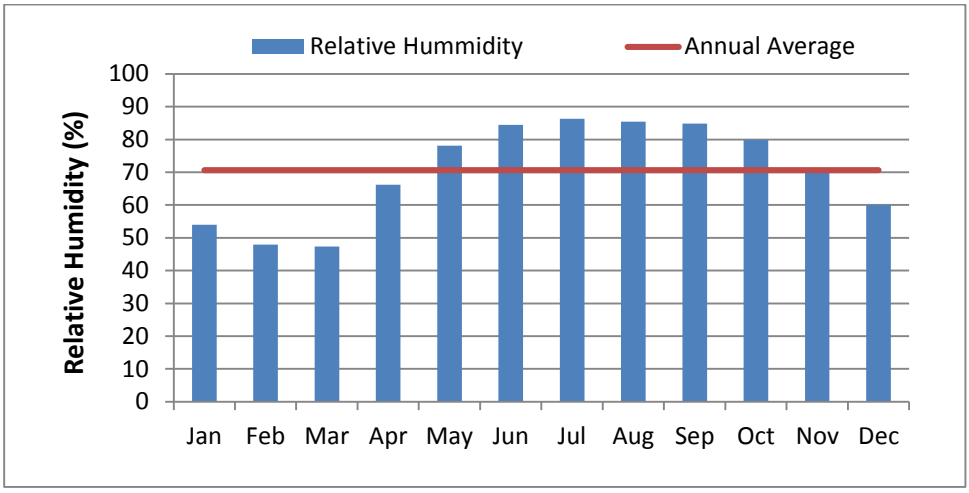
should be given for the cleaning of the solar panels. Here in the power output calculation from the PV plant is considered by taking in to account the effect of the humidity as well.

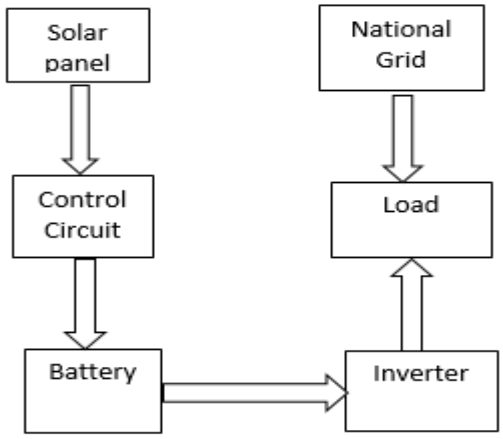
Figure **Error! No text of specified style in document.**.3: Average Humidity of the plant location (NASA Surface Meteorology)



IV. Basic Block diagram

The whole system is completely lucid and easy to install. The basic block diagram of a solar based electric cooking stove is shown in figure 1.4. Here are the different block such as solar panel, battery, inverter and control circuit and cooking stove in the diagram explained in details. Let us see each block in detail.

Fig 1.4: Block Diagram of the system



A. Solar Panel

Solar panel is a compiled and connected assembly of photovoltaic cells that transmutes solar energy into electrical energy [6]. It can be used as a constituent of a bigger photovoltaic

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system to create and distribute electricity in mercantile and residential applications. Each panel is rated in accordance with its DC output power under standard conditions, and typical specification ranges from 100 to 320 watts. We espouse a collection of 110 watt panels to form 7.28 kWp. The conjectured efficiency of these panels is 80%. A photovoltaic system conventionally comprehends an array of solar panels, an inverter, and an optional battery.

B. Battery

A storage battery is an ilk of electrical battery. It is a genre of energy accumulators that comprising of more than one electrochemical cells [7]. It is known as a secondary cell since its electrochemical reactions are electrically rescindable. Rechargeable batteries are used by grid energy storage applications for load-leveling, where they accumulate electric energy. For sustainable energy uses, the energy stored during day time can be used during peak load hours at night. Load-leveling mitigates the eradication of the desideratum for expensive culminating power plants and aids in amortizing the cost. We use a couple of batteries, each of 2V and 1540Ah capacity forming 48V and 1540Ah capacity battery bank. This generates 4 hours of output approximately at night without charging.

C. Inverter

A power inverter is a converter which transmutes direct current (DC) to alternating current (AC). The converted output can be made to any voltage and frequency according to the applications and desiderata. We use a 7kW inverter with standard output specifications of 22-240V, 50Hz to suit our requirements.

D. Control Circuit

In the system there must be a scheme to detect when a cell reaches full charge (change in terminal voltage, temperature, etc.) and to stop charging before harmful overcharging or overheating occurs [5]. We can incorporate cooling fans if needed to keep the cells from heating. Here we use a control circuit with voltage level sensors to obviate a detonation.

E. Load

In this system our main purpose to supply electricity from solar panel to electric stove which is being using as a load.

F. National Grid

Supply of electricity from the solar panel totally depends on whether condition of the atmosphere. If sunshine is not available then supply of electricity for cooking will be supplied from the national grid.

V. Design Calculation

A. Load Calculation

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Let consider 10 storied building with 18 flats (each floor has 2 flats and no flats at ground floor). Each flat needs one electric stove for their cooking, so 18 electric stoves are required for that building. And one electric stove consumed 1000 W electricity, for 18 electric stoves total electricity demand will be 18000 W or 18 kW.

B. Battery Calculation

Let consider each family use any stove maximum 6 hours for their cooking purpose
Total Wh = 108 kWh. Total battery capacity required = 108k/48 = 2250 Ah. Total battery capacity required = 2250 X 2 = 4500 Ah (Consider 50% loss due to DOD 70% & battery life cycle 80%). No. of battery required (48 V, 1580 Ah) = 4500 / 1580 = 2.848 ≈ 3. We Know, size of (48 V, 1580 Ah) battery is very large. So we use (2 V, 1580 Ah) battery [24 (2 V, 1580 Ah) battery will connect series]. Thus, required no. of battery (2 V, 1580 Ah) =3 X 24 = 72.

C. Panel Calculation

Each an everyday each cluster we need 790 Ah charge by solar panels. So, each cluster we need = 790 / 6 = 131.667 A ≈ 132 A charging current (consider 6 hours sunlight for each day). Let consider 110 W panel, Impp of 110 W panel is 6.4 A (Solar land PV model SLP110-12U 110-watt). Each cluster we need = 132 / 6 = 22 panels. So total no. of panels required = 22 X 3 = 66 panels. Total capacity of Solar PV system are = 66 X 110 = 7260 W or 7.26 kWp. Total area required for 7.26 kWp panels are = 66 X 7.878 ft^2 = 519.97 ft^2.

D. Inverter Calculation

Total capacity of solar pv system will be 7.26 kWp. So we will use 7 kW bi directional inverter, which will convert DC to AC as well as AC to DC.

VI. PVsyst Simulation Result

After Hand calculation we also simulate our project by PVsyst software, which is one of the well know Solar PV system simulation software.

A. Input Data

The shadow effect should be considered in PV array design, which should be wakened or eliminated. The general requirement is that, at the time of the winter solstice, when the longest shadow in a year appears, the spacing between the two rows of PV arrays should be big enough that the shadow of the PV array in front would not block the array behind, especially from 8 a.m to 5 p.m.

Local latitude angle has been considered for the inclination or tilt angle of the PV module facing towards the equator (south). Dhaka city is located at 23^o latitude and in northern

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hemisphere. So, to get the maximum of the incident rays of the sunlight, the module should place at a tilt angle equal to local latitude and facing towards south.

Figure 1.5: Inclination angle of PV panel

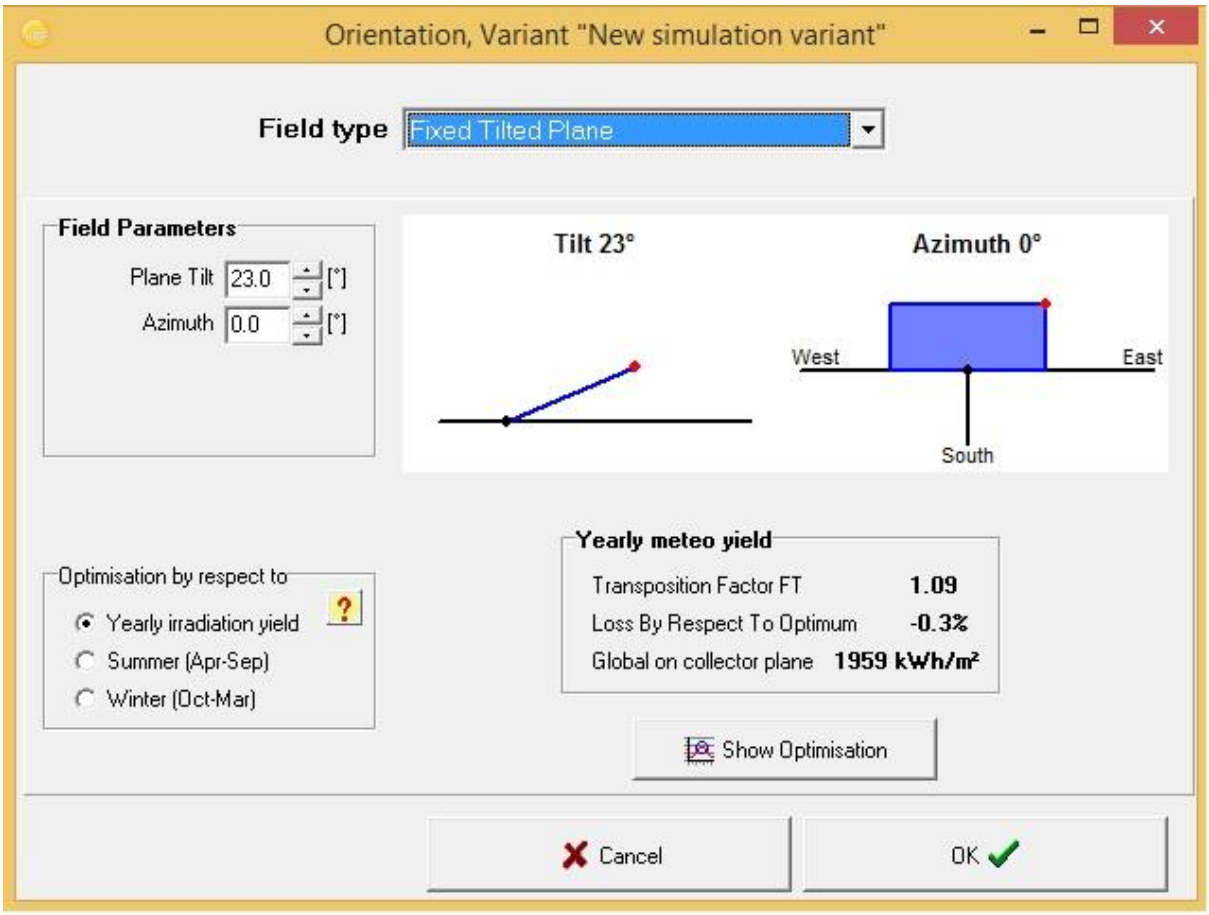

Figure 1.6: Input data of PVsyst software

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PV Array Characteristics

PV module (Original PVsyst database)	Si-mono	Model	**SG72-110/12 (110W)**		
		Manufacturer	Solartec		
Number of PV modules		In series	22 modules	In parallel	3 strings
Total number of PV modules		Nb. modules	66	Unit Nom. Power	110 Wp
Array global power		Nominal (STC)	**7.26 kWp**	At operating cond.	6.51 kWp (50°C)
Array operating characteristics (50°C)		U mpp	342 V	I mpp	19 A
Total area		Module area	**57.1 m²**		

Inverter		Model	**Sunny Boy 7000TL-US-22 -240V**		
		Manufacturer	SMA		
Characteristics		Operating Voltage	245-480 V	Unit Nom. Power	7.00 kWac
Inverter pack		Nb. of inverters	2 * MPPT 50 %	Total Power	7.0 kWac

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	302 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	2.5 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Param.	0.05

According to PVsyst software the system will produce 11.16 MWh/year with Performance ratio 78.7%

Figure 1.7: Simulation Result (Yearly power generation of the system)

Grid-Connected System: Main results

Project : **Installation of Solar PV System as an Alternate Source of El**
Simulation variant : **New simulation variant**

Main system parameters		System type	**Grid-Connected**		
PV Field Orientation		tilt	23°	azimuth	0°
PV modules		Model	SG72-110/12 (110W)	Pnom	110 Wp
PV Array		Nb. of modules	66	Pnom total	**7.26 kWp**
Inverter		Model	Sunny Boy 7000TL-US-22 -240V		7.00 kW ac
User's needs		Unlimited load (grid)			
Main simulation results					
System Production		**Produced Energy**	**11.16 MWh/year**	Specific prod.	1537 kWh/kWp/year
		Performance Ratio PR	78.7 %		

Figure 1.8: Simulation Result (Yearly loss diagram of the system)

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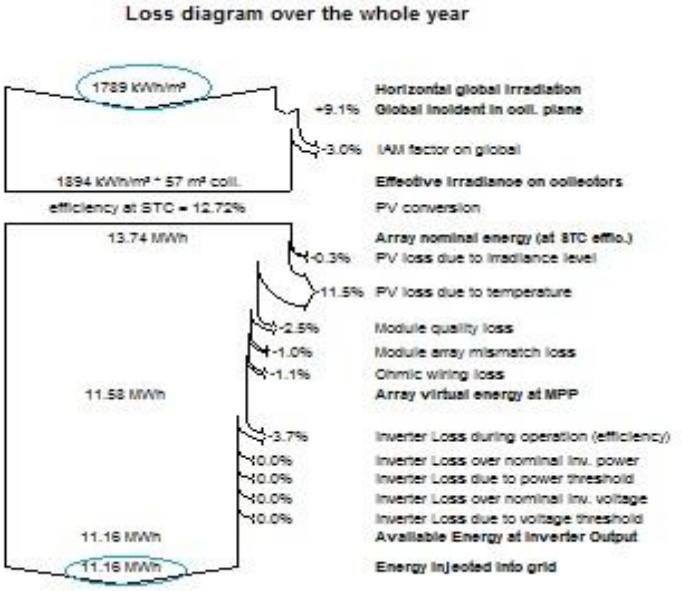

VII. Study

The price of electricity and gas is increasing day by day. In this paper, we implement a solar based system and find out the feasibility of the idea and the monetary profits of using it rather than using electric supply for cooking, as cooking gas is almost unavailable.

The project if successfully implemented, operated and maintained will have significant environment benefits mainly derived from the switch of power generation from a fossil fuel (diesel) source to a renewable source (solar energy). The only type of physical work is installing solar power generation systems on top of existing buildings. Apart from this the project will also impact in social perspective as described below.

A. Job Creation

To operate the PV system therefore there will an employment opportunity for local people. In addition, during construction a considerable number of manpower will be required to construct the project maximum of the workforce could be avail locally.

B. Use of unused rooftop

The rooftop of building to be used for the proposed 7.26 kWp grid connected solar power system is now mostly unused. Therefore, implementing the power plant the land can be used in an efficient way to produce power approximately 11.16 MWh annually.

C. Avoidance of Carbon dioxide emissions

Solar PV technology is an environmentally friendly technology. It does not emit carbon when generates power converting the sun light. The amount of carbon dioxide can be avoided throughout the period of the plant lifetime. Grid emission factor of Bangladesh is 0.67 ton per MWh.

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D. Increased Energy security

Bangladesh is an energy striving country. There is a considerable gap between demand and generation of power. Building such power plant can improve the scenario and reduce dependency on imported fuel significantly.

VIII. Conclusion

Renewable energy plays an important role in the transition towards a low carbon economy and the provision of a secure supply of energy. Many years of research and development have brought a number of renewable energy technologies to a stage where they are technologically mature and ready for a more widespread market introduction. However perceptions of the associated risks have constrained the progress of renewable energy.

The project is based on solution of real life problem. Such system can be beneficial in our life not only because it saves money but also because it is an application of utilizing solar energy which is renewable. It has opened a new era for cooking environment which seems to be the solution of the problems for tomorrow.

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