# The challenges of Solar Energy in Saudi Arabia and The Desert areas

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**Abstract**

Saudi Arabia, the epicenter of the global oil industry, has been showing keen interest in solar energy in recent years. In addition to the plentiful availability of empty stretches of desert that may accommodate infrastructure for solar power projects, however, there are many obstacles and problems facing solar energy and solar panels in climate conditions such as high temperatures, dust, and humidity because they will create many challenges and opportunities. So, these are effects on photovoltaic plants and Concentrated Solar Power (CSP) plants. The purpose of this study is to present a review of the available solutions to these challenges and discuss these solutions, and I will draw my own conclusion.

*Keywords: temperature effect, dust effect, humidity effect, photovoltaic, PCM, Self-Cleaning*

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## 1. Introduction

Saudi Arabia has one of the world's highest solar irradiation in the world, estimated at approximately 2,200 thermal kWh of solar radiation per m2. The country is strategically located near the Sun Belt. Energy from photovoltaic (PV) could be an obvious excellent alternative energy source for Saudi Arabia since it is sunny and has one of the highest direct normal irradiation (DNI) resources in the world. There are many obstacles and problems facing solar energy and solar panels in environmental factors such as high temperatures, dust and humidity.[1]

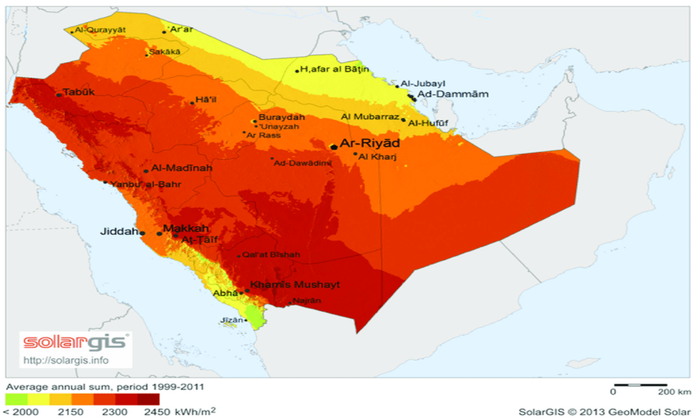


**Fig.1: solar irradiation in Saudi Arabia**


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## 2. photovoltaics: Background

When light hits the surface of materials, it might be reflected, transmitted or absorbed mostly converting the photon energy to heat. However, some materials have the characteristic of converting the energy of incident photons into electricity.[12]

A large majority of solar cells are made from silicon. When silicon absorbs sunlight, the energy from the sun excites some of the cell's electrons into a mobile state where they are free to move around the entire cell. However, in solar cells, there is a separator called a junction, where two slightly different types of silicon meet. The two types of silicon are pretty much the same, except each one is "doped" - has a tiny percentage of other materials mixed in. The two types of doping (called n-type and p-type) determine its electrical properties when a random electron reaches the junction.[10]

## 3. Problems effect

### 3.1The effect of High Temperature

The increased temperature in the cell leads to an increase in atoms vibration (phonons). In a p-n junction cell, increase and obstruct charge carrier movement which decreases cell efficiency, and this hinders the movement of the charging carriers and reduces the cell efficiency. This is proven by a study conducted on a ploy crystalline PV module on Dhahran east of Saudi Arabia that showed a similar temperature effect. the efficiency decreased from11.6% to 10.4% when the module temperature increased from 38°C to 48°C, which corresponds to 10.3% Fig.2.[2]

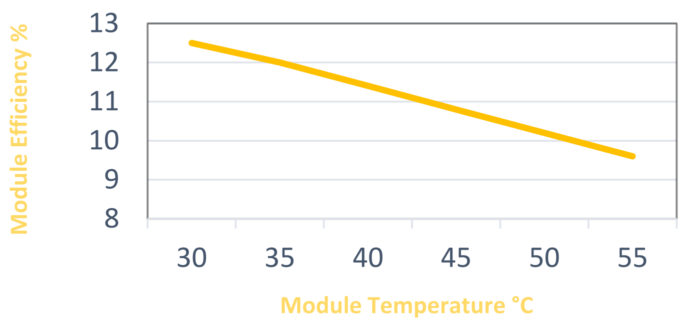


**Fig. 2: Correlation between efficiency and module's temperature.**

### 3.2The effect of Dust

The dust accumulation on the surface of the PV module blocks the solar irradiation from reaching cells, and hence impacts on the power output, current-voltage, and characteristics of PV modules.

### 3.3The Effect of Humidity

On the moisten PV surface the light is scattered either by refraction, reflection or diffraction when it hits water droplets.[3] Moreover, in a hot and humid climate, moisture penetrates into the PV cells through the cracks, causing a significant decrease in cell productivity.[4]

The table below to compared the effect of the problems in the monocrystal line PV and Amorphous PV, the temperature play a vital role in decreasing the efficiency during a day.

However, for a longer period, the effect of dust becomes more and more important and overcome the effects of temperature or Relative Humidity.

| | **Dust (%)** | **PV temperature (%)** | **Relative Humidity (%)** |
|---|---|---|---|
| **Monocrystal-line PV** | 0.095 | 0.15 | 0.06 |
| **Amorphous PV** | 0.071 | 0.43 | 0.18 |

**Table I. - Decrease in efficiency (in %), during a day in Doha, due to increase in dust accumulation, temperature or Relative Humidity for Mono-crystalline and Amorphous Panels [9]**

## 4. Proposed Solutions

- High Temperature

Phase change material (PCM)

This system was named PV–PCM or PV/PCM, a hybrid technology integrating a PV panel and a PCM into a single module to achieve higher module solar conversion.[6]

The PCM reduces the PV temperature thereby increasing its efficiency. Compared to PV using natural or forced air circulation for cooling, PV-PCM module has the advantage of having a smaller module size and offer better integration possibilities on building envelopes. However, the PV–PCM system is still in the infancy stages.[6]

This study was conducted outdoors at the Faculty of Engineering in the University of Syiah Kuala. Three PV panels were used: one of them served as reference, while the second one used paraffin wax as a phase change material (PV-PCM1), and the third one used beeswax as a phase change material (PV-PCM2) Fig3.[6]

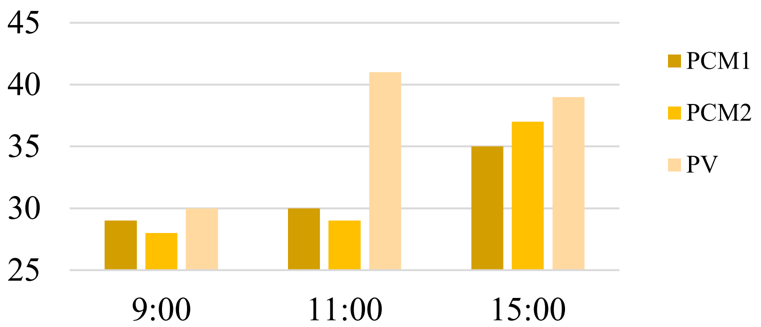


**Fig.3: Average temperature at the front surface of the PV,PV-PCM1 and PV- PCM2. paraffin wax (PCM1) bees wax (PCM2).[5]**

- Passive Cooling and Active Cooling

The Active Cooling uses energy from the PV solar modules or the external energy source. Such as fans systems that use fans or other means to create airflow and pumps. While, the Passive Cooling is a natural technique such as air ducts, the water tank, and Fins, PV cooling could limit the temperature loss to less than 3%. However, these mechanisms are affected by various variable factors. It was found that different fin sizes have three different effects where larger fins have a greater effect than the smaller ones.

Another mechanism is using air ducts attached to the back of the PV panels. This technique showed more than 10°C reduction in the panel temperature. Moreover, the water tank below the PV panels could be used to decrease the temperature and resulted in a 12% increase in energy yield. The main disadvantage is that it's heavy weight.

Another way to drop the temperature is flowing water on the top of the surface this solution resulted in an approximately 8-9% increase in energy yield Fig4. The disadvantage of the last two solutions is significant water use, which is a challenge in dry Saudi Arabia conditions. [5]

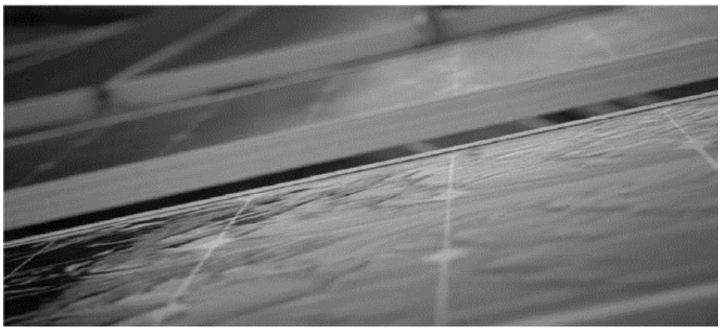

**Fig.4: Close-up of the film flowing water at surface.[7]**

- Dust & Humidity

Mechanical removal of dust removes the dust by brushing. Saudi Aramco's Research and Development Center (R&DC) produced a low-cost, competitive technology to mitigate the impact of dust on solar panels. The Robotic Dust Mitigation (RDM) project began in 2014 Fig5.

**Fig.5: The Robotic Dust Mitigation (RDM) with silicon brush to clean the solar arrays [11]**

The version three of the prototype mechanic uses a robotic mechanism with silicon brushes to clean the solar arrays. In term of advantages, the silicon rubber foam, a new type of brush, significantly reduces the cost of the brush and provides highly effective, non-abrasive cleaning.[11]

A smart Coating for Self-Cleaning Application nanofilm covered with self-cleaning; Super-hydrophilicity film the popular super hydrophilicity film is $TiO_2$ and ZnO Microstructures which has hydrophilicity and photocatalytic activity because of the hydrophilicity, the rainwater will diffuse to the whole surface instead of getting together and rinse the dust. This self-cleaning method cannot be used in a solar cell array in Saudi Arabia because it worked mostly in a desert region with seldom rain.

The super-hydrophobic film, superhydrophobic surfaces such as the leaves of the lotus plant show surface strongly repels water and extremely low wettability. The nanostructures of this surface can enhance the contact angle (CA) to higher than 150°C, so the water droplets that hit the surface would quickly roll off, carrying dust and other particles with them.[8]

## 5. Conclusion

- The work of solar cells in harsh conditions caused a significant reduction in the efficiency of solar cells.
- The solutions in this paper are some of the propose possible solutions which can increase the efficiency between 10 to 16%.
- The result of solutions depends on a natural factor. By increasing the wind velocity, more heat can be removed from the PV cell surface. On the contrary, wind leads to accumulated dust on the cell surface.

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