

# The heat recovery with heat transfer methods from solar photovoltaic systems

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**Abstract.** Although there are many fluctuations in energy prices, they seems like rising day by day. Thus energy recovery systems have increasingly trend. Photovoltaic systems converts solar radiation directly into electrical energy thanks to semiconductors. But due to the nature of semiconductors, whole of solar energy cannot turn into electrical energy and the remaining energy turns into waste heat. The aim of this research is evaluate this waste heat energy by air cooling system. So, the energy efficiency of the system will be increased using appropriate heat transfer technologies such as fin, turbulator etc.

## 1. Introduction

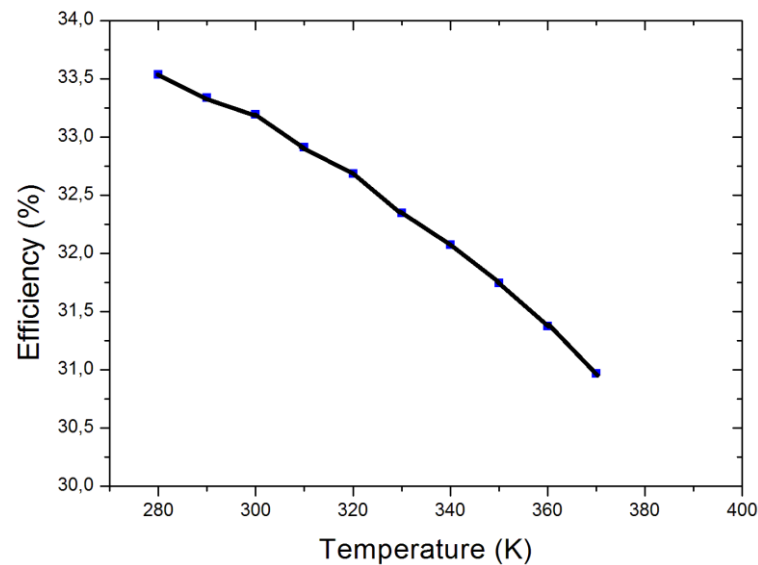
Since the humankind began to show his presence in the earth, every newborn has brought an energy burden and this burden is rising day by day [1]. Both growing world population and rising energy demand were caused an insistent uptrend. This increase in energy demand is providing with fossils as much as possible. However the global warming truth that can't be repaired has caused a prejudice to the fossils. For this reason, various government and non-governmental organizations welcomes to replace the fossils with renewables.

Solar energy has the highest energy density in renewables and has a limitless energy[2]. Solar energy source as well as being directly a source, the trigger of renewable resources such as wind energy. There are many areas in which the solar energy is used. These can mainly be divided as thermal and photovoltaic. Photovoltaic systems produced with using 4A group element of the periodic table. While scientific studies on this topic continues, theoretically efficiency reached 45% s by German researchers at the Fraunhofer Institute.

Industrial photovoltaic cells are used today with large scales. However, the efficiency obtained theoretically is impossible to achieve in practice. The efficiency of the cells used in solar power plants are only around 17%.[3] There are many reasons underlying this value. The subject of this research is cell temperature that one of the reasons of reducing the cell efficiency. The photovoltaic cell temperature rises because of wavelength of the incident photons' being less or more than remove an electron from silicon element.

When the photovoltaic cell manufacturers determining the specifications of the product, the ideal conditions are considered. When it is going out of this ideal conditions, it is impossible that reach this values given with products data sheet. With the increasing photovoltaic cell temperature, the cell efficiency drops 0.4% with 1°C temperature rising[4]. To prevent this decline the surface temperature of photovoltaics must be about 25°C which is optimum value.





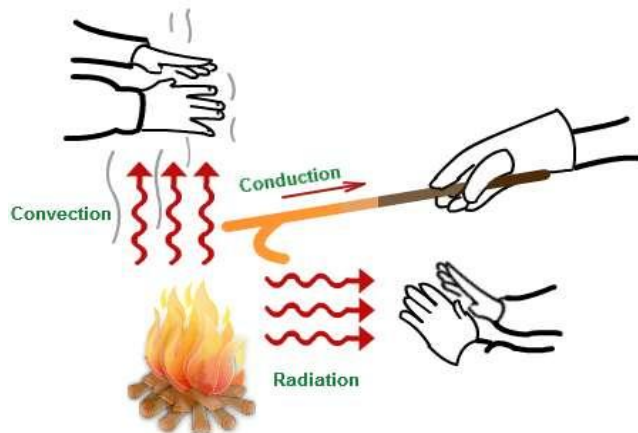
2. **Figure 1:** The temperature dependence of the photovoltaic efficiency.[5]

It is possible to use this surface temperature rising for contribute to photovoltaic cell efficiency.[6] Both for keep the temperature at an optimal level and for use the waste heat for benefit, the heat transfer methods used in engineering will be used as a practical way. The optimum one of these methods will be determined and energy that occurred waste heat recovery period will be recommended for various industrial applications.

## 2. Heat Transfer

Heat transfer is one of the subjects of scientific activity, gained importance with the progress of the industry. The laws of nature provides the perfect functioning for the heat transfer mechanism. This heat transfer mechanisms actually working even in the human body. Human skin and lung can be example to heat transfer device. [7]

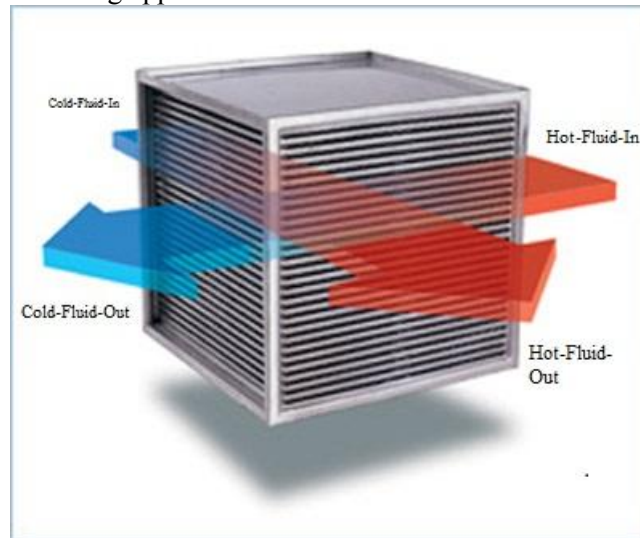
There are three types of heat transfer mechanisms; radiation, convection and conduction. For example to these mechanisms; solar energy is transferred to the world with radiation, human skin balances temperature with convection, a bar conducts heat from heated end to the other end with conduction. This heat transfer mechanisms mostly used in industry for heating, cooling and keep the thermal balance.



**Figure 1:** Heat transfer mechanisms.[7]

## 3. Heat Recovery

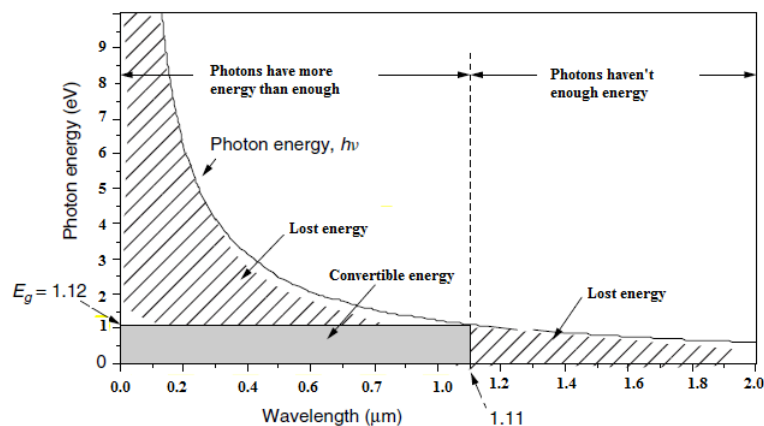
Heat recovery issues are available in every plants both large and small scales. According to the energy conversation, when the cooling fluid cool the system it will gain energy with a certain amount. In such cases if the heat releases into the environment, it will create an environmental pollution. In order to prevent this pollution and to improve the overall efficiency of the system, heat recovery unit are designed, these systems are often installed with a heat exchanger. With this heat exchangers, the energy is only to be transferred to the cold from the hot fluid without mixing[7]. While the hot fluid leaving the heat, the other one is heated for using energy in another cycle. The recovered heat from such systems mainly use in heating applications.



**Figure 2:** Heat exchanger.[8]

#### 4. Waste Heat in Photovoltaics

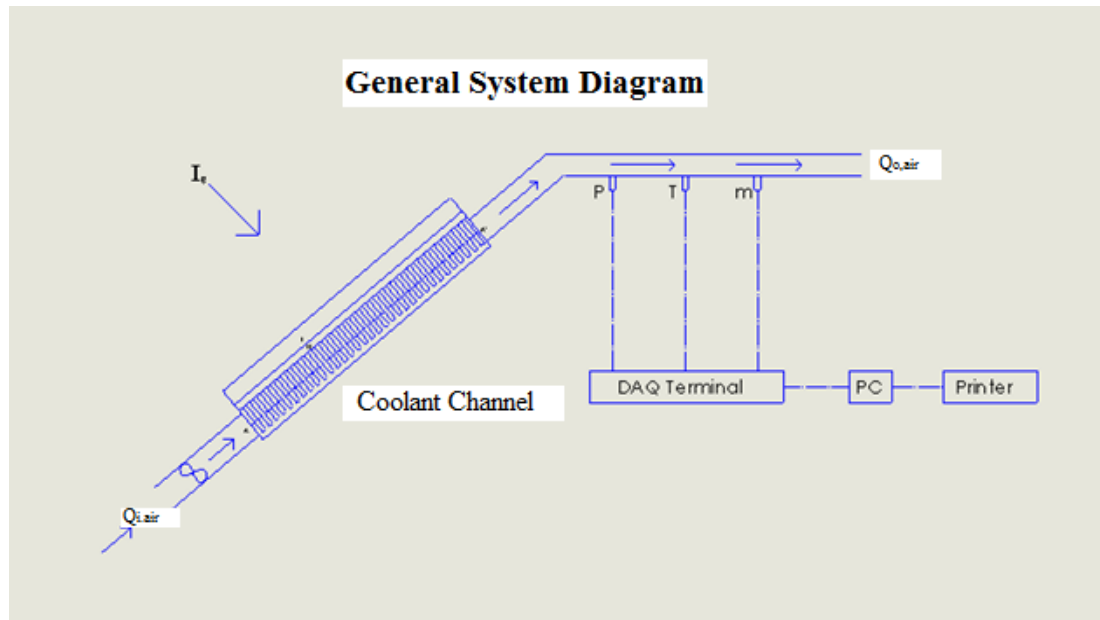
Semiconductor materials are 4A group elements of periodic table that used for photovoltaic cell production. In the solar system the most commonly used semiconductor material is silicon which is a ceramic material. Silicon has 14 electrons and valence electron number is 4. The band gap energy of silicon is 1.12 eV.[9]. When a photon with higher energy is absorbed by the cell, the electron will be excited and the remained energy will occur heat. Similarly if a photon with smaller energy is absorbed by the cell, the energy of photon will be directly turned into heat. This absorbed heat causes irregularities by increasing cell temperature. Thus cell efficiency drops dramatically. So the heat remained in the system will create a negative situation.



**Figure 3:** Photons with wavelengths above or shorter than needed to excite an electron.[9]

## 5. Results and Findings

It is known that the high surface temperature caused by solar radiation drops system efficiency drastically [10]. To prevent this decrease and waste heat recovery a secondary system used.



**Figure 4:** Designed heat recovery system.

In such systems, there are two types of efficiency [11]. Electrical and thermal efficiencies vary depending on operating conditions. System cooling is done by means of a working fluid and heat transfer calculations made to use waste heat.

$$Nu = C \times Re^m \times Pr^n \quad (1)$$

$$Q = h \times A_s \times \Delta T \quad (2)$$

The heat transfer coefficient of the system is determined in this equality and is written into the general heat transfer equation.

$$\dot{Q}_w = \dot{m} \times c_p \times \Delta T \quad (3)$$

With the help of general heat transfer equation, on July climate conditions with considering that the average surface temperature of our system is 45°C, it is calculated that every 0.1 °C increase in fluid temperature provides about 4.85W power gain in thermal efficiency. At the same time it helps increase electrical efficiency.

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