Solar-Thermal Energy: The Solution to the Energy Storage Problem in Industries

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Abstract— Renewable energies, like solar energy, are stored in batteries for later use. These batteries supply electrical energy when production is not possible or stops, for example at nights or on cloudy days. However, these batteries are not enough to power industries for their optimal operation. Solar thermal energy is a good solution to address this issue. This type of energy is stored in form of heat and can be used to generate electrical energy when it is needed. The purpose of this paper is to show the solar-thermal system as a new way to store solar energy, its efficiency and why it is necessary for the industrial sector. The first part in this paper is related to the issue of solar energy in industry in areas where the sun is not present long enough. The second part explains the proposed solution to this problem: using a solar energy storage system through supercritical steam. Finally, reasons to support the use of solar thermal energy are provided. It is expected that this work can show an alternative to supply energy when the energy produced by the solar panels is not available and the energy delivered by the batteries is not enough.

Keywords: **solar thermal technologies, renewable energy storage, electrical energy**

Resumen— Las energías renovables, como la energía solar, se almacenan en baterías para su uso posterior. Estas baterías suministran energía eléctrica cuando la producción no es posible o se detiene, por ejemplo, en las noches largas o en días nublados. Sin embargo, estas baterías no son suficientes para alimentar a las industrias para su óptimo funcionamiento. La energía solar térmica es una buena solución para abordar este problema. Este tipo de energía se almacena en forma de calor y puede utilizarse para generar energía eléctrica cuando se necesita. El propósito de este trabajo es mostrar el sistema solar térmico como una nueva forma de almacenar energía solar, su eficiencia y por qué es necesario para el sector industrial. La primera parte del trabajo está relacionada con el problema de la energía solar en la industria en zonas donde el sol no está presente el tiempo suficiente. La segunda parte explica la solución propuesta a este problema utilizando un sistema de almacenamiento de energía solar a través de vapor supercrítico. Por último, se presentan las razones que apoyan el uso de la energía solar térmica. Se espera que este trabajo pueda mostrar una alternativa para suministrar energía cuando la energía producida por los paneles solares no está disponible y la energía suministrada por las baterías no es suficiente.

Palabras clave**: energía solar térmica, almacenamiento de energía renovable, energía eléctrica**

I. Introduction

The advance in the transformation of fossil fuel-dependent energy to renewable energy is growing, but there is still a serious problem with respect to storage. The renewable energy systems use batteries to store the energy they produce. In the case of solar energy systems solar farms do not produce enough energy on cloudy days or at night because they need sunlight, so batteries must provide this energy. However, they are not capable of supplying the amount needed all day or night long. Maybe, they would be able to do it if there were several of them, but it implies a great cost [1, par 2].

A solar-thermal system is the solution to the storage issue. This technology is capable of converting sunlight into heat energy that is stored through supercritical steam. This system is a good alternative to decrease fossil fuel use [2, p 2].

A solar thermal system helps improve the environment by addressing some of the targets of Sustainable Development Goals (SDG) [1, p 2]. The SDGs that this system helps achieve are:

SDG 7, Encourage affordable and clean energy: Thanks to this form of solar energy storage, natural resources such as fossil fuels will not be used to generate and produce work. This reduces pollution and increases sustainable and renewable employment [3, p 31].

SDG 13, Take urgent action to combat climate change and its impacts: Due to the elimination of fossil fuels, the environmental impact will be reduced because the energy production method is natural and has no pollution [3, p 49].

The purpose of this paper is to show the solar-thermal system as a new way to store solar energy, its efficiency and why it is necessary for the industrial sector. If the SDGs' targets are to be met, the industry needs new proposals to keep the economy moving without damaging the environment.

In order to achieve the objective stated above, this paper is organized in three parts. The first part is related to the issue of solar energy in industries in areas where the sun is not present long enough. The second part explains the proposed solution to this problem: using a solar energy storage system

through supercritical steam. Finally, reasons to support the use of solar thermal energy are provided. It is expected that this work can show an alternative to supply energy when the energy produced by the solar panels is not available and the energy delivered by the batteries is not enough.

II. The Energy Storage issue: batteries are not enough

Although renewable energies have been used for many years, industries keep growing and need a surplus amount of energy to supply them, so the collection of sustainable energy is insufficient. Although industries have tested different types of renewable energy storage, for example batteries, they are expensive and their duration is not as expected. In places where the sun does not shine for many hours on cloudy days or long nights, the solar panels and batteries do not operate properly due to lack of sunlight and energy, so it is important to find an alternative form to deliver energy when there are long periods without sunlight.

When the sun is not shining the solar panel systems are not able to produce energy, so batteries are responsible for supplying it. However, the batteries are enough for short duration storage, generally between one or two hours depending on the type of battery [1, p 2]. Therefore, the problem arises when it is necessary to spend long periods of time without sunlight and the batteries are not enough.

III. Solar thermal energy: advanced storage system

The proposed solution to solve the energy storage problem is a solar thermal energy system. It is a system which takes advantage of the concentration of the sunlight to generate heat, which is stored to be used when necessary.

This system consists of several parts to ensure its proper and efficient operation. These are discussed below.

A. Heliostats

First, it is important to describe the heliostats, shown in [4, Fig 1]. This instrument is used in the solar system to orient and focus sunlight along a fixed direction. A typical heliostat consists of a flat plane mirror and a curved parabolic mirror. A flat mirror is aligned parallel to the Earth's equatorial axis and moves slowly using an engine to redirect sunlight. The parabolic mirror concentrates the reflected sunlight onto the heliostats in a fixed direction as the Sun moves across the sky [5, par 1].

Standard heliostats usually have surface areas ranging from 40 to 60 square meters. The overall reflective surface is restricted to around 20 to 25 percent of the total land area. Normally, 70 percent of the solar beam that strikes the heliostats is directed towards the receiver [6, p 6].

Fig. 1. Heliostat Field [4]

B. Central Receiver Tower

This part of the system is a heat exchanger mounted on a tower. Many designs with different configurations and heat transport fluid have been developed and tested. Currently, the tower supporting the receiver can be made of steel or concrete. They must support a great weight and adapt to different winds [6, p 7]. The sunlight that is sent by the heliostats is concentrated approximately 600 to 1000 times, reaching temperatures higher than 800°C [7, p 26]. A heat transfer medium, also referred to as working fluid, housed within the receiver tower, absorbs the highly concentrated radiation reflected by the heliostats and converts it into thermal energy which is used to generate supercritical steam. This steam can be stored or utilized to drive a turbine. The reflected solar radiation impinges on tubes through which the working fluid passes and that are arranged on the outside of a cylinder. The solar radiation impinges on the interior of a cavity lined with flow passages through which the heated working fluid passes. Some of these heat transfer mediums can include fluids like water, oils, molten salts, and liquid sodium. This method can directly replace natural gas in a gas turbine. This application has an excellent efficiency, around 60%. [7, p 32].

Fig. 2. Central Tower Receivers for Solar Thermal Electricity [8]

C. Working fluid

As mentioned before, different types of fluids can be used for heat transmission by means of thermal fluids heaters [9. Fig 3], such as liquid salts, liquid sodium, one of the most

well-known, water, and oils. One of the fluids most used due to cost and efficiency considerations is oil.

Fig 3. Thermal fluids heaters [9]

D. Solar-Thermal energy system

Considering each component together [10, Fig 4], they make up the solar thermal energy system, working in the following way.

The heliostats direct the concentrated sun rays onto a receiver located within the central tower. The receiver absorbs this concentrated heat and significantly increases the temperature of a working fluid. This working fluid contains what is called solar thermal energy, which can be stored in the tubes through which it circulates, as they are highly insulated from the exterior. In the case of industries, this stored energy can be used to produce steam that will drive a turbine to perform work during the night.

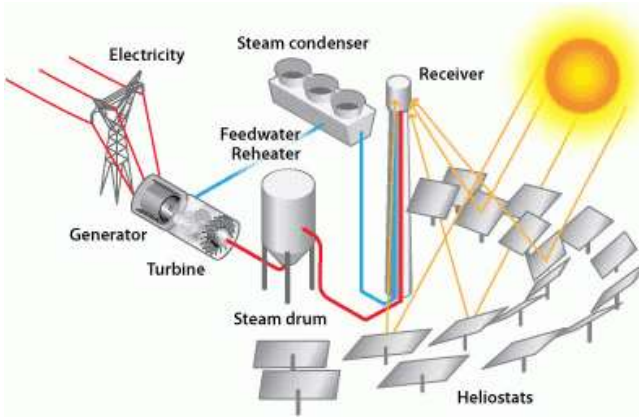

Fig. 4. Power Tower System Concentrating Solar-Thermal Power Basics. [10]

IV. Reasons for the use of solar thermal energy

The Solar Thermal System presents several advantages and disadvantages that need to be mentioned for its installation. In the first place, this system has great advantages like its efficiency, rentability, sustainability and ecological footprint. The main advantage that this system has is its practicality because the energy can be stored and used when it is necessary. Also, we can say that it is renewable energy because it does not use any fossil fuel or chemical like batteries. For this reason, solar thermal energy system does not contaminate the environment.

On the other hand, the business that requires this system needs a large place to install the heliostats, so they will need a great initial investment. Although the batteries of a conventional system take up less space, but their maintenance is much more expensive because they must be replaced every so often. As well as this, the thermal insulation is not perfect, there is heat losses in the process. This is because it is physically impossible to achieve 100% effective thermal insulation.

V. Conclusion

While the Solar Thermal System is a fairly sustainable system, it remains complex and demands a great initial investment for its implementation. Furthermore, its usage is not justified unless it is an industry that truly needs it, either to contribute to the environment in an eco-friendly manner or due to specific demands in the location where it is installed. In summary, this system provides a solution tailored for resource-intensive industries.

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