Augmenting **SOLAR POWER** Through **PHASE CHANGE** Materials

A solar dryer with thermal storage through PCMs would continuously operate 24/7 thereby eliminating the only drawback of solar drying as compared to fuel based drying while enhancing the advantages...

Solar energy should have been the most intuitive source of power to fuel the constantly increasing energy demands of a thriving human race. The biological demands for food, heat and light were being met for 3.4 billion years, but only in the past century humans were able to convert solar energy into the most sought after source of energy – 'electricity'. This development alone should have single-handedly catapulted our race in to the next phase of evolution, where energy becomes abundant and is no longer a constraint in the giant leaps of technology as visualized by so many of us today.

However, the idea of abundant usable energy through solar power had limitations, which were until a decade ago considered insurmountable. But as profusion of human ingenuity is only matched by that of abundance of sunlight, there are inventors, innovators and dedicated scientist working round the clock, around the world to make solar power usable, cheap and efficient.

Let's try to understand solar energy from the perspective of its classification, usability and limitations.

Classification of solar energy can be done under two broad categories:

- Direct solar energy is the form of energy which is directly utilised by the end source through direct contact and converted into heat or electricity. This includes biological phenomenon of photosynthesis, thermal heating, photovoltaic cells, etc.
- Derived solar energy entails the usage of converted solar energy without direct

contact with the energy source. For example, the food that we eat, fossil fuels, etc.

The current applications of solar energy fall under two categories: photo-electric applications and thermal applications.

Photo-electric applications: These applications convert solar radiations into electricity. Solar cells fall into this category, and are the most sought after devices currently for applications ranging from satellites to small calculators.

Thermal applications: These applications convert solar energy into thermal energy. Thermal energy has application in electricity generation, water heating, food drying, etc.

Certain limitations are present in all form of energy sources. With solar energy, to a great extent, limitations have stifled commercialisation potential. Some of the persistent ones are as follows:

- As abundant as the sunlight maybe, it's limited by day night cycle, location and season.Sunlight intensity varies, which causes thermal instability in certain heat specific applications.
- Generally, applications require specialised construction, special materials and have high manufacturing and maintenance cost.

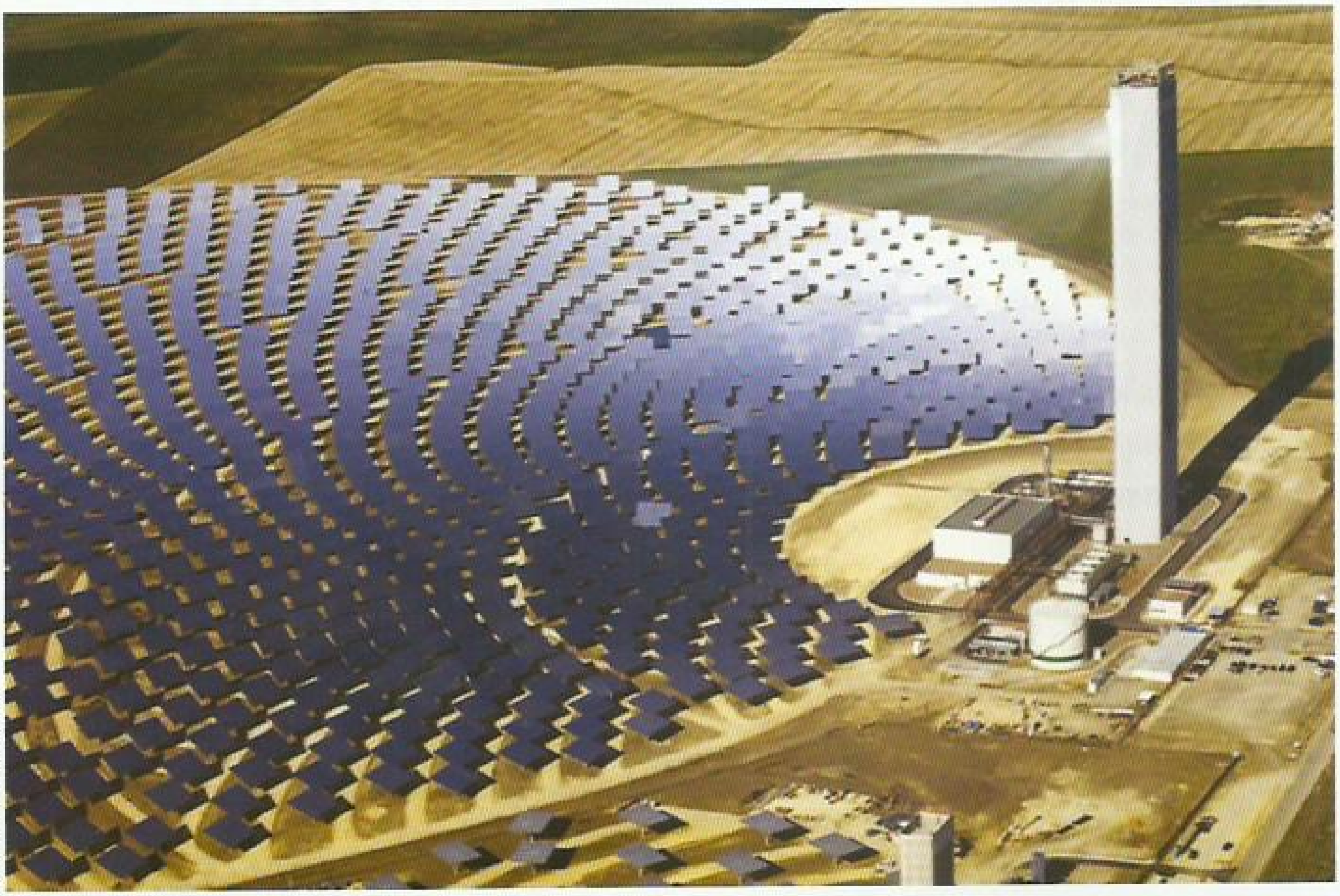
Solar drying provides much higher quality produce as compared to open sun drying and is cheaper and environment friendly as compared to fuel based drying. This has the potential to alter the landscape of food drying by replacing fuel based drying...

The primary focus of this article is utilisation of 'direct solar energy' and how through Phase Change Materials (PCM) we have finally surmounted the limitations for different applications.

Phase Change Materials (PCM) technology offers the scope of developing and deploying specific solar energy applications that are cheap, easy-to-use, efficient, dependable, and offer functionalities previously unimagined. Let's look at this class of materials that offer to change the solar energy paradigm forever. Phase Change Materials (PCMs) are innovative materials which offer the possibility to maintain desired temperatures with precision. They can store and release large amounts of thermal energy at constant temperature. They can be utilised in various solar power applications because of these properties.

Solar Water Heater: Solar water heating (SWH) is the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating systems comprise various technologies that are used worldwide increasingly. But due to certain limitations such as freezing, overheating, low efficiency and day night cycling, the commercialisation has been slow.

PCM has the potential to solve these limitations through their property of maintaining specific temperature range over a large period of time. For instance, in most households heated water requirements peak



© Credit: GreenMPs

A sea of mirrors directs a powerful beam of light toward a solar power tower...

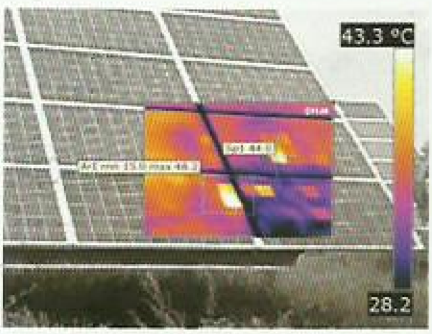
in early morning. Whereas, heated water supply is maximum around the afternoon. This imbalance of demand and supply can be solved by proper application of PCMs as buffer for maintaining temperature around the clock in the water heater.

Solar water heaters being used in township in Northern China...

Food drying: Drying is an essential process in the preservation of agricultural products. The dried produce also fetches significantly higher prices than fresh produce. Most food products, especially fruits and vegetables require hot air in the temperature range of 40 to 60°C for safe drying. Solar drying provides much higher quality produce as compared to open sun drying and is cheaper and environment friendly as compared to fuel based drying. However, the day time only operation of solar drying has been a limiting factor in wider adoption. A solar dryer with thermal storage through PCMs would continuously operate 24/7 thereby eliminating the only drawback of solar drying as compared to fuel based drying while enhancing the advantages. This has the potential to alter the landscape of food drying by replacing fuel based drying for industrial food processing units and improving the value proposition of solar drying for commercial and domestic drying units.

Advantages of phase change materials based solar dryers over conventional solar dryers:

- Higher system productivity due to 24/7 drying operation and higher collector efficiency leading to reduced capital cost per unit of dried product.
- Shorter drying duration resulting in reduced food wastage enabling higher farm productivity.
- Better quality dried product with higher nutritional value, aroma & taste due to controlled drying with no temperature fluctuations.
- Countering in all the factors we can easily see the potential for lower power consumption and cost reduction.



Temperature profile of a solar cell on a hot summer day...

'Solar panel temperature is one of the important factors that affect how much electricity your panels will produce. It's ironic – but the more sunshine you get, the hotter the panels get and this in turn counteracts the benefit of the sun. In some cases the heat factor can reduce your output by 10% to 25% depending on your specific location.'

Let's look at this problem in detail and try to understand how PCMs can solve it.

The solar panel temperature affects the maximum power output directly. As solar panel temperature increases, its output current increases exponentially while the voltage output is reduced linearly.

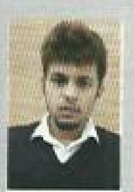
Since power is equal to voltage times current, this property means that the warmer the solar panel the less power it can produce.

Every solar cell comes with a 'Temperature Coefficient P_{max}.' For example, the temperature coefficient of monocrystalline solar panel is –0.48%. In most practical cases, in countries like India, during summers the temperature of panels may exceed 45° C for better part of the year.

Due to the constraints of 'Temperature Coefficient P_{max}', the efficiency of the solar panels drops 15 to 20% on an average.

Phase change materials due to their ability of maintaining precise temperatures for long durations, can be utilised. For instance, a PCM with operational range of 23 to 25°C can provide a stable temperature for the panels even in extreme weather conditions and thereby maintain the efficiency of the panel. ■

Anirudh Batra
Associate- Business Development in PCM Division of Pluss Advanced Technologies



Vishnu Sasidharan
Business Development
Pluss Advanced Technologies