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Scope of Solar Energy Technology in Sustainable Growth and Development of Dairy Industries

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Abstract

The dairy industry is one of the fastest-growing industries in India. This industry provides huge employment to the rural youth and is the backbone of the rural economy. Different state governments are launching new projects to boost employment in this sector. The main barrier to the growth of milk industries is to meet the increasing demand for energy supply by a renewable and cost-effective energy source. The solution is the application of solar energy technologies. The use of solar energy in the dairy is generally found for hot water supply to the boiler and hot water generator for processing of milk/CIP cleaning. There is an urgent need to develop commercially viable solar-based refrigeration systems for such applications. The use of solar energy technologies has great scope for commercial use in dairy processing operations. It requires a little more attention from the scientists and the governments to speed up the growth and development in this sector.

Keywords: Dairy, Solar Energy, Milk, Renewable Energy

Introduction:

India is the world's no. 1 milk-producing country, with an output of 117 million tons in 2010 as reported by the National Dairy Development Board, and is second only to the European Union in production. Furthermore, milk production in India is growing at an annual rate of 4.5 %, far ahead of the global average of 1.35 %. With the increase in population and enhancement in lifestyle of people, demand for dairy and food products is increasing day by day. Nearly 15 % of the milk sold in the domestic market is processed into dairy products (baby foods, ice cream, whey powder, casein, sweetmeat, and milk albumin) and that requires heat (Pandagale et, al.,). Some 700-milk processing plants in the formal dairy sector require a huge amount of energy to run. Today, major electricity generation takes place at central power stations which utilize coal, oil, water, gas, fossil, and nuclear materials as primary fuel sources. They are not renewable, less efficient (65-75%), and expensive. The earth has limitations in regenerating these natural resources. Renewable energy is that energy which comes from the natural energy flows on earth. Unlike conventional forms of energy, renewable energy will not be exhausted. Renewable energy is also termed “green energy”, “clean energy”, “sustainable energy” and “alternative energy” (Date, 2010).

To produce energy, we are using Petroleum (39%), Natural gas (23%), Coal (23%), Nuclear (8%), and Renewable energy sources (8%) in different proportions. Different types of renewable energy are Solar energy (1%); Wind energy (0.5%); Biomass energy (43%); Hydropower (50%); and Geothermal (5%). The Sun is a reliable, non-polluting, and inexhaustible source of energy, which

overcomes all the above shortfalls; it will never get exhausted. India lies in the sunny regions of the world. As a concern to the Indian scenario, we receive 5 to 7 kWh/m2 of solar energy for 300 to 330 days in a year, which is sufficient to set up 20 MW solar power plants per square kilometer of land area (Bee, 2010). The highest annual radiation energy is received in western Rajasthan while the north-eastern region of the country receives the lowest annual radiation.

We can use solar energy in dairy operations like cooling, heating, lighting, pumping, drying, electrifying, steam generation, etc. To use this technology cost-effectively it is essential to understand the resource, component, and system aspects of the PV (photovoltaic) plant and to have a load served by efficient end-use equipment with a high-value service (Jenkins, 1995).

Material and Methods:

Solar radiation is available in abundance in the country and therefore this is a quite feasible solution. Considered from the point of view of cleanliness, which is a vital requirement in the dairy industry, the application of solar energy could be a big advantage for this industry. In this study, we will explain the different devices and technologies that have versatile applications in various processes of the dairy industry.

Photovoltaic Plants: Solar energy can be transformed into electricity by using photovoltaic (PV) devices. PV devices convert light energy into electrical energy through the photoelectric effect, as French physicist Edmond Becquerel discovered as early as 1839. Individual PV cells (or so-called solar cells) are electricity-producing devices made of semiconductor materials. Among many types of solar cell material, silicon wafers, polycrystalline thin films, and single-crystalline thin films represent the typical solar panel material (Broos, 1996). Single-crystalline thin film using multi-junction solar cell structure is the most efficient one between 15% and 20%. The latest development for the single-crystalline film using a multi-junction solar cell structure resulted in a world-record conversion efficiency of 41% in an optical concentrator solar cell produced by Boeing-Spectrolab (Fthenakis and Alsema, 2006). This PV device can used for storing solar energy and utilized in the dairy plant for different unit operations heating of water and air, pasteurization, pumping, and refrigeration plant.

Solar Ponds: A solar pond is a body of water that collects and stores solar energy. Solar energy will warm a body of water (that is exposed to the sun). Water warmed by the sun expands and rises as it becomes less dense. Once it reaches the surface, the water loses its heat unless some method is used to trap it. The design of solar ponds reduces this energy loss to store the heat collected by the pond. They can operate in almost any climate. A 6000 m2 solar pond was constructed at Bhuj in India on the premises of a milk processing dairy plant. The pond attained a maximum temperature of 99.88oC. Hot water supply to the dairy started in September 1993. The total cost of construction of the Bhuj Solar Pond was US$90,000 (1997 prices), including heat exchanger and piping, etc., corresponding to a unit cost of US $15 (Kumar and Kishore, 1999).

Solar Cooker: A solar cooker, or solar oven, is a device that uses the energy of sunlight to heat food or drink to cook it or sterilize it. The vast majority of the solar cookers presently in use are relatively cheap, low-tech devices. A heat pump is a device that transfers thermal energy from a source to a sink that is at a higher temperature than the source. Thus, heat pumps move thermal energy in a direction that is opposite to the direction of spontaneous heat flow (Lorentze, 1993).

Discussion:

The dairy industry ranks fifth among the most energy-intensive industries after oil, chemical, pulp and paper mill, and iron and steel making industries. The energy requirement in the refrigeration sector plays a very significant role in the overall energy requirements of a modern milk plant, often constituting above 40 percent of the total electric power consumption. This makes research on the reduction of energy required for refrigerating the dairy industries interesting and challenging. Solar energy has various applications in different operations of the dairy industry like hot water supply to boilers, hot water generators for processing of milk or for CIP cleaning. There is an urgent need to develop commercially viable solar based refrigeration system for such applications. In this direction, much has been done to design and develop energy efficient solar based refrigeration systems for milk cooling at village level society, solar-based vapour absorption systems for milk and milk-related cooling operations, and air conditioning systems for cold stores and packaging rooms for milk and milk products, to reduce peak load penalty. We can discuss them separately in detail.

A. Solar-based Refrigeration plant: The system is intended for refrigeration at 5°C in hot climates, and is composed of a medium temperature collector, single effect water ammonia absorption chiller, and cold storage. The peculiarity of the configuration is the high-temperature difference between the chilled refrigerant temperature, about –5 °C (in consequence of using ice storage), and the condenser temperature (ambient temperature, which could exceed 35°C). In these conditions, the absorption chiller must be driven by a medium-temperature heat source (i.e. parabolic trough collector). Moreover, the selected chiller is direct air cooled and has the main advantage of having no water consumption, low maintenance work, and no legionella problems (Ayadi, et.al,. 2008). It is used for the chilling of milk in a bulk milk cooler. It is also used to run a vapour absorption system for the refrigeration plant and maintain the cooling system. A power stored in a battery at used for the running of an air conditioner. (Ishaku, 1990)

B. Solar Water Heating: The solar water heating industry constitutes a majority of solar thermal applications in both domestic and industrial sectors. They are considered the most cost-effective alternatives among all the solar thermal technologies currently available. SWH systems are now in the commercialized stage and very mature in many countries in the world. Since 1980, the utilization of SWHs has increased with a 30% annual growth rate (Langniss and David, 2004). SWHs and solar space heating systems. Solar thermal can be applied in milk at medium temperature for washing, cleaning, sterilizing, pasteurizing, drying, cooking, and other operations. (Benz, et.al,. 1999)

160 m2 unit of ARUN™ was designed and installed by Clique Developments Ltd. for pasteurization of milk at Mahanand Dairy, Latur. As a result, the dairy does not need to fire the boiler on sunny days. Mahanand Dairy (Maharashtra) has been using a solar water heating system (25000 LPD) since 1990, which was commissioned with the assistance of the Department of Non- Convectional Energy Source and the Maharashtra Energy Development Agency. The water is heated from 30°C (ambient temp.) to 85 °C with the help of a solar water heating system, which is used for the boiler as feed water, etc. This results in to saving of 200 – 250 lit furnace oil per day, with monetary savings of about Rs. 7 lakh per annum (Desai et. al., 2013).

C. Solar heating for Steam generation: Low-temperature steam is extensively used in sterilization processes and desalination evaporator supplies. Parabolic trough collectors (PTCs) are highly efficient

collectors commonly used in high-temperature applications to generate steam. PTCs use 3 concepts to generate steam (Kalogirou, et.al,. 1997) the steamflash, direct or in situ and the unfired-boiler. In the steam-flash method, pressurized hot water is flashed in a separate vessel to generate steam. (Kreetz, et.al,.2000). Oil fired Boiler is feed with normal water for the routine operation. On installation of solar water heater, the feed water of the Boiler raised to 67 °C from 27 °C. On inspection and verification it is found that an average 3000 lit of feed water is being utilized per day. Due to this the thermal load saved to the extent of 120000 kCal/day which amounts to 4774.20 liters of Furnace oil saved per annum. The Total investment was Rs. 3.82 Lakhs and the cost savings was Rs.1.57 Lakhs in the same year (Bee, 2010).

D. Solar Drying: Solar drying and dehydration systems use solar irradiance either as the sole power supply to heat the air or as a supplementary energy source. They are categorized into 2 main groups: high and low-temperature dryers. Almost all high-temperature dryers are currently heated by fossil fuels or electricity but low-temperature dryers can use either fossil fuels or solar energy. Low-temperature solar thermal energy is ideal for use in preheating processes as well (Ekechukwu and Norton, 1999). Drying of milk powder, due to the high constant energy demand, is another important consumer. In the production, milk and whey are spray-dried in huge towers with air, which is heated from 120180oC. The drying process can have a running time of up to about 8000 hours per annum (Benz, et.al.1998). Solar energy is used mainly for the preheating of air supplied to the air heater. It increases the temperature of air from 35°C to 80°C by use of solar energy. It reduces the load of air heater, cost saving, less pollution of air.

E. Solar energy for pumping: Dairy Fluids Solar pumping is one of the most important applications of PV in India. An SPV pump is a DC or AC, surface-mounted submersible or floating pump that runs on power from an SPV array. It may be used to run a hot water pump, chill water pump, milk pump, and CIP (cleaning in place) pump. The array is mounted on a suitable structure and placed in a shadow-free open space with its modules facing south and inclined at local latitude. A typical SPV pumping system consists of an SPV array of 200–3000 W capacity, mounted on a tracking/non-tracking type of structure. The array is connected to a DC or AC pump of matching capacity. SPV pumps are used to draw water for irrigation as well as for drinking. The SPV array converts sunlight into electricity and delivers it to run the motor and pump. The water can be stored in tanks for use during non-sunny hours, if necessary (Date, 2010).

F. Solar energy to lightening Dairy offices and premises: SPV lighting systems are becoming popular in both the rural and urban areas of the country. In rural areas, SPV lighting systems are being used in the form of portable lanterns, home lighting systems with one or more fixed lamps, and street lighting systems. A solar street-lighting system (SLS) is an outdoor lighting unit used to illuminate a street or an open area usually in a dairy, garden, or road approach to a dairy and chilling center. A CFL (compact fluorescent lamp) is fixed inside a luminary that is mounted on a pole. The PV module is placed at the top of the pole, and a battery is placed in a box at the base of the pole. The module is mounted facing south, so that it receives solar radiation throughout the day, without any shadow falling on it. A typical street-lighting system consists of a PV module of 74 W capacities, a flooded lead–acid battery of 12 V, 75 capacities, and a CFL of 11 W rating. This system is designed to operate from dusk to dawn (that is, throughout the night). The CFL automatically lights up when the surroundings become dark and switches off around sunrise time. The cost of a SLS is about Rs 19 000 (Date, 2010).

G. Solar Energy for Electrifying (Electric Fences): Solar Electric fences are widely used in dairy to prevent stock or predators from entering or leaving an enclosed field. These fences usually have one or two 'live' wires that are maintained at about 500 volts DC. These give a painful, but harmless shock to any animal that touches them. This is generally sufficient to prevent stock from pushing them over. These fences are also used in wildlife enclosures and secure areas. They require a high voltage but very little current and they are often located in remote areas where the cost of electric power is high. These requirements can be met by a photovoltaic system involving solar cells, a power conditioner, and a battery. (Carr, et.al,. 1999).

Conclusion:

Problems associated with conventional energy supply and use are related not only to global warming but also to other environmental impacts such as air pollution, acid precipitation, ozone depletion, forest destruction, and emission of radioactive substances. To overcome those problems the use of renewable energy has great scope for its commercial use in dairy processing operations. It is estimated that renewable energy could contribute to at least half of all electric power in each of the large economies by 2050 (Patel and Upadhyay, 2016). Today, much evidence exists which suggests the future of our planet and the generations to come will be negatively affected if human beings keep degrading the environment. Renewable energy is one of the most promising and important opportunities for value-added products in dairying (Rathore 2010). The type of renewable energy technology used in dairying depends on the type of energy required, access to renewable energy sources, and the design of the dairy facilities and processes. Solar energy can easily be integrated into the dairy industry for cooling and heating purposes, bio-energy for process heat for dairy operations, etc, and this energy can generate power at a competitive cost. Adoption of renewable energy sources in dairying can help in reducing hydrocarbon emissions. India has enough sunshine that favours solar energy investments. Investment in solar energy technology should be encouraged as the merits include: a pollution-free environment, free renewable energy sources, high reliability, and low maintenance costs.

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