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Strengthening of Infrastructure in Dairy Industry through the Application of Solar Energy Technologies

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ABSTRACT

Dairy industry is one of the fastest growing industries in India. This industry is providing a huge employment to the rural youth and is backbone of rural economy. Different state governments are launching new projects to boost employment in this sector. The main barrier for the growth of milk industries is to meet the increasing demand of energy supply by a reliable and the cost-effective energy source. Traditional electric grid supply is very irregular and costly and the alternative diesel set engines again very costly and causing air and noise pollution. The specific energy consumption is near about to 1.62 kjs/liter. The smart use of the solar PV and solar thermal energy in dairy industry will not only lead the creation of facilities of milk preservation and processing in the remotest area of the country but also contribute in cost effective manner. In this direction, much has been done to design and develop energy efficient solar based refrigeration system for milk cooling at village procurement centre, solar based vapour absorption system for milk and milk related cooling operations and air conditioning system for cold stores and packaging rooms for milk and milk products, to reduce peak load penalty. The smart Use of solar energy technologies has great scope for its commercial use in the dairy processing operations.

Keywords : Dairy Industry, Solar PV, Solar energy, non-conventional energy source.

I. INTRODUCTION

India's estimated milk production in 2015-16 is 155 million tonnes which is about 6.28% higher than the last year. Estimated per capita availability in 2015-16 was 337 gm/day and increase of 4.7% over the previous year. The dairy cooperatively collectively procure 15.58 million tons of milk registering a growth of around 12 % as compared to last year. Liquid milk marketing by the cooperatives stood 12.08 million tons with an increase of around 2.73 % over the previous year. The country is the world's largest milk producer, accounting for more than 13% of worlds total milk production. It is the world's largest consumer of dairy products, consuming almost 100% of its own milk production. Dairy products are a major source of cheap and nutritious food to millions of people in India and the only acceptable source of animal protein for large vegetarian segment of Indian population, particularly among the landless, small and marginal farmers and women. Dairying has been considered as one of the activities aimed at alleviating the poverty and unemployment especially in the rural areas in the rain-fed and drought-prone regions. In India, about three-fourth of the population live in rural areas and about 38% of them are poor. According to the National Sample Survey of 1993-94, livestock sector produces regular employment to about 9.8 million persons in principal status and 8.6 million in subsidiary status, which constitute about 5% of the total work force. The progress in this sector will result in a more balanced development of the rural economy.

Dairy industry is one of the highest employments generating sector especially in the rural India. The 1% increase in the growth of dairy industry will lead to generate 1.5 lakh employments in this sector. Therefore this sector needs to be given full attention and focus. Dairy industry is one of the highest energy consuming sectors. The energy is consumed in dairy sector in various forms like heating, cooling, pumping etc. Milk is an important food source that developing countries rely on, but it spoils quickly. Chilling milk within four hours of milking cows reduces the chances of spoilage, but that requires refrigeration units and most importantly an uninterrupted power supply. Solar powered milk cooling tank were developed to solve the issue of chilling milk as close as possible to the source for small, remote farms. With no electricity infrastructure and output too low to support on-farm diesel generation, producers needed a solution for milk refrigeration as early as possible in the process. The progress in this sector will result in a more balanced development of the rural economy.

Milk procurement centres

Some 70 million rural households are engaged in milk production, the majority of them being small and marginal farmers and landless. The system of milk collection in sparsely populated regions of developing countries is based on milk collection centers. They are generally located at village level. The farmers who often own only a few cows bring their milk to the centre where it is measured, quality tested and cooled. Milk tankers pick up the milk every two days. Presently dairy industry has created procurement centre near the processing units. So that milk can be bring to the processing units within 3 hours from the production place. They have started procuring from the farthest area provided the location has assured the power supply. Cooperatives currently procure about 16 percent of the national marketable surplus covering around 21 percent of the country's villages and 18 percent of the rural milk producing households. It will be desirable for the cooperative sector to achieve a procurement share of at least 20 percent of the marketable milk surplus by 2016-17 so that it retains an overall 50 percent share of the marketable surplus handled by the organized sector. Therefore, strengthening of the dairy cooperatives has been envisaged. Proposed activities to be financed would include (sources NDP 1):

1. Mobilization and institution building of small holder milk producers (30 per cent women and 17 per cent SC/ST members in their member DCS)through expansion of selected existing milk unions who in turn will strengthen selected existing village dairy cooperatives societies (DCSs) and organize new DCSs in the uncovered villages.
2. Training and capacity building of milk producers and other functionaries; and
3. Investments in village level infrastructure for milk collection and bulking such as milk cans, Bulk milk coolers for a cluster of villages, associated weighing and testing equipment, and related IT equipment.

Milk Processing Units

The processing plant includes the different operations, such as production of pasteurised milk, cheese, khoya, ice-cream, paneer etc. A typical milk processing plant uses raw milk from a collecting station / procurement centre through trucks and is stored in a large tank at the industry. It is then clarified that homogenised and mount to pasteurisation. Milk is chilled to 40 ^{0}C then supplies to the packaging unit. With increase in population, and enhancement in lifestyle of people, demand for the 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, and paneer and milk albumin) and that requires heat (Pandagale et, al.,). There are some 700-milk processing plants in the formal dairy sector that require a huge amount of energy to run.

Energy demand in dairy industry

Due to irregular and limited electrification in rural areas, 85 percent of dairy farms do not have access to refrigerated storage and transportation. This deficiency in the distribution chain results in less than half of the milk produced reaching dairy processors. Of the milk that is processed, up to 30 percent of it may spoil without appropriate cold-storage options. Consequently, many dairy farmers and processors unnecessarily may lose significant earning potential from their operations.

The heating of water accounts for more than 30% of the total energy consumption in Dairy Industry of India. While most of the hot water requirements are at the dairy processing plant, there is also a minimal need for hot water to clean containers at the collection and chilling centre. The strengthening of milk procurement system through mobilisation and institution of buildings for milk producers, their training to produce high quality milk, maintenance of milk procurement centres including their lightening and fencing and the expansion of infrastructure and equipment all need a relatively cheap and reliable energy grid supply.

Thermal energy is used for various processes, such as pasteurization and washing. At the dairy processing plant, a central boiler produces steam which is then used to heat water. Today, major electricity generation takes place at central power stations which utilize coal, oil, water, gas or fossil nuclear materials as primary fuel sources. They are not renewable-limited-like every one earth has limitation to regenerate, less efficient (65-75%) and expensive. Renewable energy is that energy which comes from the natural energy flows on earth. Unlike conventional forms of energy, renewable energy will not get exhausted. Renewable energy is also termed as "green energy", "clean energy", "sustainable energy" and "alternative energy" **(Date, 2010).**

Renewable energy options

Dairies worldwide are adopting green technologies to meet their energy needs. Indian dairies must catch up soon. Today there are several innovative and efficient technologies available in the renewable energy domain that can be used for catering to various energy needs of the dairy industry. Harnessing solar energy for various heat-based applications like generating steam, hot water, etc has become more viable with time. For production of energy we are using Petroleum (39%), Natural gas (23%), Coal (23%), Nuclear (8%), Renewable energy sources (8%) in different proportion. Different types of renewable energy are: Solar energy (1%); Wind energy (0.5%); Biomass energy (43%); Hydropower (50%); Geothermal (5%). The Sun is a reliable, non-polluting and inexhaustible source of energy, which overcomes of all above shortfalls; it will never get exhausted ever. India lies in the sunny regions of the world. As concern to 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 kilo meter 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 operation like cooling, heating, lighting, pumping, drying, electrifying, steam generation etc. In order to use this technology in a cost-effective manner it is essential to understand the resource, the component and system aspects of the PV (photovoltaic) plant and also to have a load served by efficient end-use equipment with a high-value service **(Jenkins, 1995).** Solar thermal and Solar PV technology can contribute together for creation of infrastructure for safe preservation and transportation of milk from remote area to processing unit. These technologies can also play cost effective and ensures the way to meet the energy requirements. The PV- solar Milk Cooling tank is a transportable, ready for use collection centre which avoids the need for Diesel generators in off grid areas with lots of sunshine. It is economical as it saves diesel and fuel cost. Krishna Allied Industries Private Limited is a leading Manufacturer and Exporter of Dairy Equipment and Collection Accessories. An ISO 9001:2008 Certified Company committed to world class quality, combined with efficient delivery, competitive pricing and dedicated after sales service. Krishna Allied Industries brings an economic and sustainable solution to rural milking operations in the developing world - Solar Powered Milk Cooling Tank. Of course, this innovation could also be used in the developed world to reduce dependence on the traditional electrical grid.

Yadav et al., 2016 give the cost benefit analysis of the solar PV system which has summarised in the given table. According to their analysis we can save money as well as environment by opting solar PV as alternative source for producing electricity in long run. In table 2 their study give the cost which will be expend for the manufacturing of 100 kW solar systems.

Units Generated Annually (in Kwh) = System Size in kW * CUF * 300 * 8 (1)

= 100 X 0.19 X 300 X 8 = 45600 kWh/annum

Table 1 CBA for Energy Savings by Solar PV System

Sr.No.	Particulars		Amount	Unit
1	**Electricity Generated per day**	=	**152**	**kW/day**
2	Electricity Units Generated per Annum (Considering Effective Full Working Day for Solar System to be 300 Days Only)	=	45600	kW/annum
3	**Cost of Electricity**	=	**7.21**	**Rs./kWh**
5	**Expected Saving in Rs/annum**	=	**328776**	**Rs./annum**
6	Expected Investment for Solar PV System with Battery, Inverter	=	10000000	Rs.

7	Net cost after reducing subsidy and tax benefit on depreciation	=	5040000	Rs.
8	Simple Payback Period	=	15.32	Yrs
			184	Months

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Capacity Utility Factor (CUF) For India, it is typically taken as 19%

Table 2 Final Cost of 100kW Solar PV System

Particulars	**Rs.**
Cost of a 1 kW rooftop solar plant	**10000000**
MNRE Subsidy @ 30%	**3000000**
Net cost after subsidy	**7000000**
Accelerated depreciation @80%	**5600000**
Tax rate	**35%**
Tax saved through depreciation	**1960000**
Net cost after both AD and Subsidy	**5040000**

This clean energy solution aims to increase dairy farm productivity and income by significantly decreasing milk spoilage. Effective cold-chain storage lowers bacteria count and improves milk quality for consumers. These improvements can play a major role in the livelihoods of approximately one million smallholder dairy farming families in Kenya. Users have stated that the solution has provided benefits that include adding financial security to the household, cell phone charging which saved time and added income to the household, as well as food preservation.

II. METHODS AND MATERIAL

Solar radiation is available in abundance in the country and therefore this is a quite feasible safe & eco-friendly solution of increasing energy demand day by day. 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 which have versatile applications in various processes of dairy industry.

Photovoltaic Plants: Solar energy can be converted into electricity by using photovoltaic (PV) devices. PV devices convert light energy into electrical energy through photoelectric effect (French physicist Edmond Becquerel discovered as early as 1839. Individual PV cells or solar cells are made of semiconductor materials and can be used as electricity-producing devices. 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 and conversion efficiency lies 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-Spectro-lab **(Fthenakis and Alsema, 2006).** This PV device can used for storing solar energy and to utilize in the dairy plant for different unit operation heating of water and air, pasteurization, pumping, refrigeration plant etc.

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 rays expands and rises as it becomes less dense. Once warm water 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 and can operate in almost any climate. The solar pond (6000 meter²) was constructed in milk processing dairy plant located at Bhuj, India (started in September 1993.), attained a maximum temperature of 99.88°C. After calculation of construction cost of the Bhuj Solar Pond the approximate unit cost is US $15 **(Kumar and Kishore, 1999).**

Solar Cooker: A solar cooker (or solar oven), is a device which 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 which is opposite to the direction of spontaneous heat flow **(Lorentze, 1993).**

III. RESULTS AND DISCUSSION

Solar energy can be used in many applications to accomplish different operations of dairy industry. We can discuss them separately each in detail.

A. Solar based Refrigeration plant: The system is intended for refrigeration at 5°C in hot climates, and is composed of 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 directly air cooled, and has the main advantage of having no water consumption, low maintenance work and no legionella problems **(Ayadi, et.al,. 2008).** It used for the chilling of milk in bulk milk cooler. It also used to run a vapour absorption system for refrigeration plant and maintain cooling system. A power stored in battery at use for the running of an air conditioner **(Ishaku, 1990).**

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

Mahanand dairy (Maharashtra) is using solar water heating system (160 m² unit of ARUN™ ; 25000 LPD) since 1990, which was commissioned with the assistance of department of Non Convectional Energy Source and Maharashtra Energy Development Agency. The water is heated from 30°C (ambient temp.) to 85 °C with the help of solar water heating system, which is used for boiler as feed water, etc. This result 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 high 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).**

D. Solar Drying: Solar drying and dehydration systems use solar rays either as the solely power supply to heat the air or as a supplementary energy source. Almost all high temperature dryers are currently heated by conventional fuels (fossil fuel or electricity) but low temperature dryers can run either by fossil fuels or solar energy. Low temperature solar thermal energy is ideal for use in preheating processes as well **(Ekechukwu and Norton, 1999; Benz, et.al,. 1998).**

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 or submersible or floating pump that runs on power from an SPV array. The SPV array converts sunlight into electricity and delivers it to run the motor and pump. A typical SPV pumping system consists of an SPV array of 200–3000 W capacity, mounted on a tracking/non-tracking type of structure. It may use to run a hot water pump, chill water pump, milk pump and CIP (cleaning in place) pump, to draw water for irrigation as well as for drinking. 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 (in the form of portable lanterns, home-lighting systems with one or more fixed lamps, and street-lighting systems) are becoming popular in both the rural and urban areas of the country. A solar street-lighting system (SLS) is an outdoor lighting unit used to illuminate a street or an open area usually in dairy, garden, road approach to dairy and chilling centre.

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).**

IV. CONCLUSION

India has sufficient amount of sunshine that favours solar energy investments. Investment in solar energy technology should be encouraged as the merits include: pollution free environment, free renewable and energy source, high reliability and low maintenance costs. 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. Today, much evidence exists which suggests the future of our planet and of the generations to come will be negatively affected if human beings keep degrading the environment. It is true that solar systems are not inherently sustainable. The negative environmental impact of solar energy systems include land displacement and possible air and water pollution resulting from manufacturing, normal maintenance operations, and demolition of the systems. However, land use is not a problem when collectors are mounted on the roofs of buildings, the maintenance required is minimal, and the pollution caused by demolition is not greater than the pollution caused from demolition of a conventional system of the same capacity.

V. REFERENCES

[1]. A-Report of BEE on Energy Conservation Achievements; Raichur, Bellary and Koppal district co-operative milk Producers Societies union limited, Bellary Dairy, Karnatak,.Bee 2010:118.

[2]. Ayadi, O.; Doell, J.; Aprile, M.; Motta, M. and Nunez, T.(2008). Solar cooling system discription, Solar energy cools milk.

[3]. Broos, P. (1996). Solar cells as optical systems: a matter of computation. Delft University of Technology Science researchbulletin. 4:8–12.

[4]. Carr, A., Fletcher, S., O'Mara, K. and Rayner, M. (1999). Solar cell principle and applications. Australian CRC for renewable energy ltd.

[5]. Date, V. (2010), Financial feasibility of solar power project with reference to rural electrification of 39 talukas in Karnataka, By NICMR.

[6]. Desai, D. D., Raol. J.B., Patel. S., and Chauhan I., (2013). Application of Solar energy for sustainable Dairy Development. European Journal of Sustainable Development (2013), 2, 4, 131-140.

[7]. Ekechukwu, O. V.; Norton, B. (1999). Review of solar-energy drying systems II: an overview of solar drying technology. Energy Conversion and Management; 40:615–55.

[8]. Fthenakis, V. M. and Alsema, E. (2006). Photovoltaics energy payback times, greenhouse gas emissions and external costs: 2004–early 2005 Statut, Progress in Photovoltaics: Research and Applications 14: 275–280.

[9]. Jenkins, N. (1995), Photovoltaic systems for small-scale remote power supplies. Power Engineering Journal, 9(2):89–96.

[10]. Kalogirou, S.; Lloyd, S. And Ward, J. (1997). Modeling optimization and performance evaluation of a parabolic trough collector steam generation system, Solar Energy; 60(1):49–59.

[11]. Kreetz, H.; Lovegrove, K. and Meike, W. (2000). Solar PACES—Solar Thermal Concentrating Technologies, Industrial Statistics :121–129.

[12]. Kumar, A. and Kishore, V. (1999). Construction and operational experience of a 6000 m2 solar pond at kutch, india, Solar energy, 65(4):237-249.

[13]. Lorentze, G.(1993). Revival of carbon dioxide as refrierant, Internation, journal of refrigeration,17(5):292-301.

[14]. Ishaku, B. G. (1990). Solar energy for power generation, Nigerian Journal of Renewable Energy 1:29–36.

[15]. Pandagale V.P., Madhuri Gajabe., Khambalkar V.P., Assessment of Energy Conservation and Solar Energy ApplicationIn Milk Processing Plant, Int. Journal of Researches in Biosciences, Agriculture & Technology.

[16]. R. H. Yadav, Mr. V. V. Jadhav, Mr. G. A. Chougule (July 2016), Exploring The Scope of Renewable Energy Technologies In Dairy Sector, IJESRT, 5(7), pp439-450.