International Journal of Advance Research and Innovation
Vol. 4(2), Apr-Jun 2016, pp. 71-77
Doi: 10.51976/ijari.421611

Article Info
Received: 25 Feb 2016 | Revised Submission: 20 Feb 2016 | Accepted: 28 Feb 2016 | Available Online: 15 Jun 2016

Use of Renewable Energy in Dairy Industry

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ABSTRACT

Today India has become number one in milk production, producing 140 million tons per annum with approx. 20% of the total milk production is handled by the organized sectors. Dairy and food industries are fast growing industries and day-by-day newer technologies are being introduced to get better quality of foods. Most of the milk processing operations, room conditioning for milk product packaging and cold stores for milk & milk products are operating on grid electric supply. Energy is one of the critical inputs for economic development of any Country. In order to overcome the present energy scenario problems, energy should be conserved and since we are consuming disproportionate amount of energy that day is not far when all our Non-Renewable resources will expire forcing us to rely just on Renewable Sources. To overcome problem the use of renewable energy mainly solar & bio energy in the dairy is generally found for hot water supply to boiler, hot water generator for processing of milk or for CIP cleaning. Use of renewable energy has great scope for its commercial use in the dairy processing operations and It is estimated that renewable energy could contribute to at least half of all electric power in each of the large economies by 2050.

Keywords: *Renewable Energy; Solar Energy; Bio-Gas; Dairy.*

1.0 Introduction

Energy is one of the most important resources to sustain our lives and plays an important role in the growth and development of any economy. The requirement is increasing with increase in the population of the world. There is direct correlation between the development and amount of energy used. The demand for energy is increasing every day due to change in life-style of the people. The demand of energy continuously increasing but supply is limited. This situation is called energy crisis [1-12].

Energy is an essential input for industrial activities – manufacturing, utilities or other services. Energy consumed in dairy's operations is in two major forms: Thermal energy and Electrical. Thermal energy consumption in the form of steam is far greater than the consumption of electrical energy in the form of power. Moreover, the quantum and manner in which steam is consumed, in most cases has direct relationship with the quantity of power consumed. To overcome problem the use of renewable energy has great scope for its commercial use in the dairy processing operations and it is estimated that renewable energy could contribute to at least half of all electric power in each of the large economies by 2050. Atcurrent rate of consumption & production, coal reserves in India would last for about 130 years and at current rate of consumption & production, oil in India would last only for about 20 to 25 years[4]. The world's average energy consumption per person is equivalent to 2.2 tons of coal. In industrialized countries, this is 4-5 times more than the world average energy consumption [8].

1.1 Indian energy scenario

The energy consumption in India is fourth biggest after China, USA and Russia [27]. The total primary energy consumption from coal (55%), Natural gas (10%), Diesel (1%), Nuclear (3%), Hydro (20%) and renewable (11%) [13]. About 70%

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of India's electricity generation capacity is from fossil fuels, with coal accounting for 40% of India's total energy consumption followed by crude oil and natural gas at 28% and 6% respectively [29].For oil and gas, India will become ever more dependent on imports from a few distant, often politically unstable part of the world. 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" [7].

2.0 What is Renewable Energy?

Renewable energy is one of the cleanest sources of energy options with almost no pollution or carbon emissions and has the potential to significantly reduce reliance on coal and other fossil fuels. By expanding renewable energy, world can improve air quality, reduce global warming emissions, create new industries and jobs, and move world towards a cleaner, safer, and affordable energy future.

Renewable energy: -'Energy obtained from natural and persistent flows of energy occurring in the immediate environment' [35].

Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power.

2.1 Renewable energy in india

India has a vast supply of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. According to the Ministry of New and Renewable Energy (MNRE), A renewable energy system converts the energy found in sunlight, wind, falling water, sea waves, geothermal heat or biomass into a form, we can use such as heat or electricity.

Among these, the largest share is 70% from wind power, 14%small hydro power, 2% from solar and 14% from biomass &waste [13].

2.2 Types of renewable energy

2.2.1. Wind energy

Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical. Wind power is not a new development as this power, in the form of traditional windmills for grinding corn, pumping water, sailing ships have been used for centuries.

Now, wind power is harnessed to generate electricity in a larger scale with better technology. has 19051 MW of installed capacity and ranks 5th and has a potential of utilization up to 102772MW. Some of the major wind energy plants are located in Tamil Nadu (7160MW), Gujarat3093MW) and Maharashtra (2976MW) [10].

2.2.2 Solar energy

India being situated between the tropic of cancer and the equator, has an average temperature of 25°C – 27.5°C and receives 260-300 clear sunny days per year making it the best solar resource in the world [23].Earth receives on an average of 5-7 kWh (kilowatt-hour) solar radiation per square meter per day.

The highest annual solar radiation is received by Rajasthan whereas the north-eastern parts of the country receive the least [22].India has an installed power capacity of 1686 MW, making it sixth largest consumer in the world. Major plants are located in Gujarat, Rajasthan, Jodhpur, Tamil Nadu and Orissa [10].

2.2.3 Bio-energy

One third contributor of energy to India is biomass which comprises of solid biomass, which is an organic, non-fossil material of biological origins. Biogas which is principally methane and carbon dioxide is produced by anaerobic digestion of biomass and combusted to produce heat. Currently,

India has 3697MW installed capacity and it results in a saving of about Rs.20, 000croresevery year [13].Following is a list of some States with most potential for biomass production:

Andhra Pradesh (200 MW), Bihar (200 MW), Gujarat (200 MW), Karnataka (300 MW), Maharashtra (1,000 MW), Punjab (150 MW), Tamil Nadu (350 MW), Uttar Pradesh (1,000 MW) [10].

2.2.4 Hydro energy

Energy from small hydro is the oldest. It is most reliable of all renewable energy sources. Hydroelectric power for large-capacity plants has been estimated to be 148700 MW. For small plants, a total capacity of 15384 MW [34].India utilizes twelve primary hydroelectric power plants: Bihar, Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat, and Andhra Pradesh.

2.2.5 Geothermal energy

This is the energy, which lies embedded within the earth. According to various theories the earth has a molten core. The steam and the hot water come naturally to the surface of the earth in some locations of the earth. With growing dependence on coal and with increasing environmental problems, India will soon have to start exploiting this source of energy which has a potential of about 10000 MW [17].

2.2.6 Wave and tidal energy

The tides in the sea are the result of the universal gravitational effect of heavenly bodies like sun and moon on the earth. Periodic rise and fall of the water level of sea is called tide.

These tides can be used to produce electrical power which is known as tidal power. When the water is above the mean sea level, it is called flood tide and when the level is below the mean sea level, it is called ebb tide.

To harness the tides, a dam is to be built across the mouth of the bay. It will have large gates in it and also low head hydraulic reversible turbines are installed in it.

3.0 Use of Renewable Energy in Dairy Industry

Renewable energy is one of the most promising and important opportunities for value added products in dairying [28]. The type of renewable energy technology used in dairying depends on the type of energy required, access to the renewable energy sources and the design of the dairy facilities and processes.

There are number of renewable energy sources which can easily be integrated in the dairy industry such as solar energy for cooling and heating purpose, bio-energy for process heat for dairy operation, etc and this energy can generate power at competitive cost. Adoption of renewable energy sources in dairying can help in reducing hydrocarbon emission.

3.1 Application of solar energy in dairy industry

Now, a day technology has been developed in such a way that the solar energy is commercially feasible to collect.

The cost of solar energy is static or rather decreasing. Solar energy system as non-convectional sources is being developed for various industrial applications such as heating of water for cleaning, washing, and/or as boiler feed water etc.

Presently, the Indian dairy industry has to bear increased cost of energy/liter of processed milk due to increased cost of traditional energy inputs. So, the use of solar energy in dairy processing operation is the best option to overcome convectional energy sources.

3.2 Solar water heating systems (SWH)

Solar water heating considered as the most cost-effective alternatives for industry and household application.

A dairy unit requires many heating operation which are at present carried out using steam from boiler. Thus, solar energy for various heating application is already being used in some of the dairy plants for reducing fuel bill[37].

A solar water heater (SWH) is a combination of an array of collectors, an energy transfer system and a thermal storage system. In active solar water heating systems, a pump is used to circulate the heat-transferring fluid through the solar collectors.

The amount of hot water produced from a SWH critically depends on design and climatic parameters such as solar radiation, ambient temperature and wind speed. SWH system heating water at 60-80˚C or even higher temperature which can be conveniently used for crate washing, cleaning, CIP, pre-heating of boiler feed water etc [24].

Himachal Milkfed Dairy (20,000 LPD) is using solar water heating in dairy processing such as boiler feed water and for cleaning purpose.

Solar flat plate collector system is developed to meet demand of pre-heating of feed water. The water is heated at 60-80˚C and used for boiler feed water and in cleaning with capacity of 6000 L (Boiler feed) & 2500 L (Cleaning). And save 14000 L of diesel /Year.

3.3 Solar energy in pasteurization

There is tremendous scope of utilizing solar energy in dairy processing such as pasteurization of milk. Solar panels/Concentrator based milk pasteurizer system is developed to meet the demand of pasteurization. It was observed that base temperature of solar heated water reached up to 100˚C. And pasteurizer have easily attained pasteurization temperature ranging from 65-75˚C in two-three hours [36]. Mahanand dairy (Maharashtra, 30,000 LPD) and Dudhman sagar dairy is using solar water heating system for the pasteurization milk. The water is heated from 30˚C(ambient temp.)to 85˚C with help of solar water heating system which is used for boiler as feed water and also in pasteurization. Mahanand and Dudhmansagar dairy saves average 200-250 lit [9] and 820 kg of furnace oil per day respectively [21].

Chitale Dairy Maharashtra is using Fresnel Paraboloid Dish collector for the pasteurization of milk .Steam is generated at 5 bar pressure and 152˚C temperature which is used in heat exchanger for milk pasteurization [3].

4.0 Solar 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 [16]the steam flash, direct and the unfired-boiler. The Heat Transfer fluid that circulates inside the solar field (primary cycle) is heated and transferred to heat exchanger, including super heaters, evaporators and pre heaters, where steam is generated for the power cycle or other applications [1].This steam can be used for sterilization and pre-heating of air and also in drying operation.

4.1 Solar energy for cooling purpose

Photovoltaic Operated Refrigeration Cycle, Photovoltaic (PV) involves the direct conversion of solar radiation to direct current (dc) electricity using semiconducting materials. In concept, the operation of a PV-powered solar refrigeration cycle is simple. Solar photovoltaic panels produce dc electrical power that can be used to operate a dc motor, which is coupled to the compressor of a vapor compression refrigeration system [19]. This system is feasible for cooling of milk in chilling centre. Same as Solar Absorption Refrigeration system was designed to operate with the ammonia water mixture for a maximum capacity of 8 kg of ice/day. It consists of a compound parabolic collector CPC with a cylindrical receiver acting as the generator/absorber, a condenser, a storage tank, an expansion valve, a capillary tube, an evaporator. The system operates exclusively with solar energy and no moving parts are required [25].

Solar powered LiBr-water vapour absorption refrigeration (SVAR) system having rated capacity of 5 TR (17.5 kW).The SVAR system consists of array of heat pipe evacuated tube collectors (HP-ETC), generator, evaporator, absorber, condenser and heat exchanger. The HP-ETC produces hot water at a temperature of 65-95°C which is used for the supply of thermal energy at the generator of the system. The values of actual COP of the SVAR system ranged from0.24 to 0.66. The thermal energy supplied at generator ranged from31.01 to 60.69 kW. The refrigerating effect is produced by SVAR system11.19 to 22.31 kW.The use of solar energy for the operation of VAR has a scope for cooling and cold storage of fruits and vegetables where temperature requirement is not very low [15].

4.2 Solar drying and dehydration systems

Currently, electricity is always used to heat the air and as an additional energy source. Conventional drying systems using fossil fuels as a source of combustion, while solar dryer use solar irradiation for drying in industries, such as brick, crops, fruits, coffee, wood, textiles, leather, green malt and sewage sludge [30].There are two main groups of dryer, high and low temperature dryers. Almost all high-temperature dryers using fossil fuels or electricity for the heating process. While the low-temperature dryers can use fossil fuels or solar energy. A low temperature generated by solar energy is ideal for use in the preheating process [14].

4.3 Direct solar drying

Direct drying consists of using incident radiation only, or incident radiation plus reflected radiation. Most solar drying techniques that use only direct solar energy also uses some means to reflect additional radiation onto the product to further increase its temperature. An example of direct

absorption dryer is the hot box dryer. The aim of this type of a dryer is mainly to improve product quality by reducing contamination by dust, insect infestation, and animal or human interference. It consists of a hot box with a transparent top and blackened interior surfaces. Ventilation holes in the base and upper parts of slide walls maintained a natural air circulation. The farmers can dehydrate vegetables when these are available in plenty and at low cost. Dehydrated vegetables can be sold in the off season when prices of vegetables are high and farmers can generate more income [26].

4.4 Indirect solar drying

Principle of indirect solar drying which is generally known as conventional dryer. In this case, a separate unit termed as solar air heater is used for solar energy collection for heating of entering air into this unit. The air heater is connected to a separate drying chamber where the product is kept. The heated air is allowed to flow through wet material. Here, the heat from moisture evaporation is provided by convective heat transfer between the hot air and the wet material.

The drying is basically by the difference in moisture concentration between the drying air and the air in the vicinity of product surface. A better control over drying is achieved in indirect type of solar drying systems and the product obtained is of good quality [32].

The use indirect solar cabinet dryer for drying of *khoa* and *chhana* which was **developed for** drying of vegetables. In this dryer, atmospheric air enters through the front air inlet vent; it gets heated due to the solar radiations received by the solar collector.

The solar reflectors help in further concentrating the radiations. The various parameters like specific heat thermal conductivity and thermal diffusivity of the product and convective heat transfer coefficient of process were applied to investigate the drying process. Solar dried ***khoa*** powder was found to have satisfactory reconstituability while dried ***chhana*** did not give desired reconstituability [31].

And also solar energy is utilize for dehydration of cow milk. ***Khoa prepared from dehydrated milk having*** acceptable chemical and sensory quality ***(***37.10 moisture***)*** as made by traditional method [6].

An advanced and alternative method to the traditional techniques is greenhouse drying. In greenhouse drying the product is placed in trays which receive solar radiation through the plastic cover and moisture is removed either by natural convection or forced air flow. The use of appropriate greenhouse dryer improves the quality of the product and lead to reduction of drying time interval [18].

4.5 Solar energy for pumping dairy fluids

An SPV pump is a DC or AC, surface-mounted or submersible or floating pump that runs on power from an SPV array. It may use 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 [9].

4.6 Solar energy to lightning 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 dairy, garden, road approach to dairy and chilling centre [9].A CFL (compact fluorescent lamp) is fixed inside a luminary which 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, and a CFL of 11 W rating. The CFL automatically lights up when the surroundings become dark and switches off around sunrise time. The cost of a SLS is about ₹19 000 [7].

4.7 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 batter [5].

5.0 Application of Bio-Gas in Dairy Industry

Currently, most dairy digester produced biogas is used on-site for energy generation. Electrical Production is generally the primary use of the produced biogas although heat is frequently also produced for use in the anaerobic digester either as part of a combined heat and power system (CHP) or separate dedicated boiler systems. Consequently many of the feasibility studies for manure digesters report their productivity and costs in terms of the system's electricity production.

5.1 Biogas as electricity and heat generation

California dairies could generate nearly 14.6 billion ft3 of methane each year (which corresponds to 140 megawatts of electrical capacity) biogas is fed directly into an internal combustion engine to generate electricity and heat, or it can be used only for heating.

iogas, a mixture consisting primarily of methane and carbon dioxide, is produced from dairy wastes through anaerobic digestion, a natural process that breaks down organic material in an oxygen-free environment[20].And also biogas is used in canteen purpose where LPG gas cylinder is used that replaced by the biogas burners.

5.2 Biogas for refrigeration

Dairies cool milk every day of the year, and compressors for refrigeration run continuously during milking operations, often 20 hours or more each day. For a 1,000-cow dairy farm, the energy requirements for these compressors are typically in the range of 30 to 40 hp (22.5 – 30 kW) The temperature of cow milk of the milking is about 98º F; the milk is typically cooled to 38º F for on-farm storage. Although many dairies use well water for pre-chilling, chilled water or glycol can be produced from biogas-fired absorption or adsorption chillers and used in milk pre-coolers. Milk cooling using absorption and adsorption chillers also presents a potential opportunity to use waste heat captured from a biogas-driven generator set. Use of this waste heat could significantly reduce the on-farm electrical refrigeration load [20].

6.0 Conclusions

Energy is one of the most important resources for the growth and development of any economy. Renewable and non-renewable sources of energy are available for this purpose. Use of non-renewable sources gives disadvantage of global warming through generation of greenhouse gases and by giving more carbon foot prints. It is also exhaustible in nature.

As against this the use of renewable energy is having the positive environmental impact and it is inexhaustible in nature. Dairy industry normally consumes thermal and electrical energy using convectional sources. The replacement of this with the renewable sources will definitely keep the dairy industry at higher profit margin level. In this context evidences show that the solar and bio-energy is giving the promising results.

Government policies are also working in this line.

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