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Potential of solar industrial process heating in dairy industry in India and consequent carbon mitigation

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ABSTRACT

An attempt to estimate the potential of solar industrial process heating (SIPH) and corresponding mitigation of greenhouse gas emissions in dairy industry in India is presented. An assessment of availability of solar radiation as well as of the ambient conditions at various locations with milk processing plants has been made. The effect of the choice of design value of direct normal irradiance on the annual performance of solar process heating systems has been studied using model developed for hourly simulation of the performance of solar process heating system. Further, state wise estimates for useful thermal energy delivery and corresponding solar fraction have also been obtained.

The total process heating potential in term of useful energy requirement in dairy sector in India has been estimated at 6.40 PJ/annum which reduces to 4.50 PJ per annum if the process heating requirement is restricted to only pasteurization stage of milk processing. The corresponding solar collector area requirement for process heating in dairy industry in India is estimated in the range of 1.54 −1.83 million m^2 with the average solar fraction estimated in the range 0.18–0.32. The use of solar energy for meeting milk processing related thermal energy demand is expected to mitigate (32 −144 thousand tonnes) of CO_2 emissions annually.

1. Introduction

To promote the use of solar energy in industrial process heating, government of India has implemented a UNDP-GEF supported project (UNDP-GEF, 2011). The project is aimed to promote and commercialize Concentrating Solar Technologies for industrial process heat applications. The dairy industry in India is also included in the scope of the project.

In the past, several studies those were primarily focused on the potential of process heating in industrial sector of a country and region invariably include the dairy industry in the scope (ABPS, 2011; BEE, 2010; Claudia et al., 2008; Lauterbach et al., 2012; Schnitzer et al., 2007; Schweiger et al., 2001). Potential assessment of solar process heating in the industrial sector of Greece has been carried out by (Karagiorgas, 2008). The scope of this study was only limited to use of solar energy for boiler feed water heating. Case studies presenting the actual performance of solar process heating systems using concentrating solar collectors (Parabolic trough and Arun 160) in the dairy industry have also been reported in the literature (Bhosale at al., 2008, Ramirez et al., 2006; Quijera and Labidi, 2013).

In the context of Indian dairy industry, solar process heating potential of 1.88 PJ per annum was estimated (GIZ, 2011). However, the study was only limited to low temperature process heat applications such as hot water generation and boiler feed water heating. It did not consider (i) the use of solar energy to meet process heating demand (through steam generation) at higher temperatures, (ii) solar resource availability at different locations having dairy plants and (iii) expected performance of solar industrial process heating (SIPH) systems in dairy industry in terms of useful energy delivery and solar fraction.

In order to develop and implement effective policies and promotional measures, policy makers and regulators in a government would require reliable information about (a) The overall potential of SIPH in the country (b) niche locations that are suitable for the interventions in the initial phase, (c) expected performance of SIPH systems in these locations and (d) expected fuel saving and emissions mitigation likely to be offered by SIPH systems.

In view of the above an attempt to estimate the potential of SIPH in dairy industry and corresponding carbon mitigation

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Table 1
Time trend of milk production in the states of India and installed capacity of milk processing plants as on (2011–12).

State	Milk production (million tonnes per annum)					No of milk processing plants	Installed capacity (tonnes per day)
	2008–09	2009–10	2010–11	2011–12	2012–13		
Andhra Pradesh	9.57	10.42	11.20	12.08	12.76	48	7843
Gujarat	8.38	8.84	9.32	9.81	10.31	33	14,477
Haryana	5.74	5.74	6.00	6.66	7.40	37	2947
Karnataka	4.53	4.82	5.11	5.44	5.78	24	4808
Madhya Pradesh	6.85	7.16	7.51	8.14	8.83	25	5012
Maharashtra	7.45	7.67	8.04	8.46	8.74	395	26,592
Punjab	9.38	9.38	9.42	9.55	9.71	77	8349
Rajasthan	11.93	12.33	13.23	13.51	13.9	38	5841
Tamil Nadu	6.54	6.65	6.78	6.96	7.00	37	9319
Uttar Pradesh	19,35	20.20	21.03	22.55	23.33	253	35,045
Others	41.93	23.19	24.16	24.74	23.19	98	10,380
Total	**112.20**	**116.41**	**121.28**	**127.90**	**132.42**	**1065**	**130,613**

potential in India has been presented in this paper. The potential of solar industrial process heating (SIPH) in dairy industry essentially refers to the amount of useful energy that can be saved (or substitute) in dairy industry by providing the process heat required. In other words the potential represents the useful energy supplied with solar energy system. Moreover, often the potential of solar industrial process heating (SIPH) is also expressed in terms of the solar collector area that can be installed to meet the part of process heating requirement. Finally, the greenhouse gas emissions (GHG) CO_2, CH_4 and N_2O etc. mitigation potential essentially represents the net amount of GHG gases those are likely to be mitigated due to replacement of fossil fuels used in dairy industry by solar energy.

2. Overview of dairy industry in India

Dairy industry in India is considered as one of the most successful development programs in post-Independence period. In the year 2012–13, with a total production of 132.5 million tonnes of milk, dairy industry in India accounted for 13% of global milk production. The time trend of milk production in some of the states of India is presented in Table 1. States mentioned in the table are contributing for more than 80% of overall milk production of the country (NDDB, 2014). In India milk from mainly three animals is consumed. These are cows, buffaloes and goats with approximately 44.5%, 51.5% and 4% contribution respectively (DAHD&F, 2012).

In India the milk is consumed both in the raw (un-processed) as well as processed forms with the raw milk being consumed locally (Fig. 1) (MOA, 2012). The use of processed milk is prevalent through both the organized as well as un-organized sectors. The milk processing in the organized sector (20% of the total milk processed) is undertaken to produce the pasteurized liquid milk as well as other value added products Table 2.

Organized sector consists of the milk processing plants are those registered with state or central authorities and having installed capacities of handling up to one million liters of milk per day. In India, 1065 milk processing plants with installed capacity of 37 million tonnes per annum are reportedly registered in the organized sector (MOA, 2012; CII, 2013). State wise installed capacity of such plants in the country is presented in Table 1.

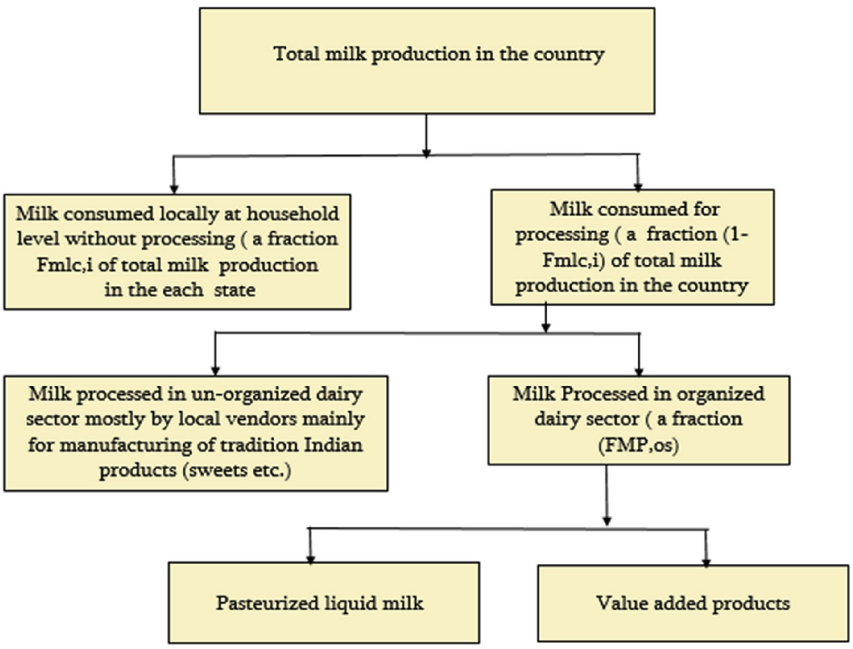

Fig. 1. A schematic of the structure of dairy industry in India.

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