ECONOMICS OF GEOTHERMAL ENERGY IN DAIRY PROCESSING INDUSTRY IN KENYA

Rotich Bernard and Jack Kiruja

Geothermal Development Company

P.O. BOX 100746-00101

NAIROBI, KENYA

brotich@gdc.co.ke, jkiruja@gdc.co.ke,

Keywords: Geothermal direct use, Milk pasteurization, Menengai.

ABSTRACT

Geothermal Development Company (GDC) is drilling geothermal wells at Menengai, in Nakuru, for electricity generation. However, excess heat from these wells can be used for direct use applications. Nakuru has an established dairy sector with fossil fuel powered milk processing plants. Cost of IDO has continually been rising due to forces in the world market and the fuel too emits greenhouse gases. This paper reports a comparison of thermal energy costs from geothermal and conventional sources. The findings indicate that total of 24,216.66 MJ of energy is required to pasteurize 120,000 litres of milk per day. This implies that KES 16,817.13 is incurred per day if geothermal source is used while KES 72,497.35 is incurred if conventional source (IDO) is utilized. This results in the reduction of the cost of thermal energy by 77% if geothermal energy replaces IDO in pasteurization of milk. It costs KES 10.78 to produce a kWht from fossil fuels while a kWht from geothermal energy costs as low as KES 2.50. This report recommends establishment of an industrial park near Menengai Geothermal field and subsequent engagement of interested milk processing investors.

1.0 INTRODUCTION

The Kenyan Rift Valley is not only home to dairy farming but also the largest geothermal resource in Africa. The expansion of geothermal energy production in the country is expected to avail surplus thermal energy. Kenya's geothermal resources are high temperature and liquid dominated. This means that large quantities of hot water are produced as by-products of power generation. It is also important to note that some of these geothermal resources are strategically situated in agriculturally rich areas such as Menengai geothermal field in Nakuru County (USAID-W and GDC, 2013). Geothermal energy can be utilized for both electricity generation and direct uses such as thermal treatment of milk and absorption cooling, whose energy requirements are within a range that the geothermal resource in Kenya can cater for. Currently, fossil fuels are used in the processing of dairy products. Kenya has about 3.4 million dairy cows producing about 2.7 million litres of milk. (USAID-W and GDC, 2013). The growth of industries is dependent on the availability and affordability of energy. However, conventional energy sources such as fossil fuels which are currently being used are getting depleted, they have adverse environmental effects and their prices are increasing rapidly due to forces in the world markets. It is therefore necessary to consider alternative sources of energy; and geothermal energy is a potential option. Geothermal energy is a good candidate for clean energy to help power the Kenyan dairy industry. Dairy products processing requires both heating and cooling to improve the shelf life, improve taste, and make it safe for consumption. Geothermal resources of below 150°C can provide direct energy for the milk pasteurization process and ultra-heat treatment. A government policy incentive introduced recently to zero rate taxes on inputs used in liquid milk processing and tax exemptions on investments to set up processing facilities in rural areas present attractive investment opportunities. One of GDC's mandates is to promote direct use of geothermal energy in the country. It is because of this that Geothermal Development Company (GDC) established a direct use demonstration facility that relies entirely on thermal energy from a geothermal resource in Menengai Geothermal Field. The facility is used to demonstrate cascade use of geothermal energy in projects including containerized milk pasteurization. The geothermal energy powering the direct use demonstration projects is obtained from Menengai Well- 03 because of its low pressure of about 2 bars. However, the well has a large flow rate of 60 ton/h and low silica concentration (USAID-W and GDC, 2013). The pilot geothermal milk processing plant in Menengai is operational and the concept of geothermal direct use in dairy industry has been proven to be technically viable.

1.1 Objective

Having established that the geothermal direct use pilot dairy processing plant in in Menengai Geothermal Field is operational, there is need for investor engagement. Several milk processing firms are situated in the country and all of them use diesel boilers to generate thermal energy for pasteurizing milk. For geothermal technology to be adopted in the dairy industry, investors need to confirm on economic viability of the venture. This paper is meant to compare the cost of thermal energy from conventional and geothermal sources in order to guide potential investors.

2.0 PREVIOUS WORKS

Geothermal direct technology in dairy industry is whereby milk is processed through indirect heat application, with a secondary fluid providing the necessary thermal energy. The energy required in dairy processing depends on the product being processed. Batch sterilization of milk requires a temperature of 70°C for 15 minutes. Thermal energy is the largest energy component in dairy processing at 65% of the total energy requirements. The geothermal resource in Menengai has the potential to provide this energy, which has the advantage of being cheaper and environmentally friendly. A geothermal milk processing facility of up to 500, 000

litres per day can be established near Menengai since the Nakuru milk shed of 100km radius can sufficiently supply milk. (USAID-W and GDC, 2013).
One of the conventional milk processing facilities within the Nakuru milk shed pasteurizes about 120,000 litres per day. The plant uses an approximate of 600 litres of industrial diesel oil to generate heat energy for their processes (USAID-W and GDC, 2013). Water is the medium used to transport the extracted energy in geothermal brine from the heat exchanger to the industrial park. Therefore, the milk processing facility will purchase hot water in order to utilize the energy contained in it. In a study done by Kiruja (2017), the price of energy obtained from geothermal fluids through heat exchange and transmission was estimated at 0.025 $/kWh.

3.0 METHODOLOGY

A concept of the Menengai pilot milk pasteurizing plant was used in the study with the proposed plant capacity being 120,000 litres per day (5 hour duration) based on the already existing conventional plant. The pasteurization thermal energy costs for the two sources were analyzed. Some previous studies also provided information towards achieving the objective.

4.0 RESULTS

The study indicates that a total of 24,216.66 MJ of energy is required to pasteurize 120,000 litres of milk per day (Table 1). This implies that KES 16,817.13 is incurred per day if geothermal source is used while KES 72,497.35 is incurred if conventional source (IDO) is utilized. This results in the reduction of the cost of thermal energy by 77% if geothermal energy replaces conventional source (IDO) in pasteurization of milk.

Table 1: Economics of Geothermal Milk Processing

	Value	Units	Comments
PROCESS DESCRIPTION			
Raw milk for processing	120000	Litres	
Initial milk temperature	20	°C	
Final Process temperature	70	°C	
Duration of Pasteurization	300	Minutes	
Heat transfer rate($\dot{M}c\delta t$)	1,345	KJ/s	
Thermal energy required	24,216.66	MJ	
Density of milk	1027	kg/M3	
Mass of milk	123,240.0	Kg	
specific heat capacity of milk	3.93	K J/(kg. K)	
specific heat capacity of water	4.19	J/(kg. K)	
SYSTEMS			
Geothermal			
Geothermal fluid temperature	110	°C	
Heated fresh water temperature	80	°C	
Conventional			
Density of IDO	850	Kg/M3	
Calorific value of IDO	44.8	MJ/Kg	
Volume of IDO required/day	635.9	Litres	
ENERGY COST			
Conventional			
Price of diesel	114	KES/Litre	
Price of energy	10.78	KES/kWht	Conversion base : 1 kWh = 3600 kJ
Cost of diesel	72,497.35	KES	
Geothermal			
Price of energy	2.50	KES/kWht	From previous study(Kiruja, 2017)
Cost of energy	16,817.13	KES	
Savings from use of geothermal energy	**77%**		

5.0 CONCLUSIONS & RECOMENDATIONS

Based on the findings of the study, geothermal direct use technology helps in lowering the cost energy and subsequent production cost. This is because it costs KES 10.78 to produce a kWht from fossil fuels while a kWht from geothermal energy costs as low as KES 2.50. A geothermal milk processing facility is therefore recommended to replace fossil fuels which are not only expensive but they also emit greenhouse gases. This report recommends establishment of an industrial park near Menengai Geothermal field and subsequent engagement of interested milk processing investors. There is need to look into widening the processing portfolio to include other milk products including cheese, yoghurt, skimmed milk powder, butter and ghee, and UHT milk. This will improve the investor earnings and sufficiently utilize cascade energy as a result of continued geothermal development in Menengai Field.

6.0 REFERENCES

Bylund, G., 1995: Dairy processing handbook. Tetra Pak Processing Systems AB, 442 pp.

Gunnarsson, I., and Arnarsson, S., 1999: Amorphous silica solubility and thermodynamic properties of H4SiO4 in the range 0°C to 350°C. Science Institute, University of Iceland, 13 pp.

USAID-W and GDC, 2013: Geothermal Mega Dairy (GMD) Prefeasibility Study, Kenya. Powering African Agriculture (PAA) project, 81pp.

Kiruja, J, 2013: The viability of supplying an Industrial park with Thermal Energy from Menengai Geothermal Field, Kenya. MSc Thesis, Iceland School of Energy School of Science and Engineering Reykjavík University, Iceland, 13pp