Economics of Geothermal Energy in Dairy Industry

Rotich Bernard and Jack Kiruja
• 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.
• 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).
• 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.
Introduction

Brookside Dairy Wellman-Robey Class 1 diesel powered boiler supplying up to 2,000 lbs./hr.

Happy Cow Dairy Kuiper 400 kW diesel powered boiler

Daima 2.5 MW MultiStar wood fired boiler which consumes ½ ton per day of firewood.
Proof of Concept

• In 2015, GDC established a direct use demonstration facility in Menengai Geothermal Field.
• Menengai Well-03 with large flow rate of 60 ton/h and surface temperature of 110ºC, provides the thermal energy used.
• The geothermally heated water at 80ºC is delivered to a 150 litres batch pasteurizer
• The pilot geothermal milk processing plant in Menengai is operational.
Study Objective

• 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
Methodology

- When at full capacity for one shift-5 hours, would process 120,000 liters per day of milk.
- Basis of the study is the conventional plant within the Nakuru milk shed pasteurizes 120,000 litres per day.
- The conventional plant uses an 600 litres of IDO to generate heat energy for their processes (USAID-W and GDC, 2013).
- The venture would pasteurize for 260 days per year
- Batch sterilization of milk requires a temperature of 70°C for 15 minutes
## Findings

### ECONOMICS OF GEOTHERMAL MILK PROCESSING

<table>
<thead>
<tr>
<th>PROCESS DESCRIPTION</th>
<th>Value</th>
<th>Units</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw milk for processing</td>
<td>120000</td>
<td>Litres</td>
<td></td>
</tr>
<tr>
<td>Initial milk temperature</td>
<td>20</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Final Process temperature</td>
<td>70</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Duration of Pasteurization</td>
<td>300</td>
<td>Minutes</td>
<td></td>
</tr>
<tr>
<td>Heat transfer rate(\text{Mc}\delta t)</td>
<td>1,345</td>
<td>KJ/s</td>
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<tr>
<td>Thermal energy required</td>
<td>24,216.66</td>
<td>MJ</td>
<td></td>
</tr>
<tr>
<td>Density of milk</td>
<td>1027</td>
<td>Kg/M3</td>
<td></td>
</tr>
<tr>
<td>Mass of milk</td>
<td>123,240</td>
<td>Kg</td>
<td></td>
</tr>
<tr>
<td>Specific heat of milk</td>
<td>3.93</td>
<td>KJ/(kg. K)</td>
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</tr>
<tr>
<td>Specific heat of water</td>
<td>4.19</td>
<td>KJ/(kg. K)</td>
<td></td>
</tr>
</tbody>
</table>

### 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: 0.0067 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%
Comparison of the cost of thermal energy from geothermal and diesel oil

- 77% Savings
THANK YOU