PREFEASIBILITY STUDY ON DIRECT USE OF GEOTHERMAL ENERGY IN ABATTOIRS AND PROCESSING OF LIVESTOCK PRODUCTS IN KENYA

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ABSTRACT

A prefeasibility study on potential for direct use of geothermal energy in abattoirs and processing of livestock Products in Kenya was carried out in 2015 through collaboration between GDC and USAID. The study was done in five major livestock producing counties, and in which significant amounts of geothermal energy exist. The findings of the study indicate that, basic slaughter slabs are widely used with minimal value addition and that energy demand is a major cost item in all the major operations thus endorsing the potential for direct use of geothermal energy. This opportunity can be realized by co-locating abattoir plants and geothermal fields. A medium level abattoir with slaughter capacity for 200 head of cattle and 225 small stock per working day for a maximum 7.5 hours single working shift is sufficient. The facility would utilize electrical and thermal energy from geothermal resource. The energy demand is estimated at 70,000 KWh per day. The plant will engage in both slaughter and processing of a range of meat products to increase viability of the operation. The facility will require 550M^3 water a day, including the hot water at about 85° C needed for sterilization , wash–down water for cleaning at 60°C and warm water for washing hands and showering at 42°C. A substantial operational cost saving, estimated to about USD 700,000 per year would be achieved when geothermal energy replaces conventional energy.

1.0 INTRODUCTION

A pre-feasibility study on the potential of utilizing direct geothermal energy for abattoir processes was carried our between 2014-2015 under Geothermal Development Company (GDC) and the United States International Development Agency (USAID) collaboration The study was done in five counties major livestock producing counties (Narok, Nakuru, Baringo, Samburu and Turkana) within the Kenyan Rift Valley where geothermal energy exists (Figure 1). These five counties hold an estimated 22.9%, 32.6%, 27.6% and 29.0% of national herds and flocks of cattle, goats, sheep and camels respectively.

1.1 Status of value addition in livestock industry

An analysis of the livestock value addition facilities and processes shows a wide range of technologies in use, from the very basic slaughter slabs in remote town centres to highly mechanized abattoirs like the Kenya Meat Commission, Farmers's Choice and Turkana Meat Processors at Lomidat near Lokichoggio in Turkana County. However, the most critical aspect of processing, even for the export market, is not the level of innovation of the abattoir but the level of hygiene and compliance to international standards and norms in the meat industry. About 70% of the red meat is raised from ASALs Due to lengthy marketing chains and poorly organized producer groups, pastoralists currently receive less than 10% of the final price paid by consumers compared to an average of 30% received by ranches who sell to top class urban butcheries. Using geothermal energy both for hygiene purposes and for energy cost savings would greatly improve the abattoirs processes and the products.

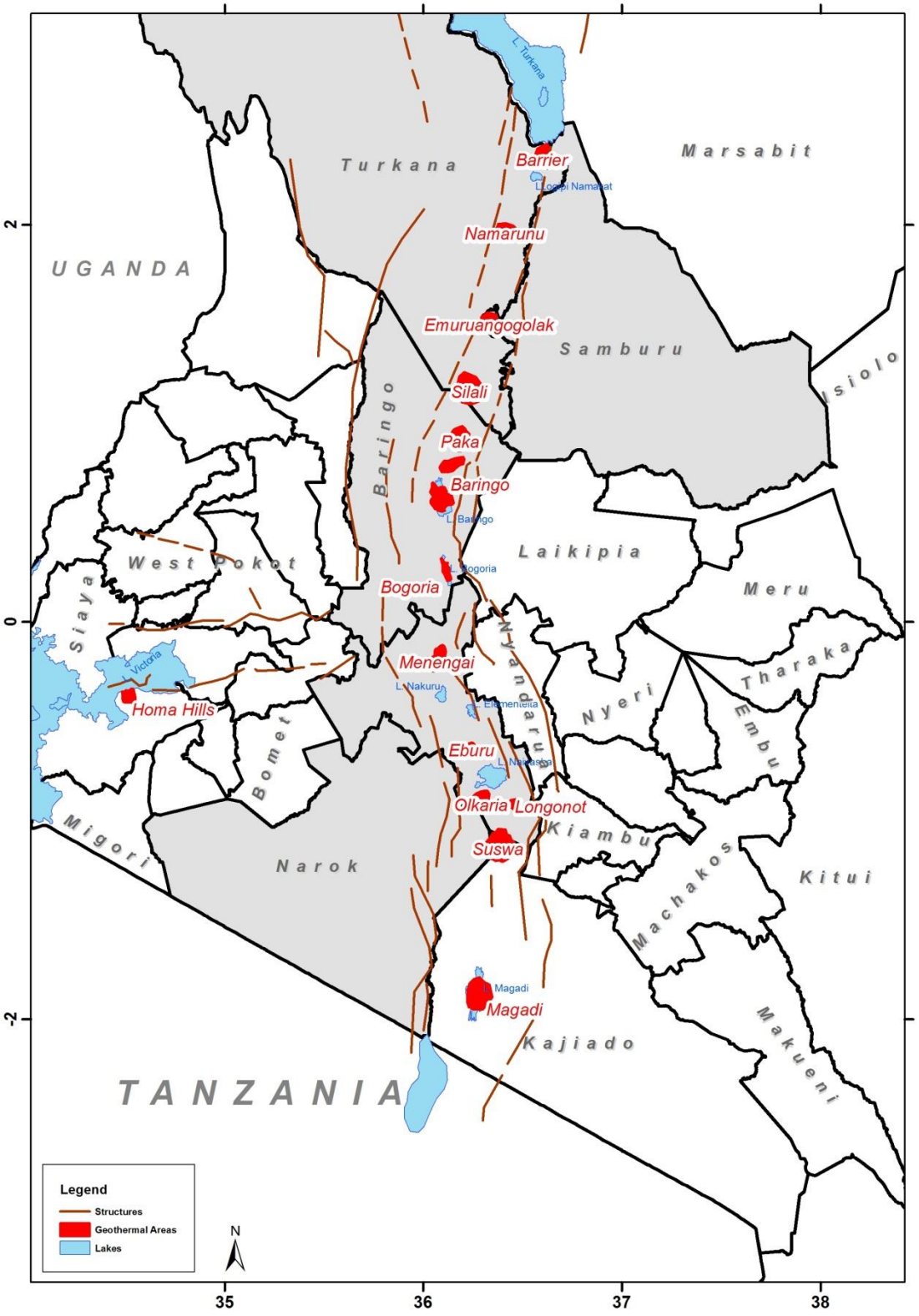

Figure 1: Map of sites for proposed Geothermal powered abattoirs sites (GDC, 2015)

1.2 Status of geothermal energy in Kenya

Kenya has substantial geothermal resources all along the Great Rift Valley estimated to be in excess of 10,000MWe. Current installed geothermal power generation capacity is 500MWe and the target for the 2030 vision is 5000MWe of Geothermal Power. To achieve the target, most of the geothermal prospects will be developed availing electricity and thermal energy nearer the sources of livestock. The county governments can therefore collaborate very closely with GDC to achieve the full benefit of the energy, specifically by setting up abattoir and meat processing facilities near the geothermal fields,

1.3 Geothermal energy - potential use in an abattoir and meat processing facility

Electrical Power is generated using geothermal energy in either a binary or conventional steam turbine driven generator to provide reliable, environmentally friendly and cost effective electricity. In an abattoir and meat processing facility electricity is used for lighting, refrigeration and to power equipment like pumps, compressors, conveyors, fans, meat mincing machines, processing machines, packaging machines and water treatment plant.

Thermal Energy, a by-product of electricity generation and can be used for various processes such as in a rendering plant which requires steam for at 167^{o}C and pressure of 680 kPa, sterilization using hot water at 82^{o}C, hot wash down water for cleaning is needed at 62^{o}C, and warm water at 42^{o}C for washing hands and showers. Water is used for general hygiene and for the processes. Electricity, thermal energy and water are all products of geothermal energy development (Figure 2).

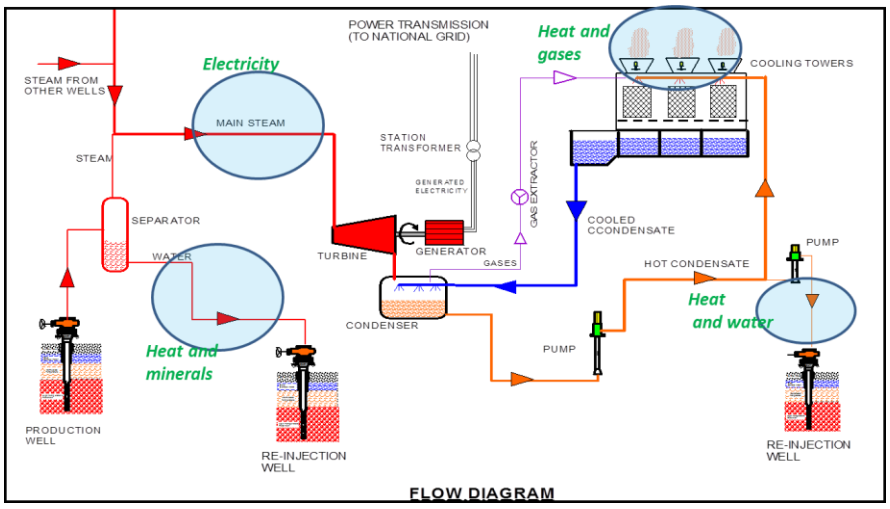

Figure 2: Flow diagram of geothermal resource utilization

Geothermal energy can also be used for refrigeration and chilling processes in the abattoir and meat processing plant, through absorption cooling technology (Figure 3). The direct heat from geothermal resource provides energy needed to drive the cooling process.

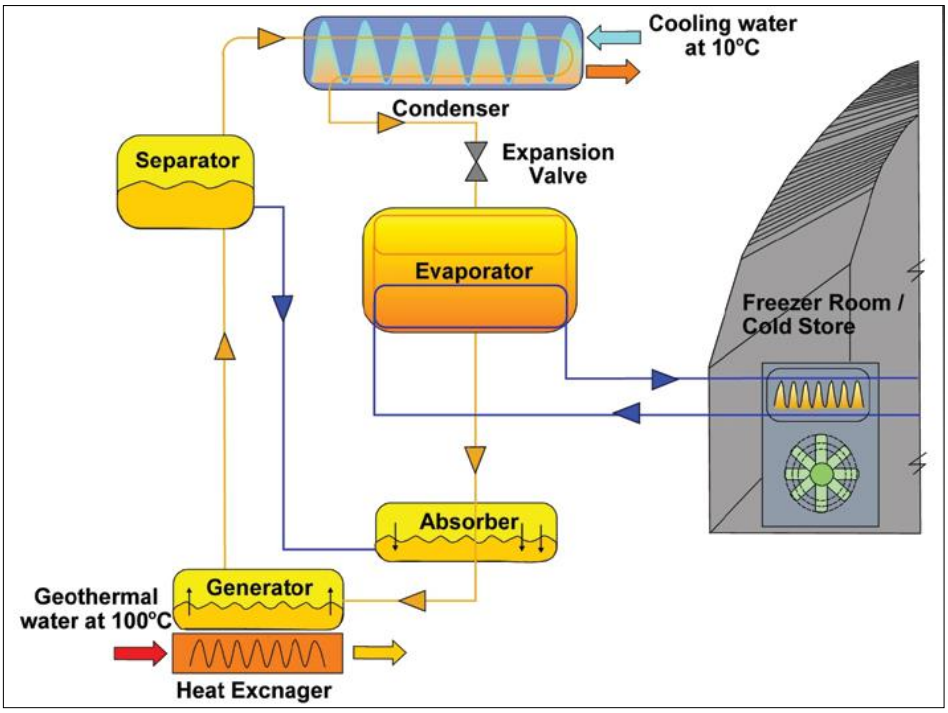

Figure 3: Absorption cooling cycle (Lund, 2010)

2.0 THE PROPOSED ABATTOIR AND PROCESSING PLANT

The findings of the study indicate that most of the abattoirs along the Kenyan Rift do not meet the required level of hygiene and compliance to international standards. The abattoir plants and operations in Kenya need to be replaced with modern and hygienic facilities. The findings are based on a medium level abattoir with slaughter capacity for 200 head of cattle and 225 small stock per working day. The plant is meant to engage both slaughter and processing of a range of meat products to increase viability of the operation with due regard given to the potential markets and livestock availability.

2.1 Energy and water use requirements for livestock value addition

A medium abattoir is designed to use substantial amount of energy and water to ensure hygiene and acceptable products. Both energy and water can be obtained as a by-product of geothermal energy development.

2.1.1 Energy Requirements

The traditional sources of energy for modern abattoirs for both electricity and thermal energy; oil or coal fired boilers. Steam at the abattoir used in the rendering plant where waste organic material is melted down and converted into saleable high protein animal feed, and tallow. In order to achieve sterilization of any pathogens which may be present in this waste material requires operating temperatures of 167°C. The energy requirements of the heating processes involved use steam at 6.8 bar gauge pressure as the energy medium. A boiler will be installed as an allowance for routine maintenance shut downs and break downs. A standby boiler may be required for annual maintenance of the geothermal system. The required energy to run all the abattoir plant will be at a peak load of 590kW (Table 1).

Table 1: Estimates of electrical power consumption

Duty	Connected Power (kVa)	Peak Power (kW)	Average Power(kW)	Duration per day(hrs)	Daily Energy Requirement (kWh)
Processing and general	700	590	420	9	3780
			100	15	1500
Refrigeration and air conditioning	350	300	250	16	4000
			170	8	1360
By-products rendering and steam generation	350	280	200	14	2800
			20	10	200
TOTAL	**1400**	**1170**			**13640**

2.1.2 Water Requirements

Water is the lifeblood of an abattoir and meat processing plant. An adequate and reliable source of potable water is therefore essential to the successful operation of such a plant, whether it be mains or borehole water. As a rule in the industry, for the slaughtering and further processing activities proposed, the water requirement will be about 2,600 litres per head of bovine slaughtered and relatively smaller for sheep and goats. On this basis, the maximum daily water usage will be 550,000 litres (550 m^3) a day. If there is any possibility that the water source may be at all unreliable, then it is wise to provide bulk water storage facilities on site with a capacity equivalent to 2 to 3 days' usage. Hot water will be required in three(3) categories; hot water at 82°C for sterilization, wash down water for cleaning at 62°C, and warm water at 42°C for washing hands and showering. Geothermal fluids (brine and condensate) can provide adequate water for use in abattoir plants depending on its chemistry and uses. Some geothermal fields can be used as gray waters whose chemistry allows for direct usage, especially for cleaning of abattoirs. Geothermal steam condensate is suitable for use in abattoirs with pH adjustment.

3.0 ECONOMIC AND FINANCIAL ANALYSIS

The study's main objectives is to evaluate use of geothermal energy in abattoir processes to replace the traditional sources of energy, which is mostly fossil fuels and assess the benefit of such a venture.. The major energy uses at an abattoir facility are:

- Electricity for equipment, and for lighting, refrigeration and air conditioning, and
- Thermal energy for rendering processes, cooking and drying operations, as well as hot water generation

Geothermal energy source has the potential to provide both electricity and thermal energy for all the operations. In some instances, thermal energy available from geothermal may need to be boosted using fossil fuels to achieve required parameters.

3.1 Financial comparison between geothermal and conventional energy sources

The annual energy costs for an abattoir and processing plant powered by geothermal energy are far lesser than those of the identical plant using conventional energy sources. Table 2 shows an energy cost of US$ 456,140 for geothermal source and US$ 1,175,640 for conventional source, which is more than 2.5 times lower for geothermal. This implies a 60 % reduction in variable costs realized through intervention of geothermal energy to replace conventional sources. This is a substantial reduction in energy cost and can attract an investment.

Table 2: Comparative variable costs between geothermal and conventional energy sources

Energy Source	Annual Energy Requirement (kWh)	Annual Quantity (kg)	Unit	Rate (KES)	Annual Total (KES million)	Annual Total (US$)
Conventional Energy Sources						
Electricity	4,092,000.00		kWh	15.3	62.61	695,640.00
Coal for steam boilers	18,551,400.00	2700000	kg	16	43.20	480,000.00
Total					**105.81**	**1,175,640.00**
Geothermal Energy Sources						
Wellhead electricity generation	2,484,000.00		kWh	7.65	19.00	211,140.00
Refrigeration(absorption)	1,608,000.00	300 days	days	19500	5.85	65,000.00
Geothermal steam generation	18,555,400.00	300 days	days	54000	16.20	180,000.00
Total:					**41.05**	**456,140.00**
Savings in annual energy costs					**63.95**	**710,500.00**

The capital costs of setting up an abattoir facility is slightly higher than a conventional powered facility at 15% more as a result of the capital investment in making a provision for a wellhead unit for converting geothermal energy into electrical and usable heat energy. Table 3 indicates a capital cost of US$ 22,205,700 for a geothermal powered complex while a conventional energy powered plant costs US$ 19,312,700. The benefits of the operation costs based on the energy costing outweigh the initial investment cost.

Table 3: Comparison of capital costs using conventional sources versus geothermal sources of energy

Description	Estimated Capital Cost	
	Conventional sources of energy (US$)	**Geothermal energy (US$)**
Abattoir and processing plant and supporting infrastructure	14,577,000.00	14,577,000.00
Ancillary services	2,980,000.00	2,130,000.00
Geothermal energy source		3,480,000.00
Wellhead electrical power plant		2,800,000.00
Refrigeration plant		280,000.00
Steam generation system		400,000.00
Contingency, 10%	1,755,000	2,018,700.00
Overall Total	**19,312,700.00**	**22,205,700.00**

4.0 CONCLUSIONS AND RECOMMENDATIONS

The findings indicate a viable business case resulting from the relationship between abattoir processing and geothermal development in Kenya. With the target of generating 5000MWe from geothermal energy sources by the year 2030, pastoralists, situated in geothermal rich areas can benefit from the exploitation of the resources by setting up abattoir processing facilities. Geothermal resources will provide the required electrical and thermal energy as well as water. Though the initial set up cost for a geothermally operated is slightly higher than that of a conventionally powered one, there is a substantial cost saving in energy cost for a geothermal powered facility. The profitability for a geothermal powered abattoir is enhanced by value addition to the abattoir products to. From the study, geothermal energy has a great potential to transform the abattoir processes as well as increase their profitability. Collaboration with all stakeholders is of paramount importance in determining the success of a geothermally powered abattoir. A full feasibility study is recommended.

5.0 REFERENCES

GDC (2015). Prefeasibility Study Report on Processing of Meat and other Abattoir By-products using Geothermal Energy, June 2015. Case Study of Kenya.

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