An optimized solar camel milk powder processing for arid and semi-arid regions: A theoretical approach

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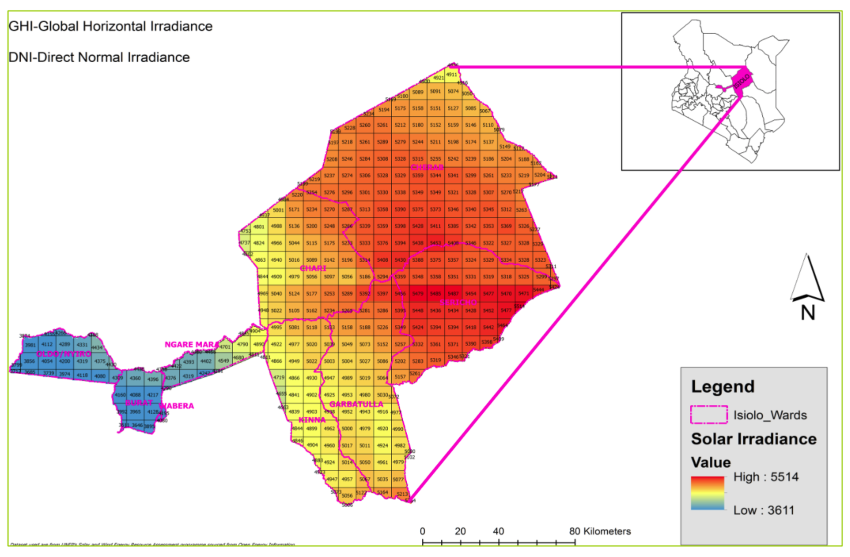
Introduction

- Kenya's camel milk industry contributes significantly to the economic and nutritional security of the populations in the arid and semi-arid areas (ASALs)
- Inadequacy of preservation technologies limits its production and consumption to ASAL populations
- Processing the milk into milk powder is one approach for the extension of shelf life. This process is, however, very energy intensive.
- The exemption from Value Added Tax on solar products by Kenyan government and the high solar irradiance in these regions provides an alternative energy source.

Methodological approach



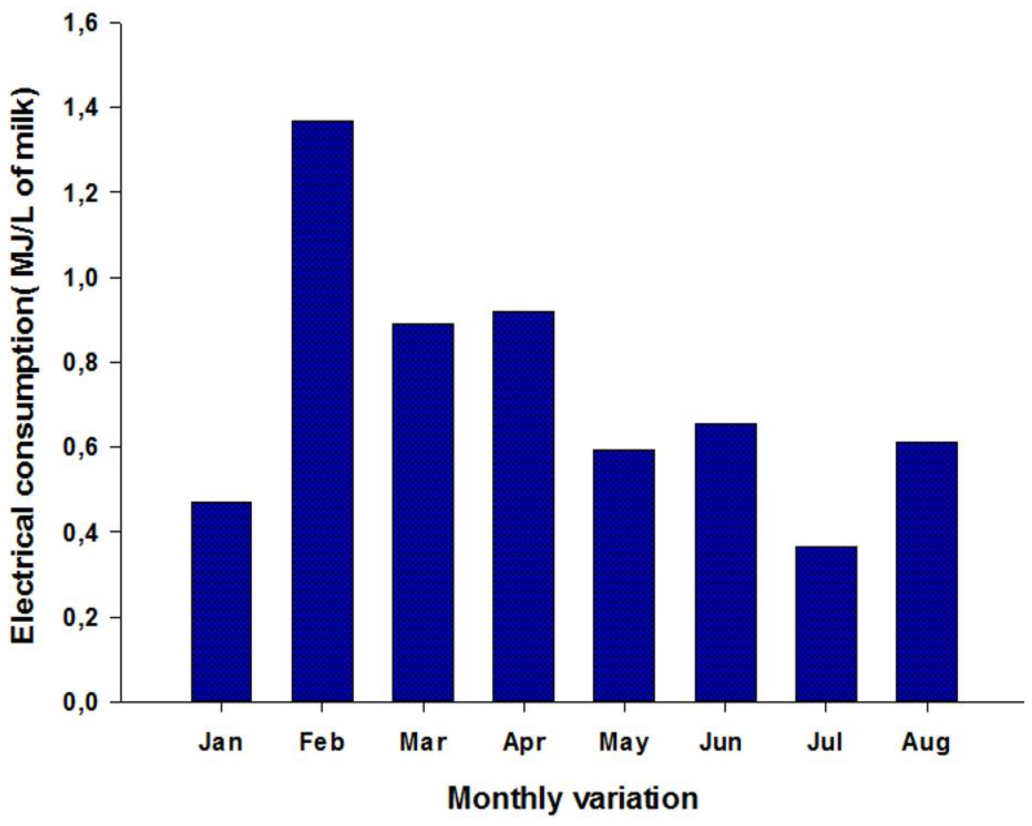
- Altitude 200-300m
- Mean temperature 23.3°C
- Bimodal rainfall of 580 mm

Figure 1: Solar irradiance of Isiolo County, Kenya

- Secondary data collection on monthly milk volumes, temperatures & electrical consumption in Isiolo County, Kenya.
- The theoretical plant is considered which process 3135 litres of milk to powder per day, runs 5 days a week and 40 weeks per year
- Methodological approach based on: step wise heat recovery[1], PinCH2 analysis[2] and IEA SHC Task 49[3]

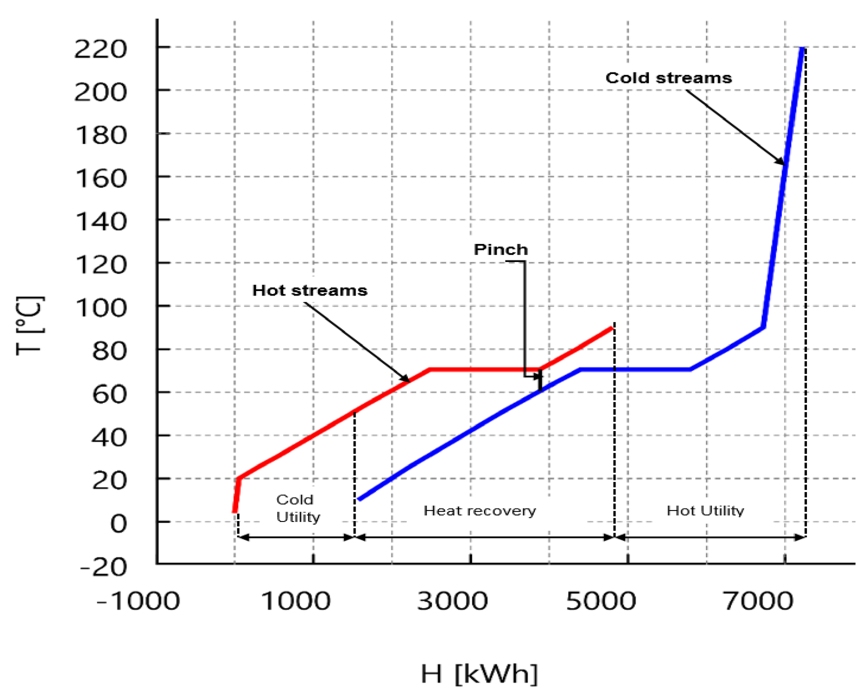
Figure 2: Methodological approach

Results



- Only chilling occurs at the bulking centre, no further milk processing
- Highest electrical consumption in seasons of milk scarcity.

Figure 3: Electrical consumption for milk chilling per litre of camel milk in 2015 in Isiolo County



- Cooling energy to be provided to processes of temperatures below 50°C while heating to processes that require heating above 90°C

Figure 5: Milk powder processing composite curve calculated with the time average model (TAM) for a T_{min} of 10K

Camel milk powder process flow

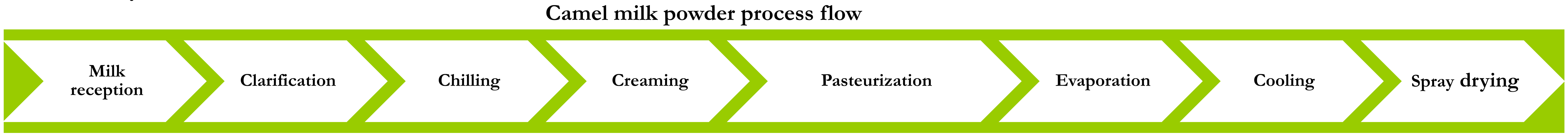


Figure 4: Process flow in milk powder production

Table 1: Summary of energetic results of different optimization scenarios

Scenario	Hot Utility demand (MWh/a)	Heat utility replacement (MWh/a)	% Heat recovery
Current demand	1265.1	-	-
TAM	847.6	417.5	33.0
TSM	617.6	647.5	51.2
Condensate recovery	1172.6	92.5	7.3
Pre heating inlet air	1233.6	31.5	2.5
CIPwater preheating	1113.0	152.1	12.0
Regeneration Heat recovery	1248.9	16.2	1.3
Flue gas heat recovery	783.7	481.4	38.1
Total modifications	491.5	773.6	61.1

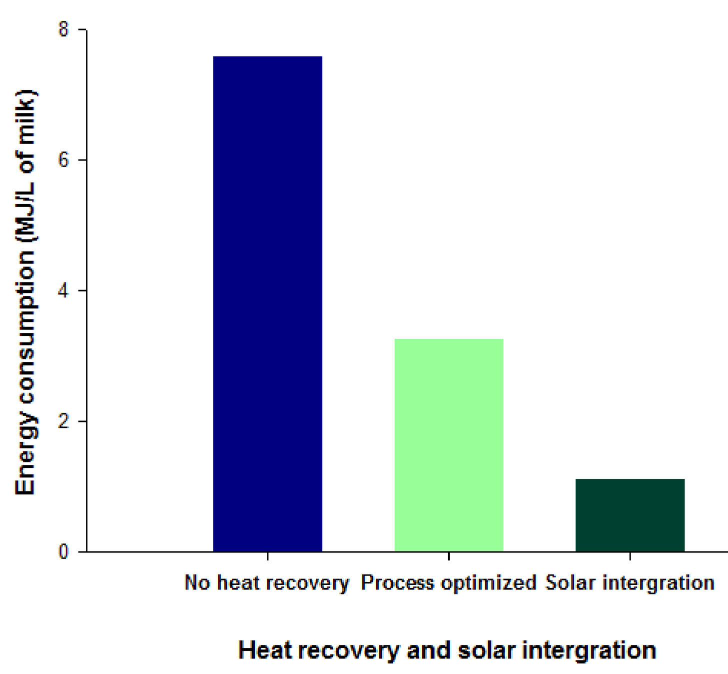


Figure 6: Heat recovery and solar integration

- Solar intergration for processes belo 90°C through solar hot water systems (pasteurization, evaporation & CIP)
- For drying air, first preheated to 90°C, then using fuel oil boilers, temperatures raised to the desired temperatures
- Water consumption was estimated to decrease by 50%

Conclusions and Future work

- By optimizing the system through heat recovery at various points of the process, approximately 61.1 % of the heat supplied could be reduced.
- Solar integration after optimization further reduces the energy demand by approximately 20% of the thermal demand.
- Further work, is on economical analysis of the proposed system to determine its feasibility for the ASAL regions.

References

[1]Schmitt, B. 2014. Integration thermischer Solaranlagen zur Bereitstellung 616 von Prozesswrme in Industriebetrieben (in German). Dissertation (Dr.-617 Ing.), University of Kassel, Kassel, Germany.
[2]Olsen, D., Egli, A., Wellig, B., 2010. PinCH: An Analysis Tool for the Process 592 Industries. 23rd International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems (ECOS), June 14-17, Lausanne
[3]Muster-Slawitsch, B. (Coordinating Author), Hassine, I., Helmke, A., Hess, S., Krummenacher, P., Schmitt, B., Schnitzer, H., 2015. Solar Process Heat for Production and Advanced Application - Integration Guideline, IEA SHC Task 49, Deliverable B2.

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