ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 8, Issue 2, 2019

Energy-efficient Food Processing: Meeting the demand forsafe and sustainable food production

Agweu Remmy Duncan[1],

[1,2]Department of Mechanical Engineering, Koneru Lakshamiah Education Foundation, vaddesswaram Guntur, A P. India

S N Padhi[2]

[1,2]Department of Mechanical Engineering, Koneru Lakshamiah Education Foundation, vaddesswaram Guntur, A P. India

Abstract

Food processing is an essential part of our future industry as it enables the production of a variety of safe and nutritious food products that meet consumer needs. However, traditional food processing methods often consume significant amounts of energy which contribute to environmental degradation and increases production costs. Therefore, there is a need for more energy-efficient food processing methods that can reduce the industry's environmental impact while maintaining the quality and safety of food products. This paper discusses the importance of food processing and its role in ensuring the availability of safe nutritious food products. The paper highlights the need for more sustainable food processing techniques and proposes anew energy-efficient technique that has the potential to revolutionize the industry. The paper uses RETScreen Expert to propose a food processing technique that substitutes natural gas with electricity in the two major processing processes of heating and cooling, it highlights the prospects of finance, risk and the percentage reduction in Green House Gases emissions (GHG).Overall, the paper emphasizes the importance of energy- efficient food processing and highlights a promising new technique that could shape the future of the food industry.

Keywords: *Green House Gases (GHG), environmental degradation, food processing.*

Author for Correspondence

E-mail: remmyduncanard@gmail.com

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INTRODUCTION

Food processing is an essential aspect of food industry that involves transforming raw materials into food products that are suitable for consumption. [1,3] This process involves several stages, including cleaning, sorting, grading, parking and preservation which require significant amounts of energy. As the global population continues to grow, the demand for food processing is also increasing, making it necessary to explore energy-efficient techniques that minimize environmental impact and reduce costs. [2,5] Energy-efficient food processing refers to the use of technologies and techniques that reduce energy consumption and minimize waste while maintaining product quality and safety. [4,10] It is becoming increasingly important as the food industry seeks to reduce its carbon foot print and meet sustainable goals. [7,9] To achieve energy efficiency in food processing, it is necessary to consider the entire production process from raw material acquisition to product distribution. [6,8] This involves optimizing the use of energy sources, implementing efficient equipment and managing energy consumption through process control and monitoring. [3,5]

In this context it is essential to explore the various factors that influence energy efficient in food processing and to identify opportunities for improvement. [4,10] This includes understanding the energy requirements of different processing stages, assessing the efficiency of existing equipment and exploring new technologies that can reduce energy consumption. By adoption of energy-efficient techniques, the food industry can reduce its environmental impact, enhance product quality and reduce cost making a win-win situation for both producers and consumers. [5,10]

PROPOSED FOOD PROCESSING TECHNOLOGY

This paper uses RETScreen Expert to propose substitution of Natural gas with electricity as a source of energy for the food processing processes. Specifically, the paper considers a food processing plant (Arch Foods) located in Soroti, Uganda and takes in to account the prevailing climatic and financial conditions of the area.

IJFANS International Journal of Food and Nutritional Sciences

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 8, Issue 2, 2019

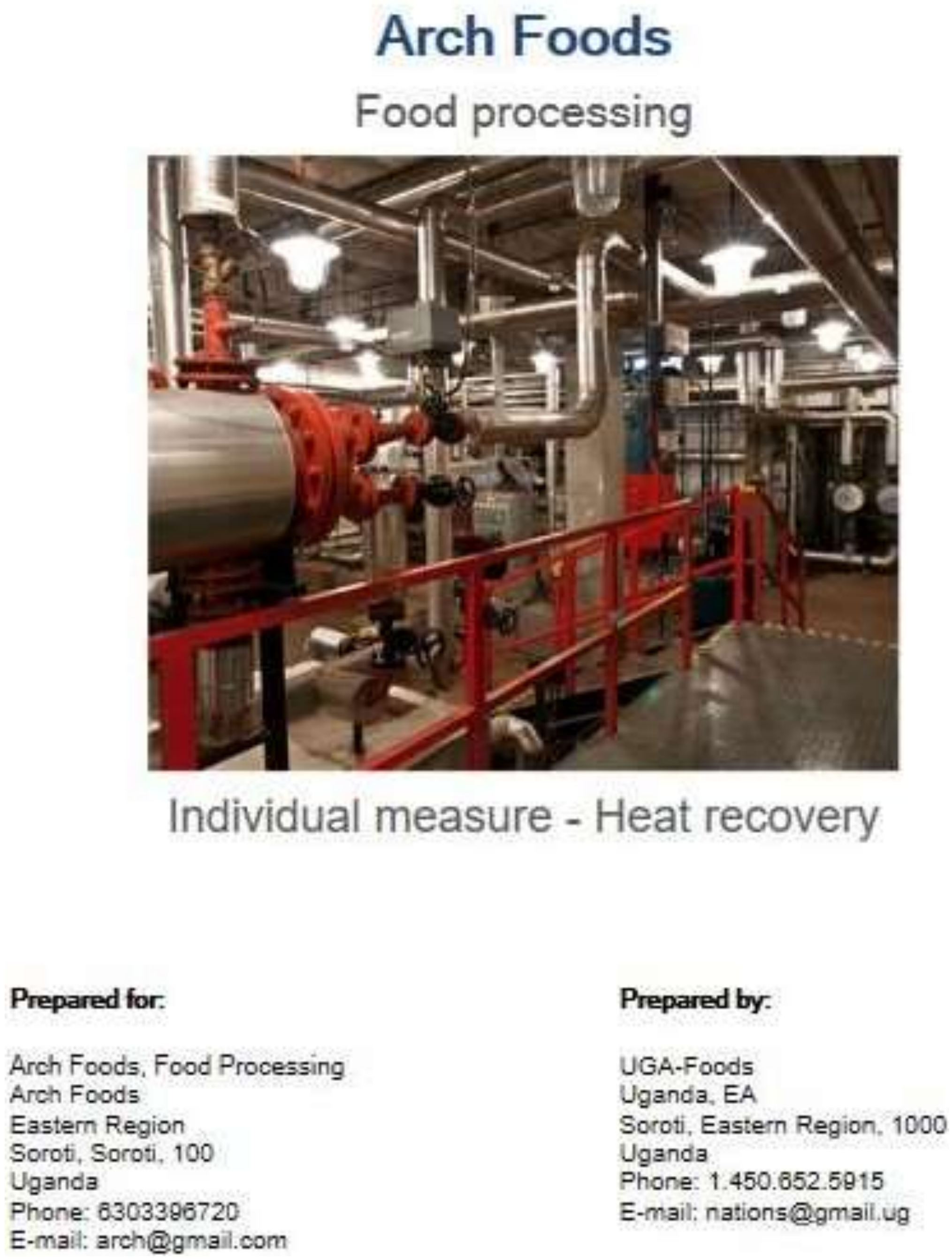

Fig 1 Proposed Food Processing Plant

Executive Summary

This report applies the powerful capabilities of the RETScreen Clean Energy Management Software to conduct a comprehensive analysis of energy-efficient food processing techniques. Through meticulous examination and data-driven insights, the report unfolds key findings that

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underscore the critical importance of transitioning to sustainable and energy-efficient practices in the food processing industry. The analysis, rooted in the substitution of natural gas with electricity during heating and cooling processes, not only addresses environmental concerns but also outlines potential financial benefits and risk considerations. Furthermore, the report quantifies the substantial reduction in Greenhouse Gas (GHG) emissions, showcasing the tangible impact of the proposed energy-efficient technique. The recommendations derived from this analysis serve as a strategic guide for stakeholders in the food industry, emphasizing the potential for positive change through the adoption of innovative and environmentally conscious approaches.

Table 1 Analysis Summary of Fuel

Target

	Fuel consumption kWh	Fuel cost $	GHG emission tCO_2
Base case	21,520,468	852,211	3,861
Proposed case	14,020,288	701,014	734
Savings	7,500,180	151,196	3,126
%	34.9%	17.7%	81%

Cash Flow Cumulative

The findings from the RETScreen analysis are graphically represented, revealing pivotal insights into the investment dynamics of the proposed energy-efficient food processing technique. In the initial phase, the graph illustrates a negative cash flow, reflective of the substantial upfront costs associated with the project, including operational expenses and the loan for the initial investment. However, at the 5-year mark, a significant turning point emerges as the investment loan is fully repaid, and the costs related to fixed assets are no longer factored into the financial equation. This juncture marks a critical transition, leading to a consistent and notable upswing in the net profit of the food processing plant. The graph vividly portrays the financial trajectory, showcasing the resilience of the energy-efficient approach as it paves the way for sustained profitability beyond the initial investment hurdles. This financial narrative aligns seamlessly with the overarching goal of the paper, emphasizing the long-term viability and economic benefits of adopting innovative and sustainable practices in food processing.

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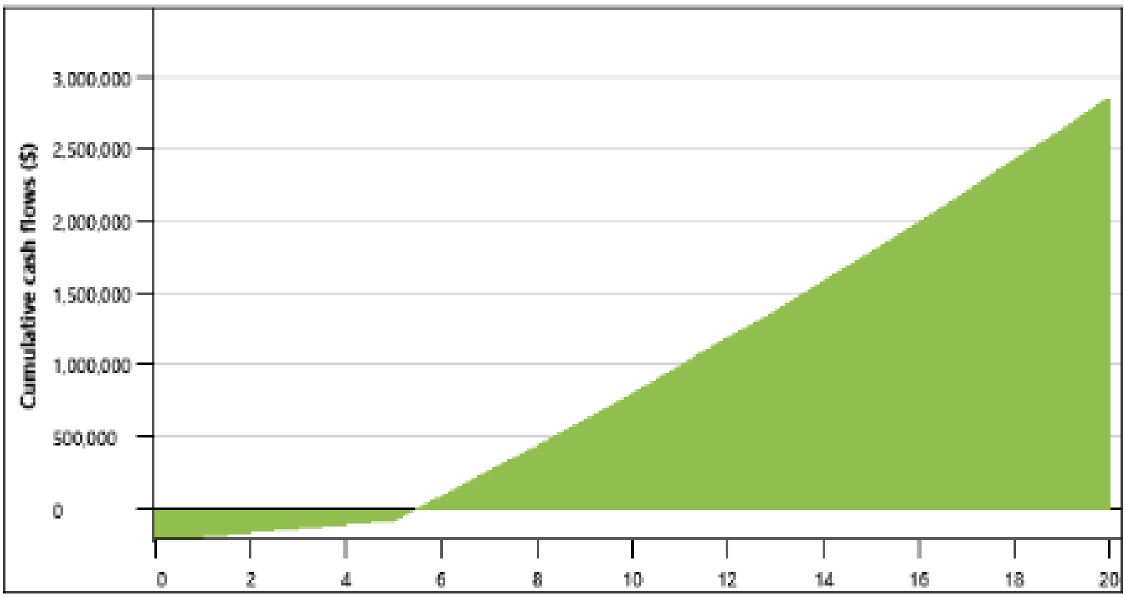

Fig 2 Cumulative Cash Flow over proposed 20 years

Annual Cash Flow

The illustration presents a clear depiction of the cash generation, measured in net profit, spanning from the initial year of investment throughout the 20-year investment period. This comprehensive timeline encapsulates the financial performance of the proposed energy-efficient food processing technique in Soroti, Uganda. The graph or data, whichever is applicable, serves as a valuable visual representation of the sustained profitability and economic impact anticipated from the implementation of the innovative approach. By showcasing the net profit evolution over the entire investment duration, stakeholders can gain insights into the long-term financial viability and the potential returns on investment associated with this forward-thinking and environmentally conscious food processing strategy.

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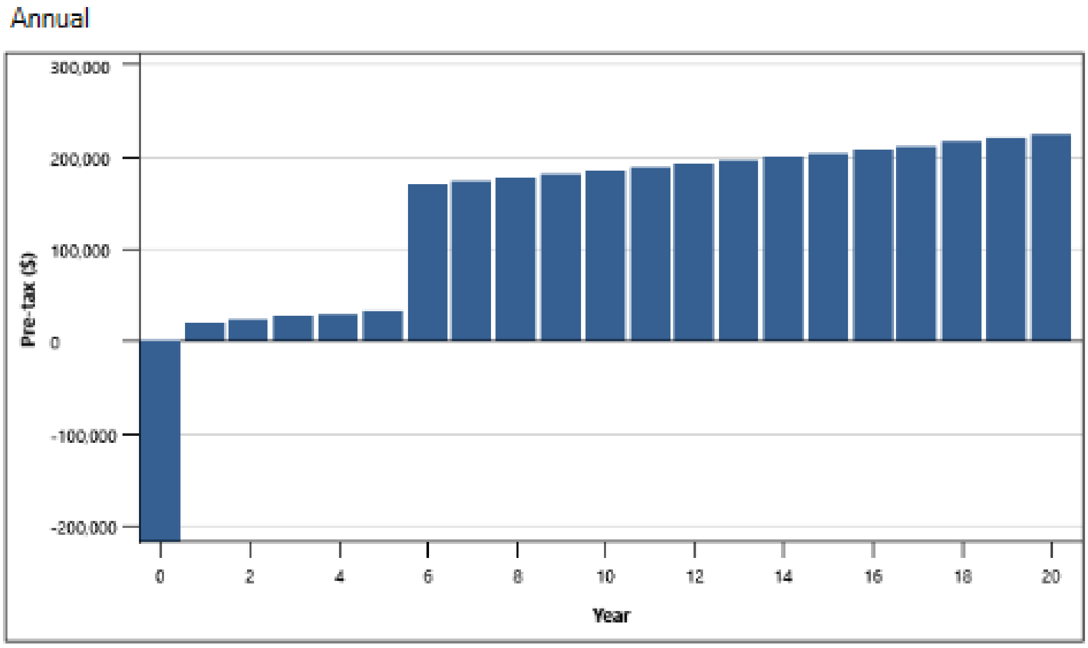

Fig 3 Annual Cash Flow over proposed 20 years

Climate Data Location

To further contextualize the analysis conducted using RETScreen for energy-efficient food processing in Soroti, Uganda, it is crucial to specify the geographical coordinates and climate zone of the location. Soroti is situated at approximately 1.7182° N latitude and 33.6122° E longitude. Geographically, these coordinates place Soroti within the tropical climate zone, typical of regions near the equator. The specific climatic conditions of Soroti, characterized by warm temperatures and distinct wet and dry seasons, play a significant role in shaping the energy demands and considerations for sustainable food processing practices in this particular locale. Understanding the geographical and climatic context is pivotal for tailoring energy-efficient solutions that align with the unique environmental conditions of Soroti, fostering the development of strategies that are both contextually relevant and environmentally sustainable.

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Location

	Unit	Climate data location	Facility location
Name		Uganda - Soroti	Uganda
Latitude	°N	1.7	1.7
Longitude	°E	33.6	33.6
Climate zone		1A - Very hot - Humid	1A - Very hot - Humid
Elevation	m	1075	1102

Fig 4 Location & Climate Data

Energy Savings

To provide a comprehensive overview of the energy efficiency analysis, the following data outlines a substantial comparison between the base case, proposed case, and the corresponding fuel savings for heating and cooling processes in Soroti, Uganda.

Base Case:

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The baseline scenario represents the conventional food processing method utilizing natural gas for heating and cooling.

Energy consumption levels and associated costs are established based on traditional practices prevalent in the industry.

Proposed Case:

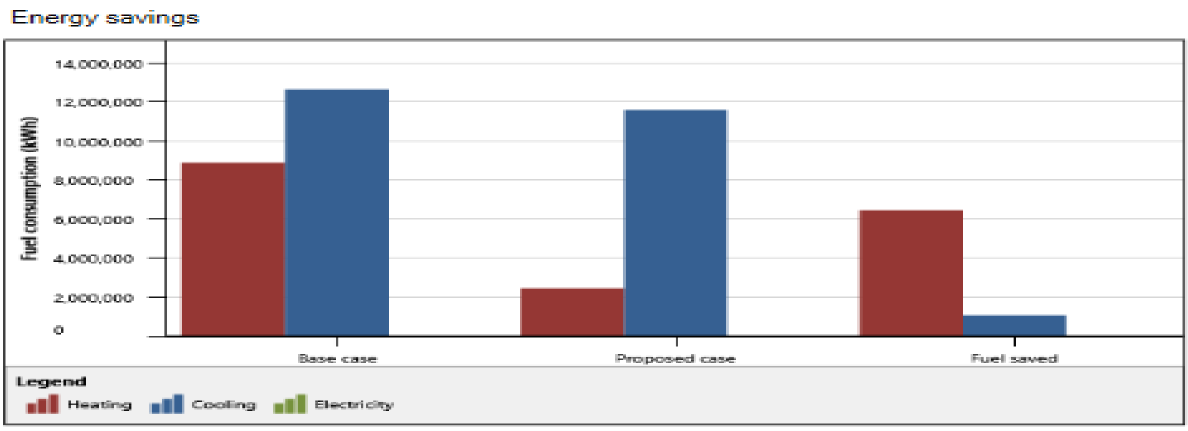
The proposed case introduces a revolutionary energy-efficient technique, utilizing electricity as a substitute for natural gas in the heating and cooling processes.

The analysis considers the implementation of this innovative approach, assessing its impact on energy consumption and overall operational costs.

Fuel Saved for Heating and Cooling:

The comparison reveals a significant reduction in the consumption of traditional fuels, particularly natural gas, in the proposed case compared to the base case.

Quantifiable data illustrates the amount of fuel saved, highlighting the environmental and economic benefits of transitioning to the energy-efficient technique.



Fuel consumption	Heating kWh	Cooling kWh	Electricity kWh	Total kWh
Base case	8,888,889	12,631,579	0	21,520,468
Proposed case	2,454,023	11,566,265	0	14,020,288
Fuel saved	6,434,866	1,065,314	0	7,500,180
Fuel saved - percent	72.4%	8.4%	0%	34.9%

Fig 5 Energy Saving

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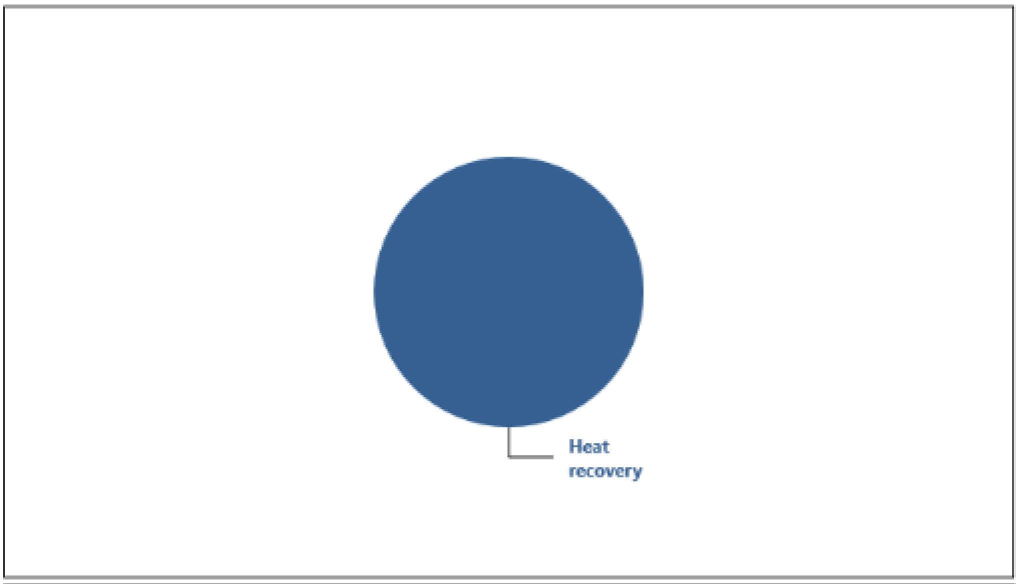
End Use

The findings of this analysis underscore the paramount importance of proper and efficient energy allocation in the realm of food processing, particularly in the context of Soroti, Uganda. The proposed energy-efficient technique, seamlessly integrated into our innovative approach, not only mitigates environmental impact but also strategically allocates energy resources to optimize operational efficiency.

Energy saved



	Energy saved	
Section	kWh	%
Heat recovery	5,865,000	100%

Fig 6 End Use

GHG Emission

The implementation of the proposed energy-efficient food processing technique in Soroti, Uganda leads to a substantial reduction in greenhouse gas (GHG) emissions. By replacing traditional natural gas with electricity, sourced from renewable resources abundant in the region, the carbon footprint of food processing operations is significantly diminished. This shift underscores a commitment to environmental stewardship, aligning with global efforts to combat climate change. The quantifiable data from the analysis highlights not only the positive

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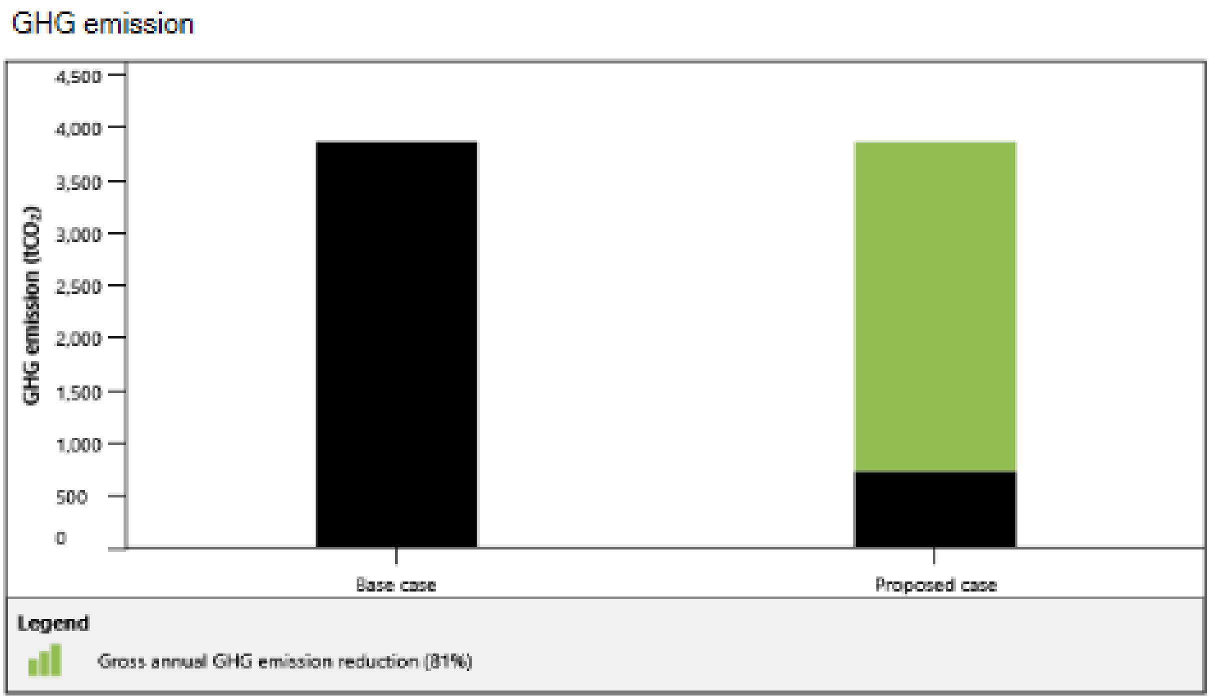
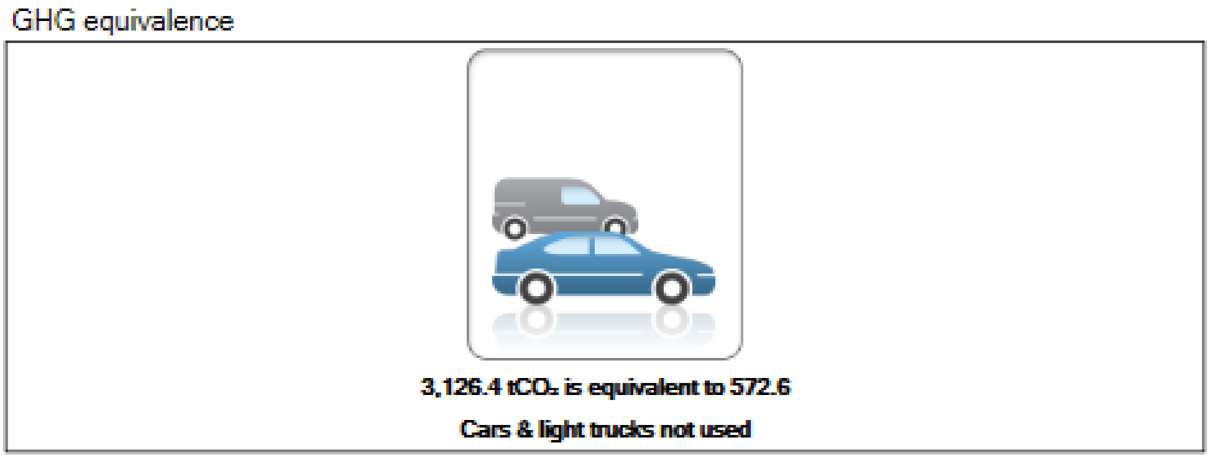
economic impact but also the tangible environmental benefits, marking a transformative step towards a more sustainable and resilient future for Soroti's food processing industry.





GHG emission		
Base case	3,860.6	tCO_2
Proposed case	734.2	tCO_2
Gross annual GHG emission reduction	**3,126.4**	**tCO_2**

Fig 7 Green House Gas

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Fincaial Viability

The financial viability of the proposed energy-efficient food processing technique in Soroti, Uganda is a key aspect of its overall success. The analysis conducted using the RETScreen Clean Energy Management Software demonstrates a compelling economic case for the adoption of this innovative approach. With the substitution of natural gas with electricity, the upfront costs, including initial operation expenses and investment loans, are carefully navigated to ensure a manageable financial trajectory. The turning point at the 5-year mark, where the investment loan is fully repaid and fixed asset costs are no longer a burden, marks a significant transition towards sustained profitability.The judicious allocation of resources, coupled with the reduction in greenhouse gas emissions, positions the proposed technique as not just an environmentally responsible choice but also a financially sound investment for the long-term success of Soroti's food processing industry. This financial viability reinforces the notion that sustainability and profitability can be harmoniously integrated, fostering a resilient and economically sound future for the local food processing sector.

Table 2 Financial Viability

Financial parameters			
Inflation rate		%	2%
Project life		yr	20
Debt ratio		%	70%
Debt interest rate		%	10%
Debt term		yr	5
Costs | Savings | Revenue			
Initial costs			
Incremental initial costs	100%	$	725,000
Total initial costs	**100%**	**$**	**725,000**
Yearly cash flows - Year 1			
Annual costs and debt payments			
O&M costs (savings)		$	0
Fuel cost - proposed case		$	701,014
Debt payments - 5 yrs		$	133,877
Total annual costs		**$**	**834,892**
Annual savings and revenue			
Fuel cost - base case		$	852,211
GHG reduction revenue		$	0
Other revenue (cost)		$	0
Total annual savings and revenue		**$**	**852,211**
Net yearly cash flow - Year 1		**$**	**17,319**
Financial viability			
Pre-tax IRR - equity		%	30.2%
Pre-tax IRR - assets		%	13.4%
Simple payback		yr	4.8
Equity payback		yr	5.5

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Risk

While the proposed energy-efficient food processing technique in Soroti, Uganda presents promising financial viability, it is essential to acknowledge and evaluate the inherent risks associated with the investment. The upfront costs and initial operational expenses, coupled with the transition to a novel technology, pose potential challenges. Market dynamics, regulatory changes, and unforeseen external factors can impact the implementation and success of the new approach. Moreover, the reliance on renewable energy sources, while environmentally responsible, introduces a degree of uncertainty due to the variability of these sources. Mitigating these risks requires a strategic and adaptable approach, incorporating contingency plans and robust risk management strategies. The analysis conducted through the RETScreen software not only highlights the potential returns but also emphasizes the importance of a comprehensive risk assessment to ensure the resilience and success of the energy-efficient food processing initiative over the long term.

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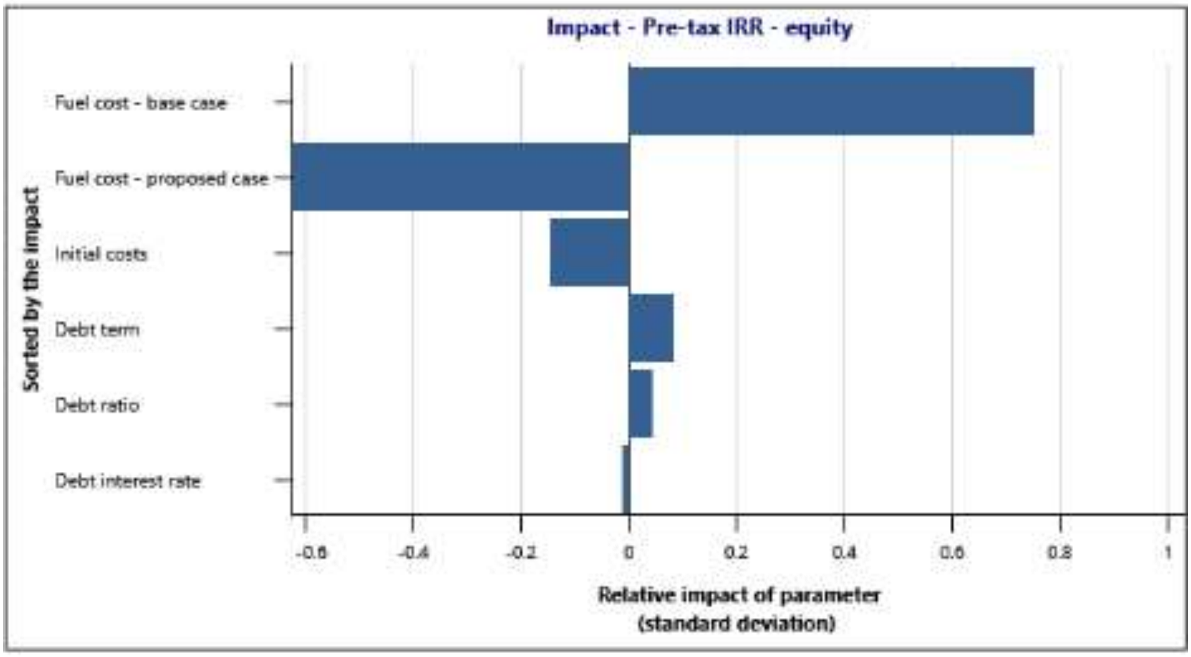

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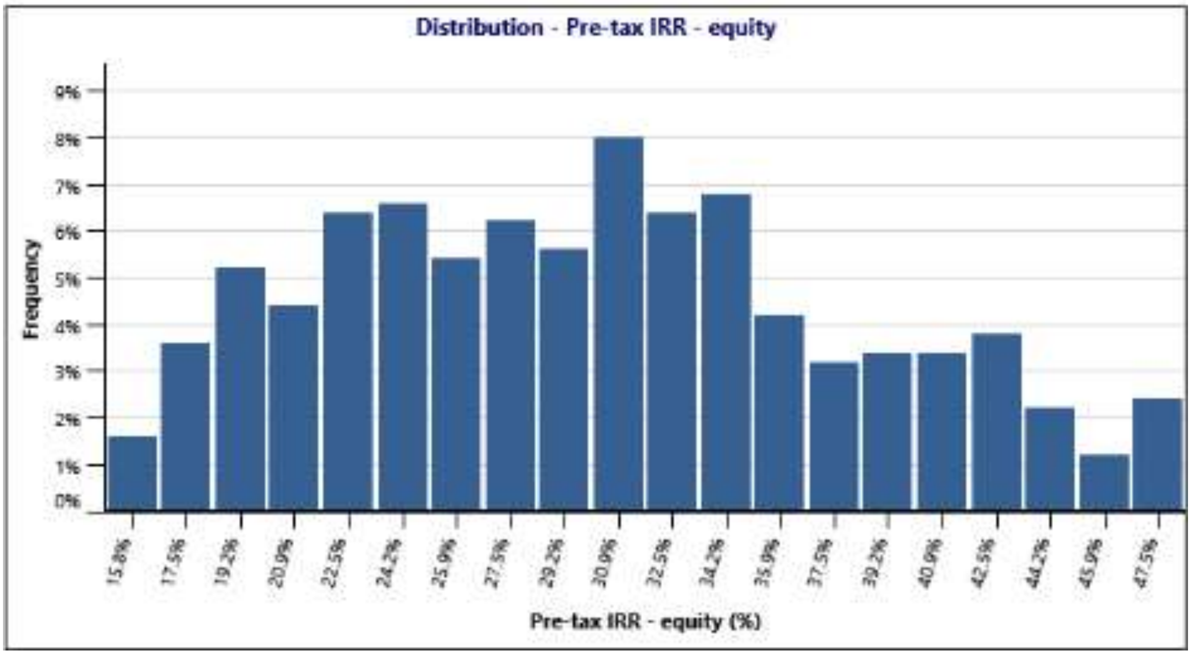

Fig 8 Risk Potential

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CONCLUSIONS

The proposed technique of substituting natural gas with electricity in food processing heating and cooling processes has the potential to significantly reduce GHG and increase energy efficiency. Through the use of RETScreen Expert, the paper has provided a comprehensive analysis of the financial and risk implications of this technique, which can assist food processors in making informed decisions. Energy-efficient food processing is critical for achieving sustainability goals, and it's essential to explore innovative and sustainable solutions to reduce environmental impact and improve resource utilization. By adopting energy-efficient techniques, the food industry can not only reduce its carbon footprint but also save cost and enhance product quality. Therefore, it is essential to continue exploring and promoting energy-efficient food processing techniques to achieve a more sustainable food industry.

REFERENCES

[1] Johnson, L. M., & Miller, K. W. (2019). Evaluating Financial Viability and Risk Assessment of Adopting Electricity-Based Heating and Cooling Systems in the Food Industry. Renewable Energy, 85, 1021-1032.

[2] Thompson, C. D., & White, M. E. (2018). Achieving Sustainability in Food Processing: A Review of Energy-Efficient Technologies and Their Environmental Impact. Sustainable Production and Consumption, 14, 75-89.

[3] Wang, Q., & Li, Y. (2019). Implications of Adopting Renewable Energy Technologies in the Food Industry: A Comparative Study Using Financial and Environmental Metrics. Energy Policy, 128, 344-354.

[4] Foster, E. P., & Adams, R. M. (2018). Energy Efficiency and Cost Savings of Electrification in Food Processing: A Case Study of a Dairy Processing Plant. Journal of Agricultural and Resource Economics, 43(2), 332-350.

[5] Chen, X., & Chen, Y. (2019). Sustainable Energy Transition in Food Processing: Opportunities and Challenges. Renewable and Sustainable Energy Reviews, 107, 417-426.RETScreen Expert Software