Potential and Economic Impact of Renewable Energy in Improving African Rural Food Processing

Presented by R. K. Padi

Dr. A. Chimphango
Prof. J.F. Görgens

Overview

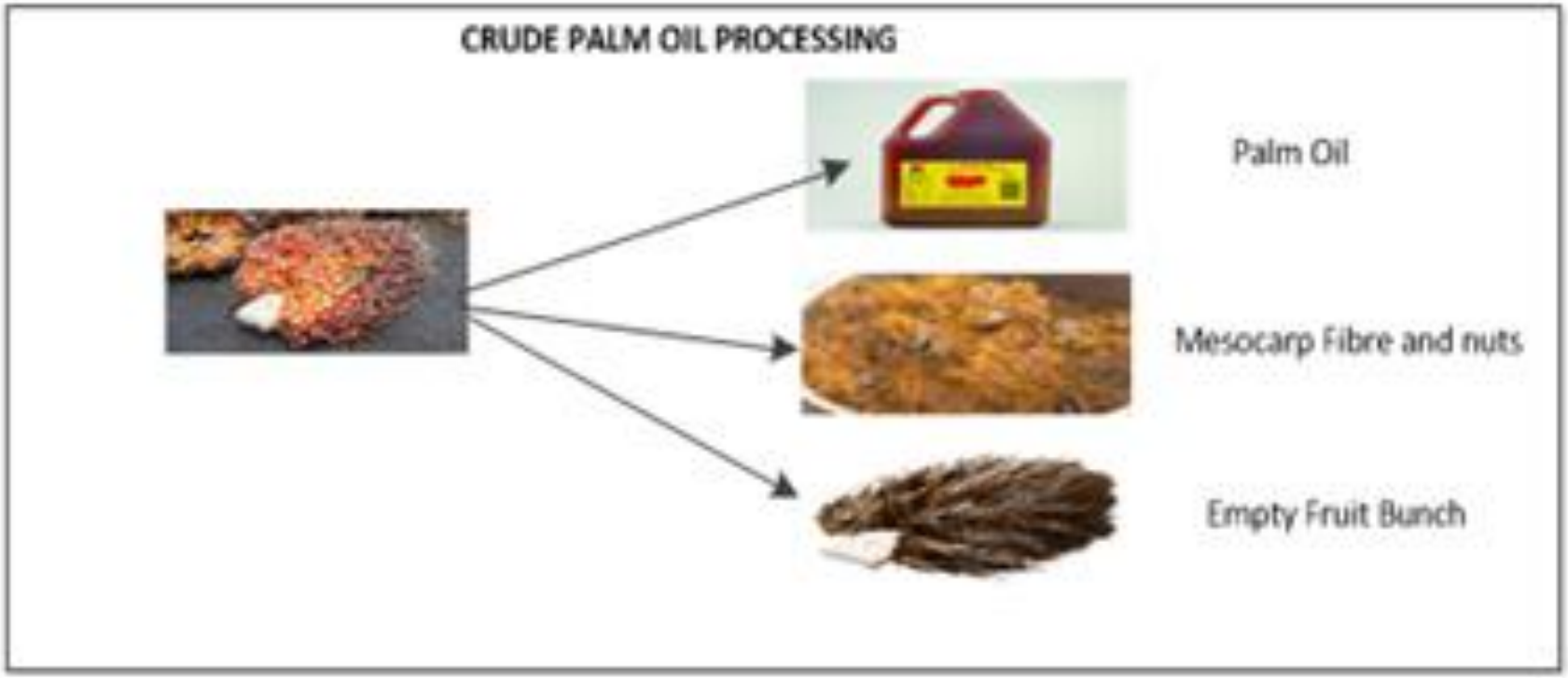
- Introduction
- Problem Statement
- Objectives
- Process Modelling Approach
- Preliminary Results
- Conclusion
- Future works

Introduction

- RE Portfolio
  - Wind (about 550 MW implemented (GWEC, 2011))
  - Geothermal (Potential of 9000 MW)
  - Hydro (1750 TWh; 5 % exploited)
  - Solar insolation varies between 3 to 6.2 kWh/m^2/day
  - Biomass (wood, Animal waste, agricultural residues and charcoal)

- Application in rural food processing
  - Potentials (Biomass & Solar)
  - Limitations
    - Biomass: Inefficient combustion; deforestation
    - Financial & Technical barriers
  - Improved application by strategic & optimal energy-mix

Crude Palm Oil Processing (Case Study)



CPO

- One of the world's leading sources of vegetable oils
- Food applications: soup-mix, cooking oil, margarine and confectionary fats
- Predominantly consumed in developing countries in Africa and Asia (cheap cost)

African CPO

Export market potential in West Africa

- 2.6 million tons; only 0.8 million tons is produced annually (Kyei-Baffour and Manu, 2008).

Dominating traditional processors.

- Eg. Nigeria: traditional processors-80%; Semi-mechanized processors - 16 %; Mechanized processors - 4 % (Ohimian et al, 2012).

Problem Statement

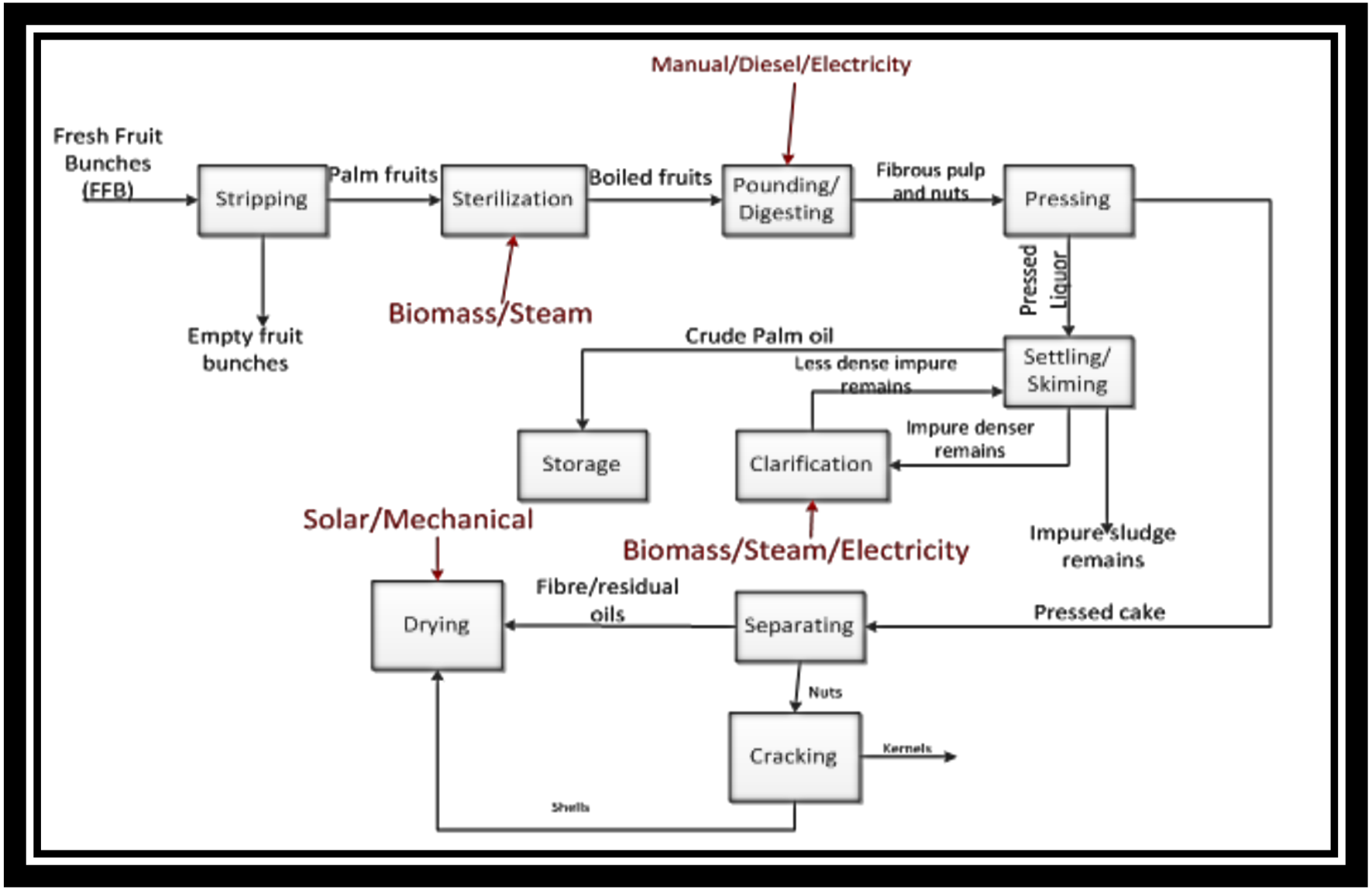
- Challenges of Traditional (dominating) Processing
  - Poor quality
  - Lower production capacities
  - Labour Intensive

- Why Minimal Mechanisation?
  - Perceived risk factors and implications on profit margins
  - Unavailable and expensive fossil fuels and electricity

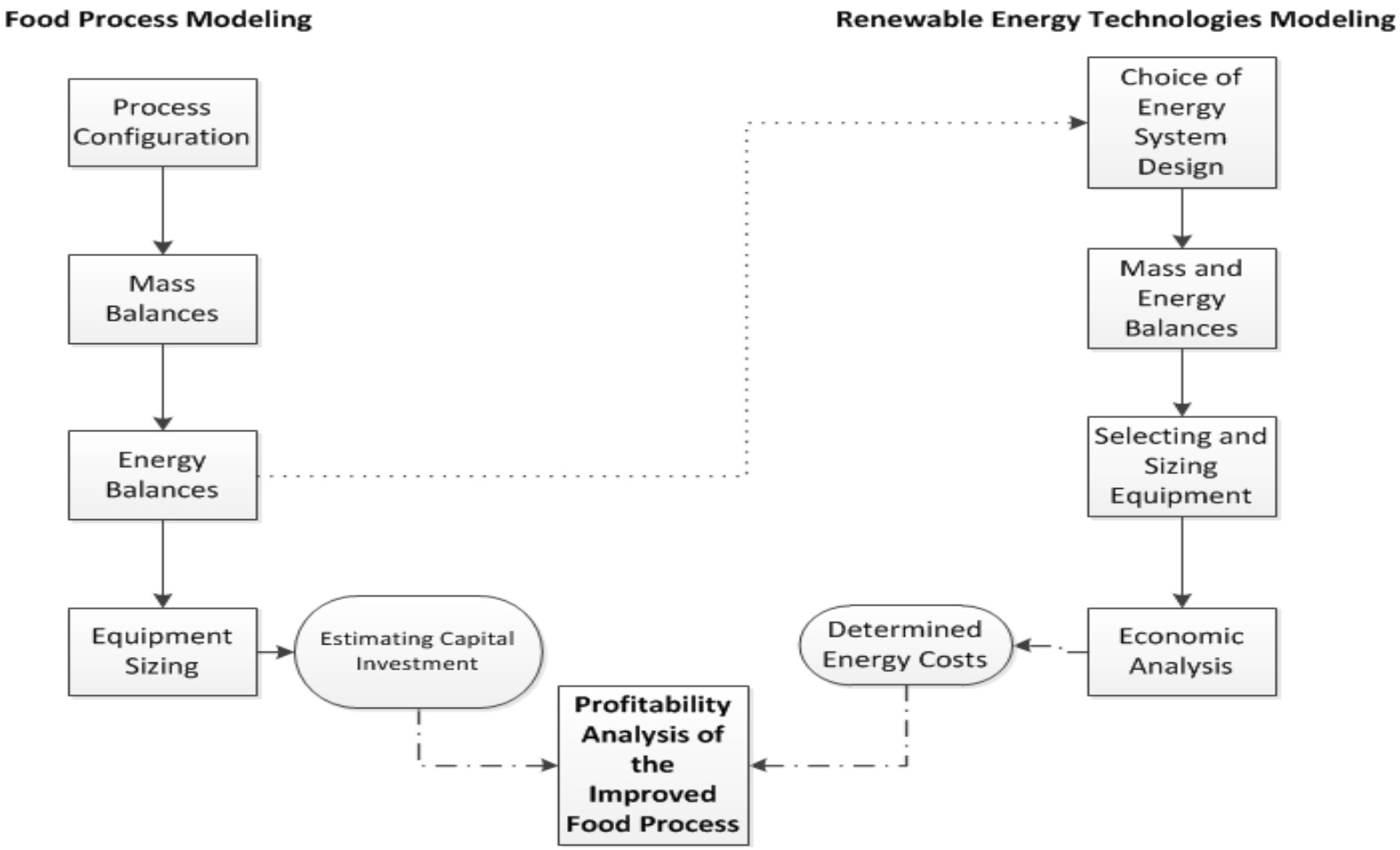
Objectives

- Establish the possible extent of mechanizing rural CPO processing with respect to economic viability.
- Determine the appropriate renewable energy-mix (emphasis on biomass residue)
- Ascertain the economic benefits of renewable energy integration in the rural CPO processing.

Simplified CPO Process



Process Modelling Approach



Food Process Modelling

- Performed in Excel Spreadsheet
- 3 levels of mechanization considered
  - Traditional
  - Semi-Mechanized
  - Mechanized
- Each level above:
  - Base-Case : typical processing approaches; conventional energy sources presently employed.
  - Corresponding Improved-Case: Suggested improvement in processing approach; energy sources from potential renewables

Energy Integration

- Traditional
  - B/C: Firewood, Inefficient tripod stoves (15% efficiency)
  - I/C: Mesocarp Fibre & EFB, Improved-cookstoves(30% efficiency)

- Semi-Mechanised
  - B/C: EFB/MF/ Diesel, Inefficient tripod stoves (15% efficiency)
  - I/C: MF/Biogas (POME), Improved-cookstoves(30% efficiency)

- Mechanised
  - B/C: Steam(shell/MF), Electricity from national grid
  - I/C: CHP (EFB,MF,Shell), Biogas (POME)

Preliminary Results

- Traditional Process:

Overall Material balance			
Inputs	**Value (kg/day)**	**Outputs**	**Value (kg/day)**
FFB	58	Mesocarp fibre	7.83
Water	70.90	Nuts	10.09
		POME	46.28
		CPO	9.73
		EFB	23.2
B/C Energy		**I/C Energy**	
Amount of fuel wood (kg/day)		**Amount of fuel (kg/day)**	
Sterilisation (wood)	19.8	Mesocarp Fibre	7.83
CPO drying (wood)	0.87	EFB	6.26
Total	20.67		

- Semi-Mechanised Process:

	Overall material balance				
	Inputs	**Value (tons/day)**	**Outputs**	**Value (tons/day)**	
	FFB	8	EFB	3.2	
	Water	4.76489	Mesocarp fibre	1.08	
			Nuts	2.423699	
			POME	0.288	
			Residual oil in fibre	0.336	
			CPO	1.056	
B/C Energy			**I/C Energy**		
Amount of fuel per day			**Amount of Fuel per day**		
EFB	2889.101	kg/day	M. fibre	1080	kg/day
M. fibre	1080	kg/day	Residual oil	238.244	kg/day
Residual oil in fibre	336	kg/day	Electricity	31.67816	kWh
Diesel oil	0.00259	cubic metre/day			

- Mechanised Process

Overall Material Balance			
Input	**Value (tons/day)**	**Outputs**	**Value (tons/day)**
FFB	208	Dry CPO	45.7
Steam	72.8	Kernels	27.75
		Shells	14.61
		Mesocarp Fibre	28.08
		POME	121.23
		EFB	97.38
	Overall Energy Balance		
	Description	**Input/day**	**Unit**
	Mass of steam (2.5 bar & 140 deg. Cel)	87360	kg/day
	Mass of hot water (0.47 bar & 80 deg. Cel)	66399.27	kg/day
	Electricity	3536	kWh

Conclusion

- At each mechanisation level, available biomass residues are adequate to sustain heating stages in the process.

Future works

- Process modelling of Biogas and BCHP in Aspen Plus software
- Profitability analysis of renewable energy integration in the CPO processes

References

- Ohimain, E.I., Daokoru-Olukole, C., Izah, S.C., Alaka, E.E. (2012). "Assessment of the quality of crude palm oil produced by smallholder processors in Rivers State, Nigeria." Niger J. Agric. Food Environ, 8(2): 28 – 34.

- Kyei-Baffour, N., Manu, C. (2008). "Small-scale palm oil process improvement for poverty alleviation and national development." Proceedings of 3rd International Conference on Appropriate Technology, November 12-15, 2008 at Serena Hotel, Kigali, Rwanda.

Acknowledgement

- CRSES

THANK YOU

QUESTIONS?