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Waste valorization for a circular economy

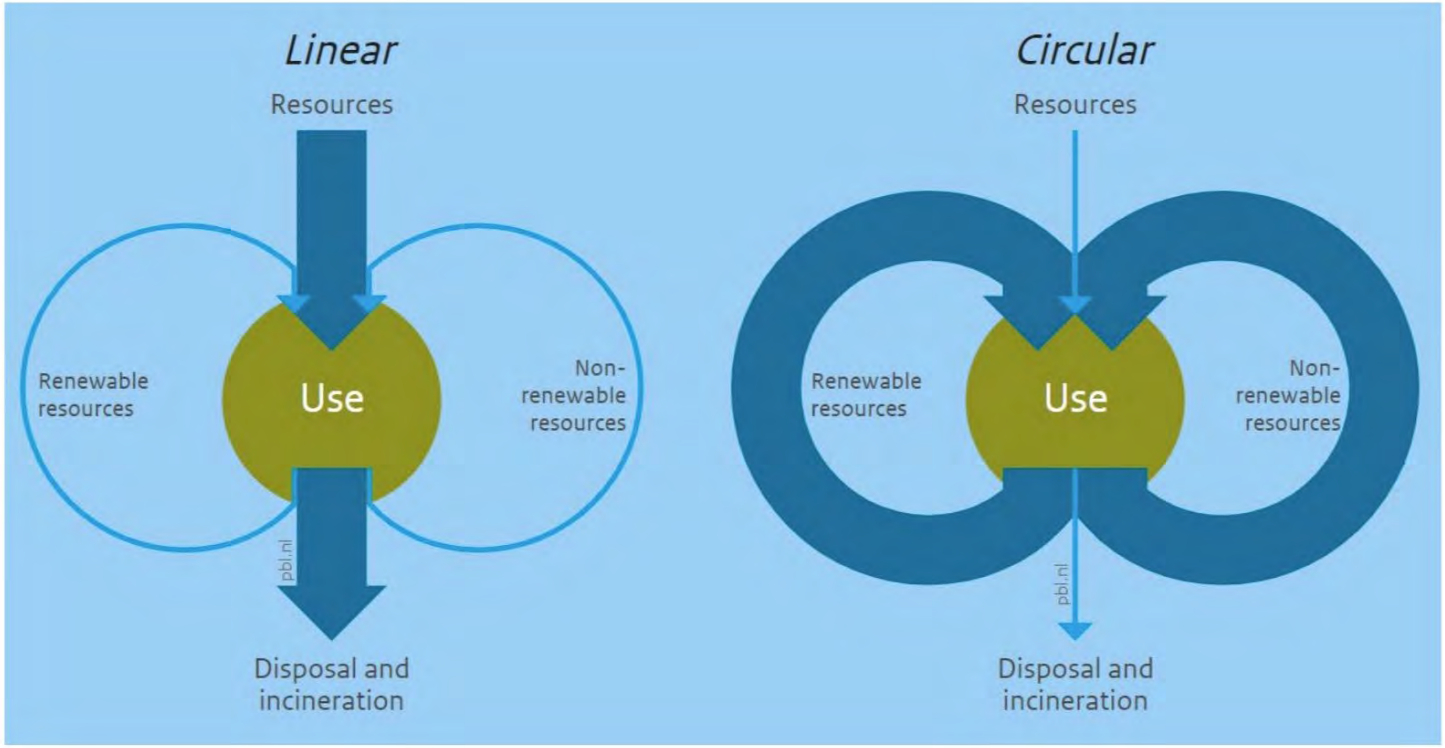
Zwonaka Mapholi | Annie Chimphango | Neill Goosen | Christie Dorfling | Robbie Pott | Johan Gorgens | Eugene van Rensburg

Department of Chemical Engineering

Photo by Stefan Els

Waste valorization

- **Waste valorization:** process of converting waste materials into valuable products or energy.
- **Traditional take-make-dispose** (linear economy)
  - Emphasis on mass extraction, consumption, and disposal of resources.
  - Resource depletion, **waste generation**, environmental impact, economic inefficiency, and social impact.
- **Circular economy:**
  - Principles: Reduce, Reuse, and Recycle and Recover
  - Specifically: Recycling, upcycling, energy recovery, and production of secondary raw materials.



Contrast between linear and circular economy (PBL,2019)

South African economy

CSIR LAUNCHES INITIAL FINDINGS ON THE OPPORTUNITIES OF A CIRCULAR ECONOMY IN SOUTH AFRICA

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The Council for Scientific and Industrial Research (CSIR) has launched early findings its 'Science, Technology and Innovation for a Circular Economy' (STI4CE) Project. The report highlights findings on what a more circular economy could mean for South Africa in terms of much-needed social, economic and environmental opportunities.

- South Africa has a **very linear economy (resource-extractive based economy)**
  - High resource throughputs, predominately inland extraction, and manufacturing.
  - Export of resources for further beneficiation, minimal resource investment in local stocks.
  - Small resource returns into the economy.
- Country at risk of resource **depletion or overexploitation**.
  - Transitioning towards a circular economy has the potential to create value across all sectors of the economy.
  - Regenerative agriculture, decouples economic development from the demands placed on our energy and water systems.

Identifying circular economy opportunities for South Africa through Cross-sectoral Approach (adapted from CSIR,2021)

Types of wastes

- The linearity of our economic model continuously leads to waste generation.
- Evident in our major economies; the **mining industry** and **agricultural** sectors.

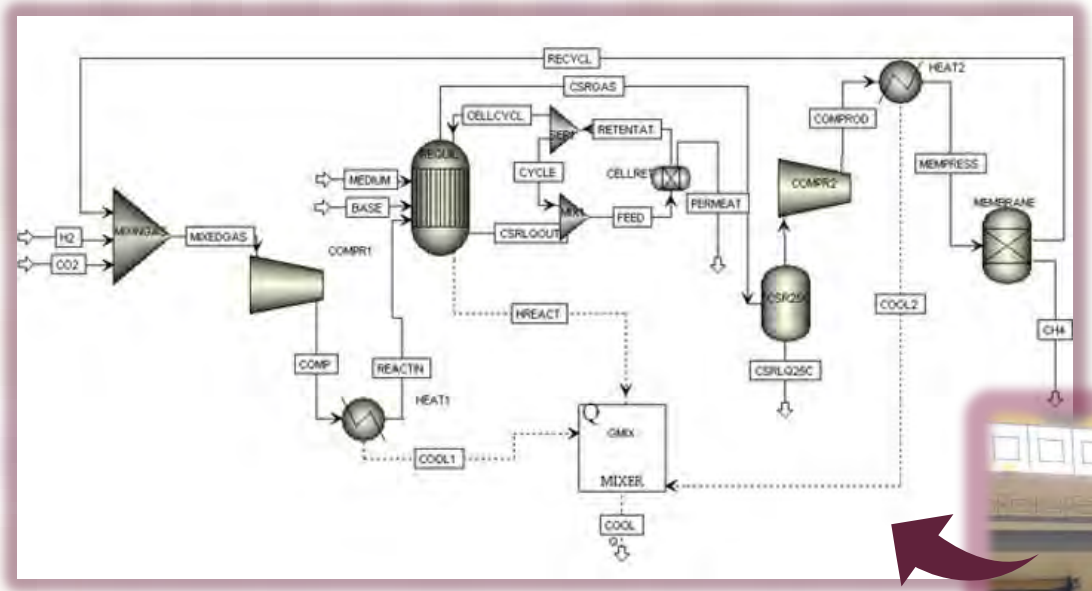
Bagasse

Mango peels

Fish wastes

Electronic wastes

Transforming waste: Innovative valorization projects in the Department

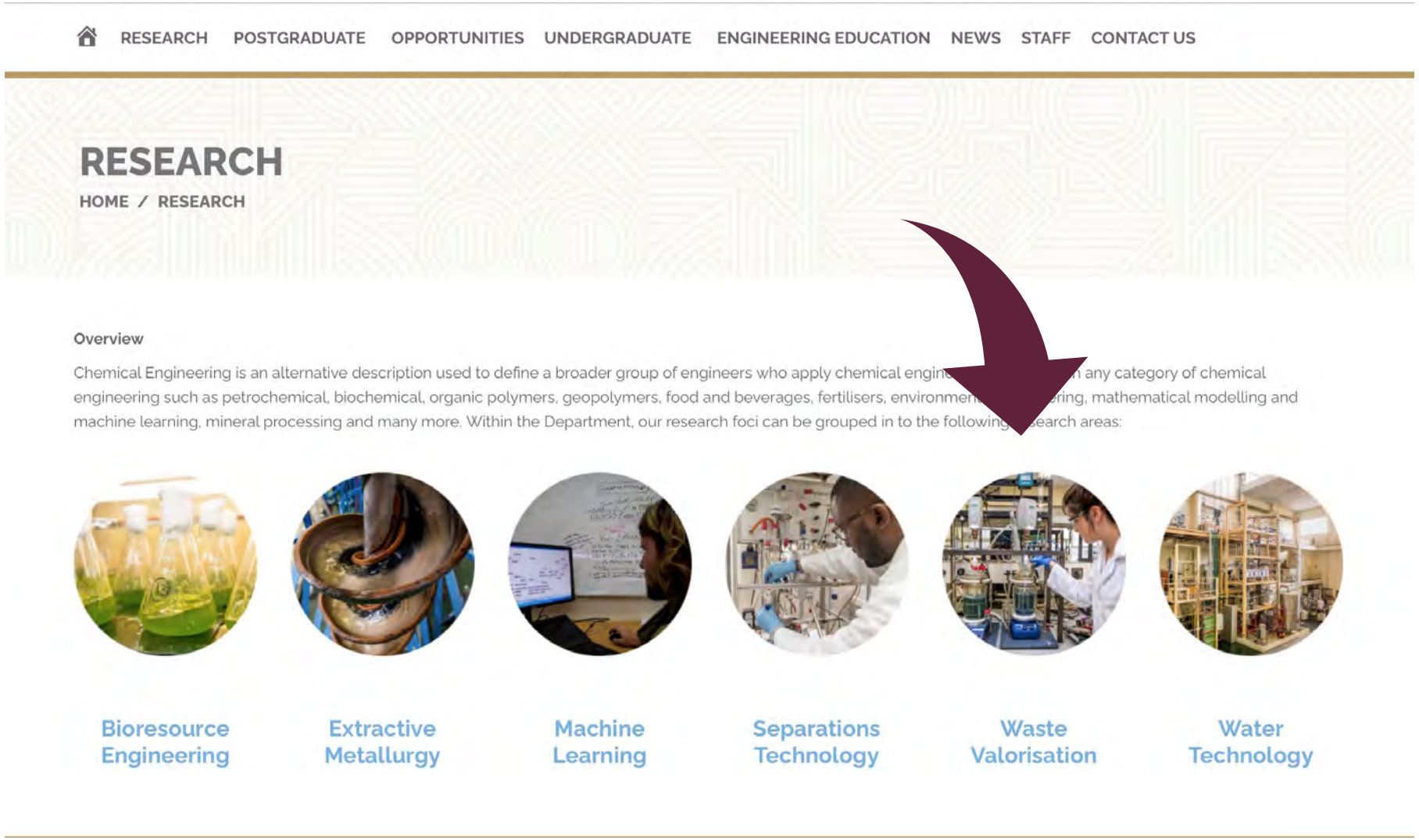


Integrating wastes processes into existing process

Extractions

Biofuels (energy)

Waste valorization research at the Department



Extractive Metallurgy

Research group academics

Prof Guven Akdogan

Pyrometallurgy

Metal Recycling

Tailings Reprocessing

Plastics

Prof Steven Bradshaw

Metal Extraction

Metal Recycling

Machine Learning

Prof Christie Dorfling

Urban Mining

Metal Recycling

Process Modelling

Life Cycle Assessments

Dr Margreth Tadie

Mine Tailing Valorisation

Environmental Assessment

Biobased Chemicals

Mr Petrie van Wyk

Metal Recycling

PGM Recovery

Techno-economic Analyses

Extractive Metallurgy's waste valorization project

Research focus – Metal extraction and recycling – Urban mining

Li-ion

~55 Mt electronic waste was discarded globally (2019)

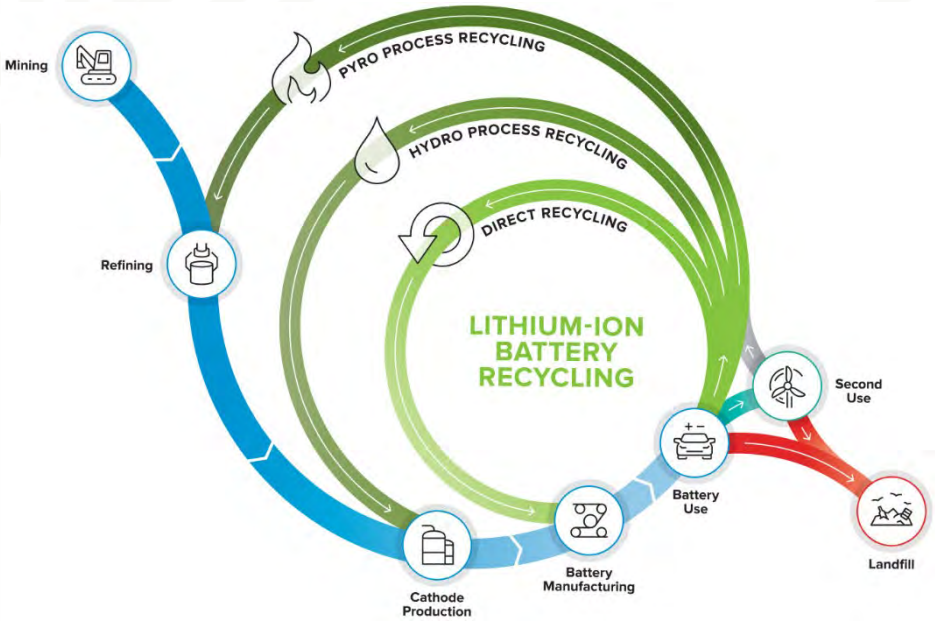
Recovery of base, precious, hi-technology and critical metals from electronic waste is critical from an economic and environmental management perspective

Develop hydrometallurgical processes for metal recovery:

- Printed circuit boards (copper & gold)
- Fluorescent lamps (rare earth elements)
- Lithium-ion batteries (lithium, cobalt & nickel)
- Automotive catalysts (precious metals)

Example: lithium ion batteries (LIBs)

- Used in cell-phones, laptops, hybrid electric vehicles
- Significant use of "critical metals" in LIBs, e.g. Co & Li
- 20% of Co from DRC, half of that artisinally-mined (child labour)



Bioresource group’s waste volarization projects

Research group academics

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ASSOCIATE PROFESSOR

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ASSOCIATE PROFESSOR

ANNIE CHIMPHANGO

ASSOCIATE PROFESSOR

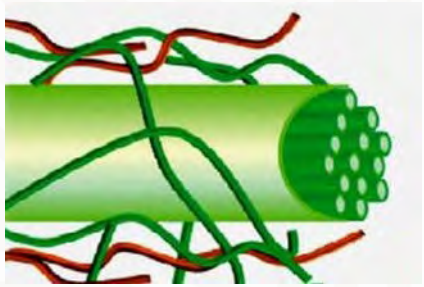
JOHANN GÖRGENS

DISTINGUISHED PROFESSOR

Prof Annie Chimphango

Development of bioactive packaging film

Agri residue

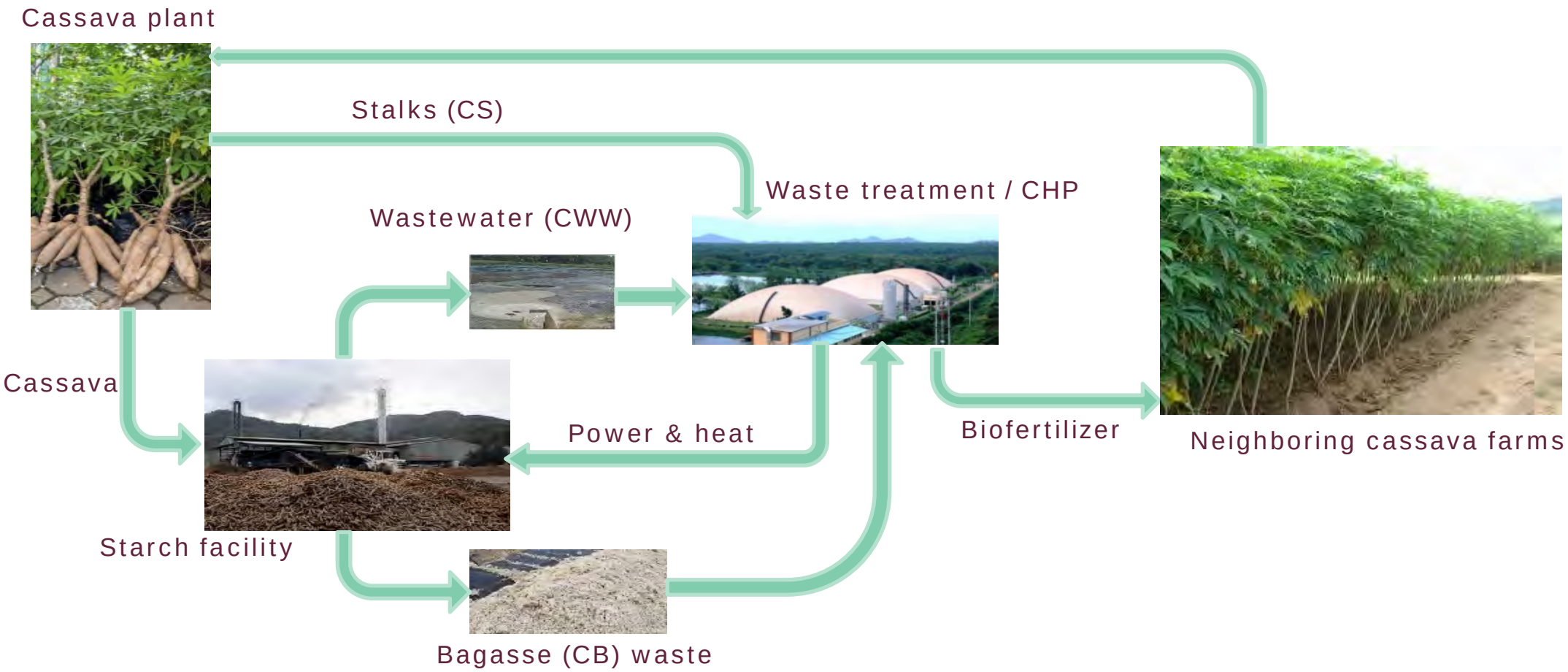


Nanocellulose

Rooibos

Bioactive Food Packaging film

Biorefineries Integrated into Cassava Starch processing to maximize resource recoveries and promote circularity.



Grape4green Project

Chemical Engineering Dept and The South African Grape and Wine Research Institute (SAGWRI) at Stellenbosch are coordinating a network of experts to conduct a scoping study on the state of the art of the circular economy (CE) in the SA Grape and Wine Industry

Objectives:

- To formulate a clear understanding of the CE concept
- To identify barriers that prevent the industry from moving towards this sustainability goal.
- Identify and explore viable CE pathways

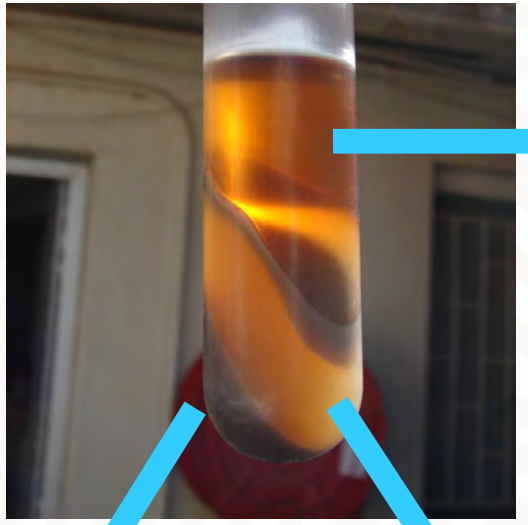
Prof Neill Goosen

Fish wastes protein hydrolysis and recovery

By-products

Protein hydrolysis

Fish protein hydrolysate



Oil

Insolubles

Protein

Prof Neill Goosen

Fish wastes protein hydrolysis and recovery

Hydrolysis

Spray drying

Protein powders

Prof Robbie Pott

Biohydrogen via photo-fermentation – industrial wastewater

Mr Zwonaka Mapholi

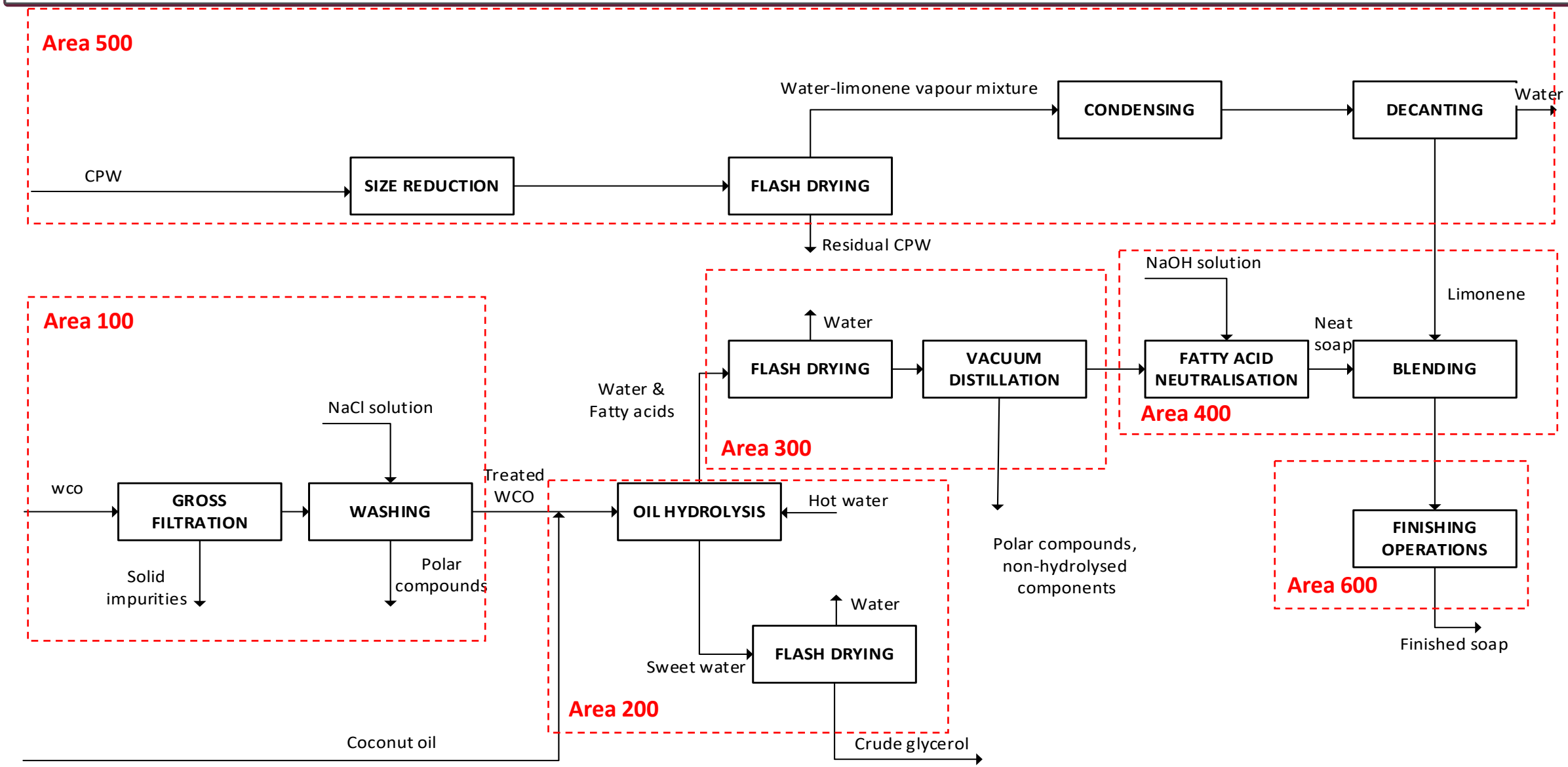
Soaps from waste cooking oil with additives from citrus peel waste

Waste cooking oils

Citrus peel waste

Anti-microbial soaps

Industrial symbiosis approach (WCO + CPW) for soap production



Prof Eugene van Rensburg

Anaerobic digestion of organic and biowastes

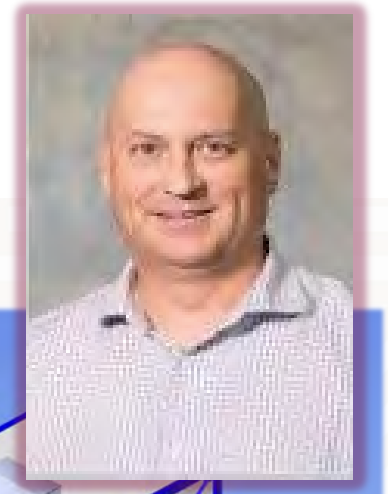
Bagasse

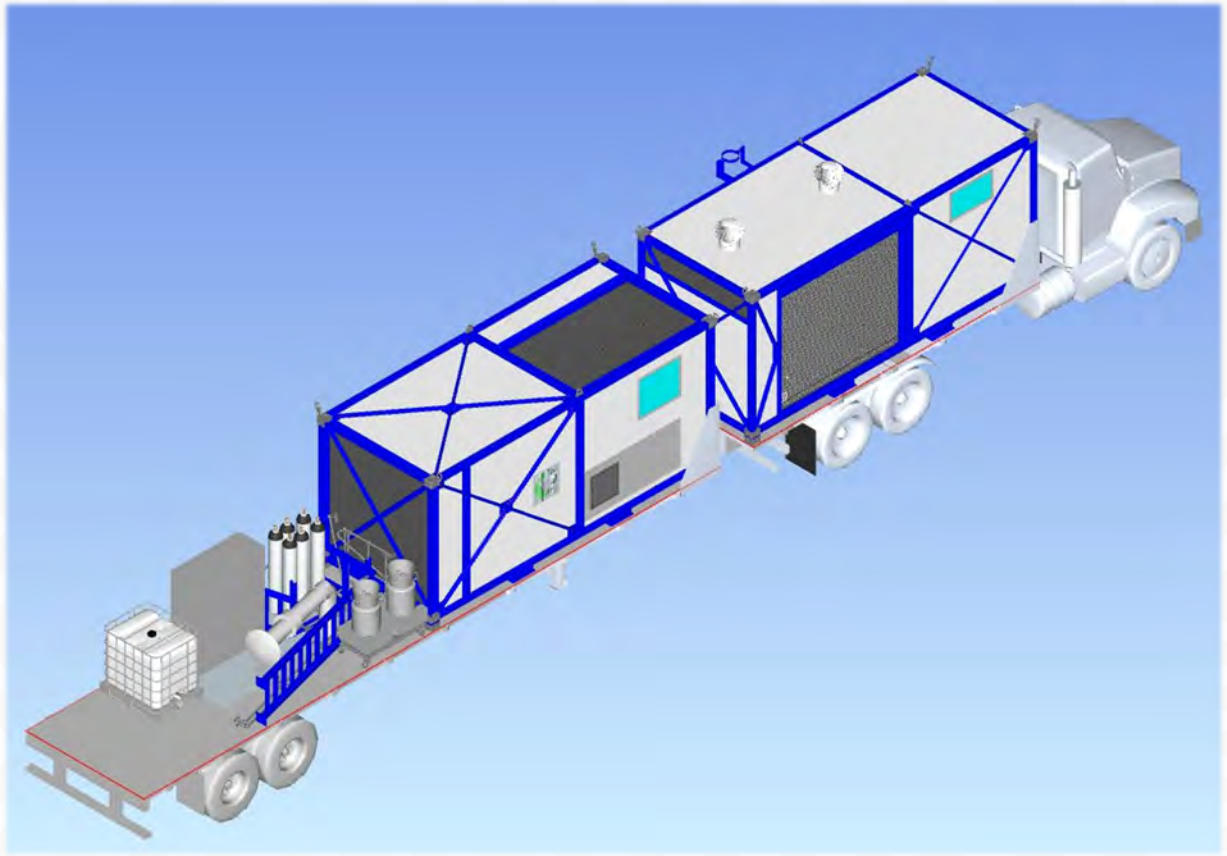
50 L digesters

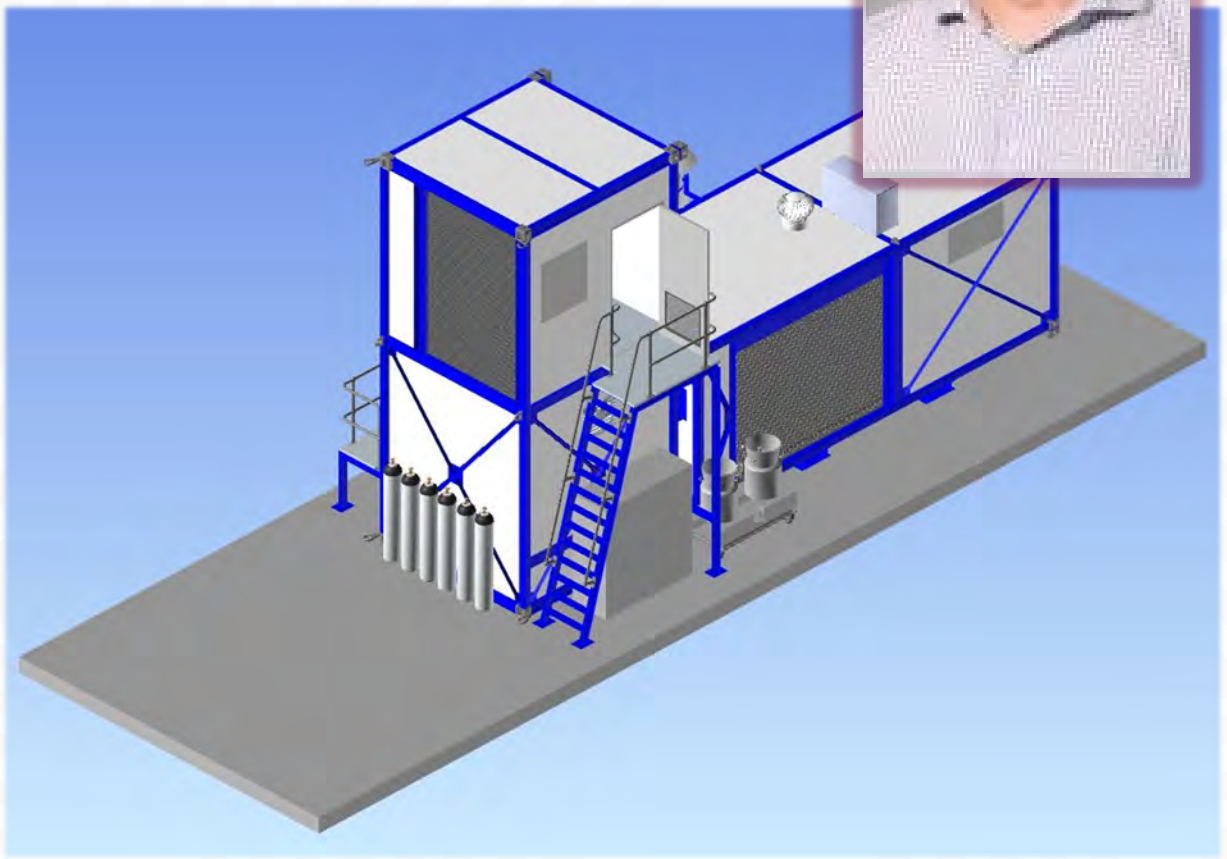
Biogas

Prof Johan Gorgens

Industrial demonstration of Novel bioprocessing technologies







Conclusions.

- Waste valorization offers a unique opportunity to ‘close the resource loop’ in South Africa.
- Waste resources can be turned into ‘alternate products’ or energy.
- Integrating waste valorization into existing processes offers alternative products, energy, and waste reduction opportunities, leading to environmental and ‘economic benefits’.
- Pursuit of waste volarization -> collaborative efforts from stakeholders.
- Industry -> Consider making products to be made again.
- Community -> Perceptions on ‘secondary products
- Government -> Policies promoting waste volarization, circularity, and sustainability.

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Thank you
Enkosi
Dankie

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Photo by Stefan Els