BIOMASS GASIFICATION FOR MAKAPADS PRODUCTION IN UGANDA

UNIVERSITY OF MICHIGAN SUSTAINABILITY WITHOUT BORDERS

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PROBLEM STATEMENT

Technology for Tomorrow Ltd. (T4T) is a company in Uganda that manufactures "MakaPads", sanitary pads out of papyrus. We are interested in addressing the heat and electricity needs of their production facilities through biomass gasification of papyrus and paper waste materials.

Through this project, we aim to answer these questions:

- Is it possible to use the discarded material of papyrus husk as a feedstock for biomass gasification?
- How much heat and/or electricity output will we be able to generate given this input?

CURRENT MODE OF PRODUCTION

- Currently, MakaPad production facilities use direct solar energy as heat and photovoltaic electricity for drying and sterilization of the pads.
- During the rainy season and when the sun is not out, production comes to a halt. This discourages employee retention at production facilities.
- Therefore, T4T is in need of a more reliable source of heat and electricity to improve productivity. By using waste materials as feedstock in gasification, we can close a loop and make the production system circular.

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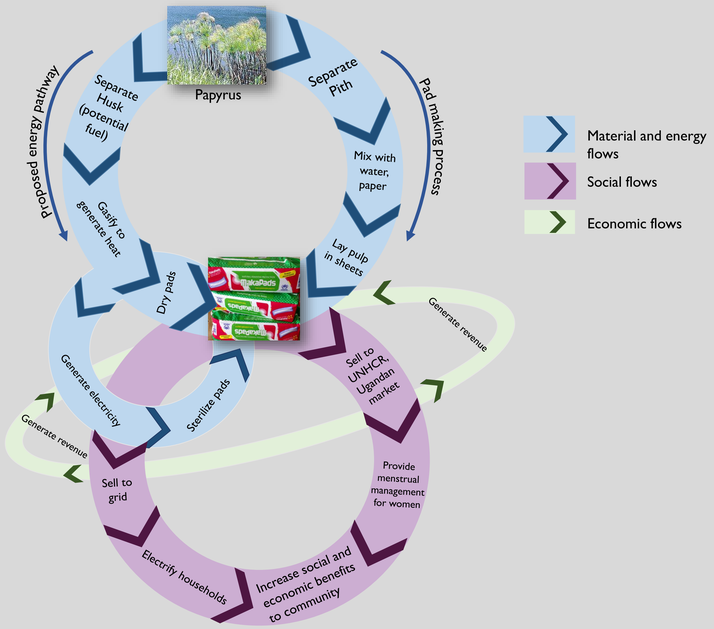
- Dr. Jose Alfaro, Faculty Advisor

THE CIRCULAR SYSTEM



FEASIBILITY

1. How much heat power and/or electricity can be generated with a given amount of mass?			
Mass needed (kg)	Heat Energy (BTU)	Electricity (kWh)	Number of people supplied
1000	10700000	781	6.89

2. Given a steady supply of papyrus, how much heat and/or electricity could be produced in one year?					
Mass given (kg)	Duration (weeks)	Heat Power (kW)	Heat Power (BTU/hr)	Annual Electricity (kWh)	Number of people supplied/year
200	2	5.58	19000	4070	108

3. How much biomass is needed to power a x kW gasifier each day?					
Mass needed (kg/day)	Time operated (hr/day)	max. Heat Power (kW)	Heat Power (BTU/hr)	Annual Electricity (kWh)	Number of people supplied/year
76.8	8	30	102000	21700	579

Key assumptions:

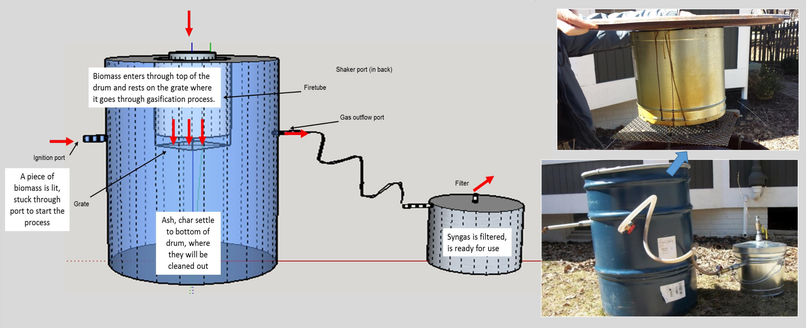
Heating value of papyrus (BTU/kg): 14217 | Gasifier efficiency: 0.75 | Electricity generation efficiency: 0.25 | Duty factor: 0.33 (8 hours a day) | Energy consumption per capita (kWh/person): 39

Implementing a gasifier is feasible because of its generally low startup cost, and ease of construction, maintenance and take down. The gasifier itself is made of relatively inexpensive and available materials, and energy can be generated out of abundant papyrus husk. If adopted, Sustainability Without Borders would finance initial costs, and the project would be self-sustaining in the long run because of increases in revenue for T4T.

BIOMASS GASIFICATION

- A thermal energy conversion process that converts feedstock material into syngas, which can then be used for heat or generated into electricity.
- Unlike the burning of fossil fuels, using biomass is considered renewable because the biomass that is burned can easily be replaced within our lifetimes, and net-zero because the energy generated as output through the process cancels out the energy needed for input.
- The feedstock used should be a biomass material, have high energy content, low moisture content, and needs to be cut into small, blocky pieces. For this reason, not all waste materials can be used.

Top: Firetube *Bottom:* Gasifier drum with filter



Our model is based on guidelines by Federal Emergency Management Agency (FEMA), meant to be used in times of emergency. FEMA provides a basic outline for necessary parts and sizing, most of our design is based on what materials we could easily obtain

Drying: reduces moisture content of biomass, making it ready for gasification → Pyrolysis: heating in absence of oxygen, burns volatile gases, creates char → Combustion: burning of char to create CO2 and H2O → Tar cracking: liquid tar byproduct becomes syngas → Reduction: CO2 and H2O become syngas (CO and H2) → Cooling and filtration: makes syngas ready for use

FUTURE

- Using papyrus as a feedstock is also a novel method, and if successful, could open up possibilities for gasifying other non-traditional materials. There is a possibility for the gasification of other waste materials with high carbon content, in order to achieve carbon-neutral goals.
- The MakaPad production process is not perfectly circular, as there are still inputs that come from outside the loop, such as plastic for the outer wrapping of the pad.
- Future work can focus on conducting research based upon concepts of Industrial Ecology and Life Cycle Assessment in order to get closer to the goal of perfect circularity. The biomass gasifier, as proposed here, is one key step to reaching that end.

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