Future options

Greater profitability and energy efficiency can be achieved by fuel improvement. Where alternative ways of drying are possible then energy losses within the process can be reduced. The polymer coating preventing pathogen and smell spreading could contribute to the solar drying process during storage, even at a local level. Solar drying would allow the sludge to be further dried and thus less syngas being diverted for drying.

Options to improve drying efficiency include:

- mixing sludge with biomass residue that contains absorbent cellulose
- feedstock blending to reduce the overall moisture content is possible where this increase the CV
- biomass can allow the mixture to be further dried, thus availability of residual biomass needs assessing
- the possibility of including municipal solid waste management offers an alternative dry source
- combining sewage sludge, municipal solid waste and high CV waste stream (as medical waste) through gasification are also possible

The nano membrane development offers the potential solution for household excreta separation and storage of faecal sludge, pathogen free water and an ammonia solution while blocking odours and the spread of pathogens. This business case investigates the preliminarily feasibility of utilizing gasification technology to treat the sludge generated from these toilets and apply this to a developing country, Kumasi, Ghana. These technologies create options for a commercially attractive business model that is not only a technological innovation but a life-saving mechanism for diseases control though improved sanitation.

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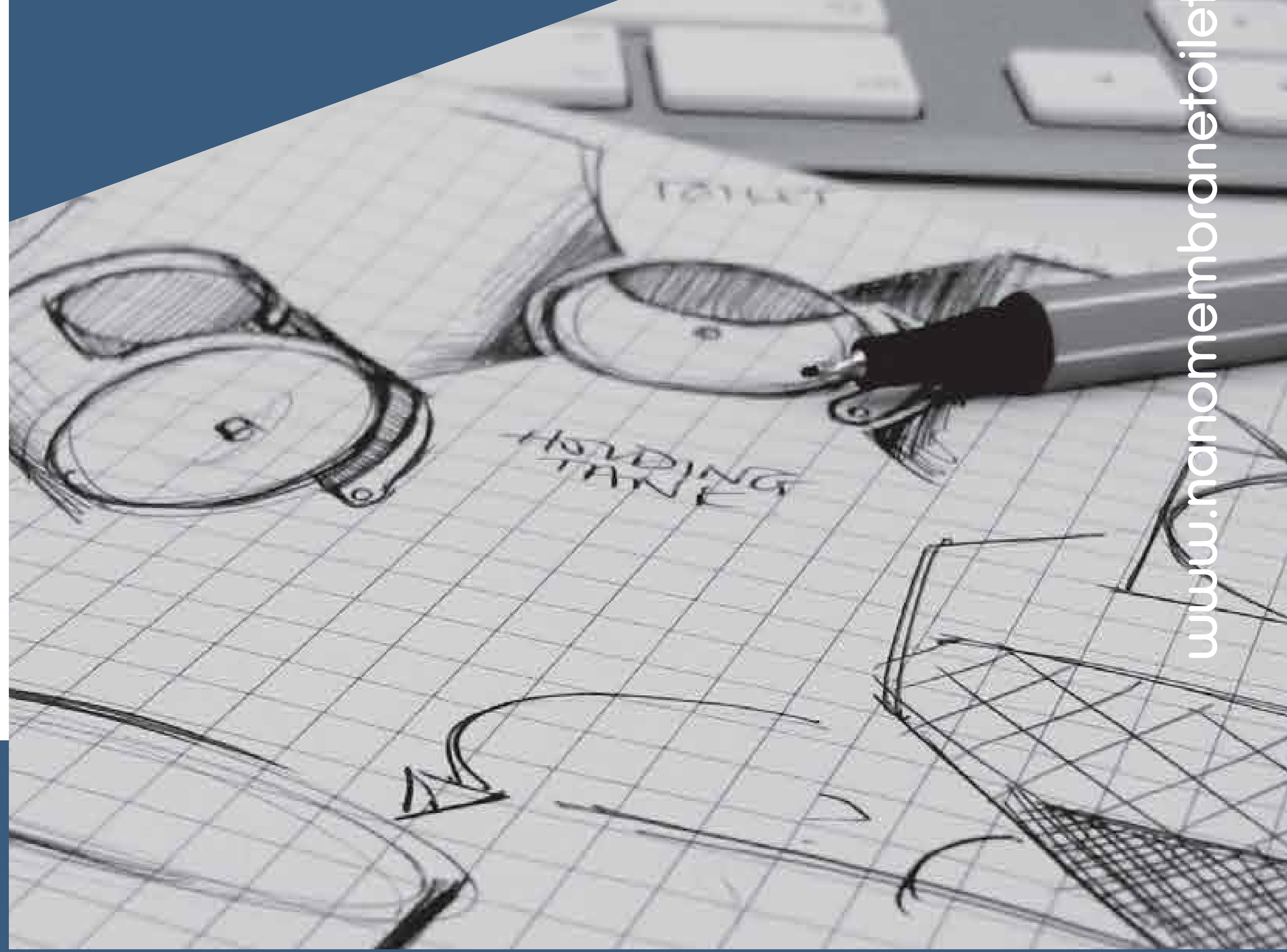
Nano membrane toilet

The Business Case
Local waste treatment free from city infrastructure



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The nano membrane toilet treats human waste without external energy or water creating a commercially attractive enterprise. Local business provides a mechanism to deliver sanitation for low-income households.

Enterprise development for local sanitation

Project benefits

- Sanitation units independent of local infrastructure
- Income options from, electricity, water and ammonia sales
- Purchase, lease or shared ownership models
- Maintenance and servicing contract opportunities

The nano-membrane toilet design provides

Infrastructure independence

Achieving protection for communities from faecal pathogens is a significant challenge for developing communities as infrastructure costs create political and resource demands that often cannot be easily overcome. Developing a toilet unit that generates pathogen free water, retains pathogens within coated solids, and then kills pathogens with gasification whilst recovering energy offers a viable route to sanitation that is independent of local infrastructure. Creating water and energy as valuable by-products enables a business to deliver sanitation services which are sustainable in the long term.

Key design features for the nano-membrane toilet relevant to the business case are:

Capital Cost	$750 USD
System life expectancy	7 years
Users accommodated by the system	10 users
Estimated daily operational cost per user	$0.05/user/day
Energy will be recovered	90Wh/user/day
Usable water will be recovered	approx. 1.5L/user/day
Fertilizer produced or recovered	0g/user/day
Estimated business opportunity or revenue potential	$0.03/user/day
Business Opportunity	Franchise business to service the toilet for a regular fee

Kumasi, Ghana

A case example of Kumasi in Ghana is used here to explore the implications of using this toilet design in a community. Key to the business case is the creation of valuable by-products.

Ghana has 25.2 million inhabitants with approx. 50% living in urban areas. More than a quarter of its population lives below the poverty line with only 14% of the population having access to improved sanitation facilities. 40% of the population use public and communal latrines but these are not considered adequate. In addition, the availability of water is predicted to decrease. Electricity consumption is dominated by industry at 49% of total load, with residential using 35%.

Population demographics make it possible to estimate a population density of approximately 8,000 people per km2. The nano membrane toilet is designed to process 20 litres of waste mixture produced from 10 people equivalent to 2.5 litres of dry matter or 62g per person per day.

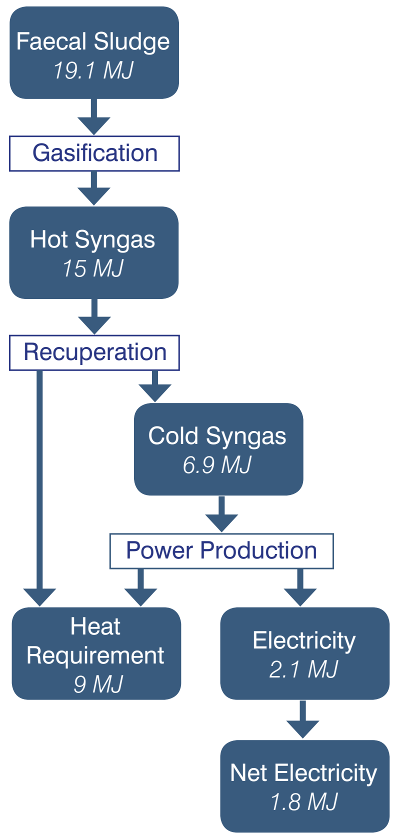
Faecal sludge in Kumasi has a calorific value of 19.1 MJ/kg. Considering the total amount of dry sludge and parameters from energy analysis undertaken, the overall energy contained in the sludge is 5,547 MJ. Energy needed for drying accounts for 2575 MJ to achieve evaporation to 85% solid content.

Summary Parameters

Calorific Value (CV)	19.1 MJ/kg
Target Solid Content	85%
Hot Gas Efficiency	80%
Cold Gas Efficiency	70%
Latent Heat Coefficient	3.1 MJ/kg
Engine Efficiency	30%
Recoverable Heat from Syngas	22%
Parasitic Electrical Requirement	15%

Gasification energy flow for Kumasi

Energy flow for one kilogram of sludge used in the gasification process is shown above, with a calorific value of 19.1 MJ. After gasification, the raw hot syngas contains both thermal and chemical energy, 15MJ. Part of the gas is diverted to heat recovery within the system for sludge drying. The rest of the syngas passes through cleaning and cooling devices for use in reciprocating engines. The cold gas contains 6.9 MJ of chemical energy. The engines are able to produce 2.1 MJ of electricity with this amount of syngas. After subtracting these parasitic loads the net electricity generated per kilogram of sludge is 1.8 MJ.



Gasification options

Several different types of gasifiers and operating conditions can be used for energy recovery. However, this approach to understanding the feasibility of sewage sludge gasification is based on an energy analysis of the gasification process alone. It is important to know the amount of feedstock available for gasification as the characteristics and amount of sludge available is site dependent. In the case for Kumasi, Ghana past experience of this type of development along with local information gathered by the nano membrane project team have provided the evidence for calculation.

The potential energy generated appears small, both in percentage and absolute terms. However, the service provided by the gasification plants is not solely electricity generation. The technology offers low environmental impact associated with treatment and volume reduction of sewage sludge. As a final disposal option, gasification offers for pathogen kill whilst generating energy generation as an additional benefit.