Exhibitor Technology Guide

Reinvent the Toilet Fair 2012

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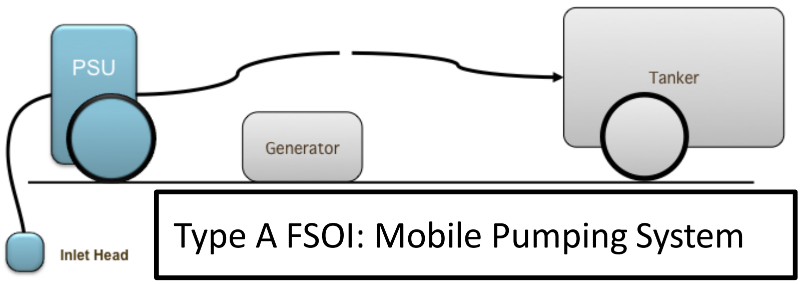
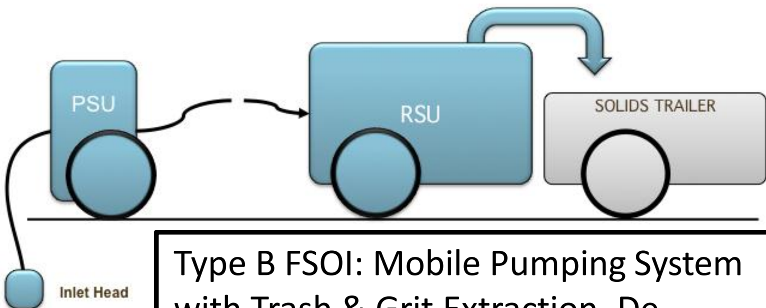
Exhibitor 1

AGI Manufacturing, DCI Automation, Synapse Product Development & Beaumont Design - Fecal Sludge Omni-Ingestor (FSOI)



Type A FSOI: Mobile Pumping System



Type B FSOI: Mobile Pumping System with Trash & Grit Extraction, De-watering & Treatment of Effluent

The technologies are estimated to be between TRL 1-4 by the time of the Fair.

The team predicts that a fully functioning FSOI meeting 100% of the requirements could be achieved in 2 years with $7M.

System Description

The FSOI includes a family of equipment and modular components that will enable pit/tank emptiers to safely and profitably perform their services. The FSOI will permit mechanical emptying of difficult to access pits/tanks and effectively empty them.

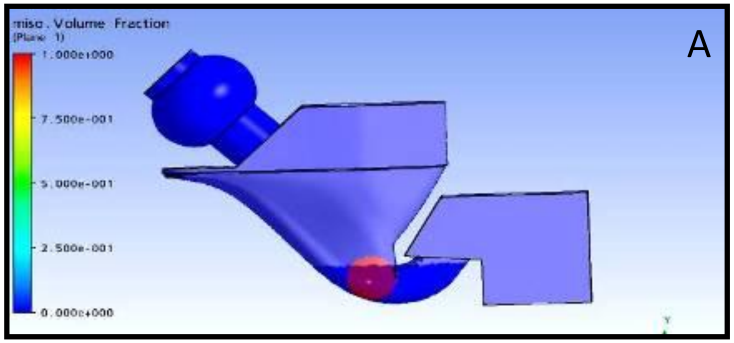
Economic Analysis

- Est. capital cost of final unit: 7-25k; Est. operating cost of final unit: $5/m3
- While the operating costs will vary widely dependent upon many factors, the baseline cost per user per year is approximately $0.25
- Power and water consumption is dependent upon configuration and operating scenarios (material conditions, pit size, etc). Power may range from 2kW to 25kW and the water consumption per pit emptied could range from 0 to 800 Liters
- At a minimum, the FSOI will produce water suitable for re-use that could be valued at $.06 to $6 per m3 depending on region and buyer.

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Pit Extraction & Pre-processing	Omni-Ingestor Criteria
Project Title	Fecal Sludge Omni-Ingestor	Omni-Ingestor
BMGF funding mechanism (RTTC, GCE, Contract, other)	Contract	All
Project Start Date	10/2011	07/2011
Remaining time in funding cycle	5 months for P2	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Pumping, Dewatering, Disinfection	N/A
Consumable		
• Water/user	Potentially for dilution and pumping	For personal hygiene, no flushing
• Electricity/user	Via diesel generator	Off grid
• Others	Potentially compressed air, hydraulic, vacuum	0
Limitations		Off grid
Waste to be processed off-site	Fecal Solids	None
Waste dumped / infiltrated in soil	None that is untreated	None
Revenue stream		
Energy recovered produced/user (kw/h)	Unknown	N/A
Water recovered/user	Unknown	N/A
Nutrient/fertilizer recovered/user (g or L)	Unknown	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	N/A	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	Varies 1-4	N/A
Estimated at end of funding Phase	4-5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	Varies by subsystem – 5 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	Varies by subsystem	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	10-20 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**N/A**	**0.01 – 0.05**

Exhibitor 5

American Standard Brands – Improved latrine pans for pour-flush systems



A) CFD simulation of pour flush latrine pan.
B) & C) Molds used in production of prototypes.

The technology is estimated to be at TRL 5 by the time of the Fair.

The team predicts 3 months are needed to produce 100 samples for field trials and full production can be achieved in 9 months.

System Description

American Standard will exhibit three new concepts for improving the performance and hygiene of pour-flush latrine pans commonly used in Bangladesh, India, and other areas of South Asia. The final design will provide a reliable, hygienic water seal, and function on only 1.5 liters of water with no required change in user behavior.

Economic Analysis

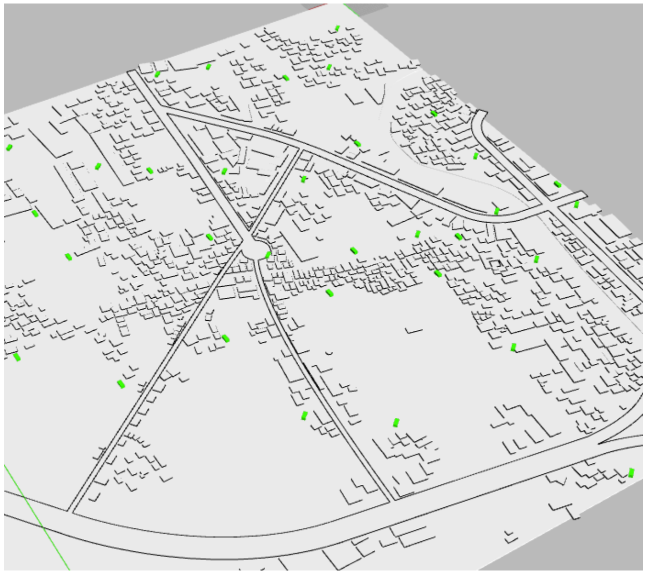
The plastic latrine pans widely used in Bangladesh are available at a retail cost of roughly $0.35 USD. Final production units of our final design will be produced from locally recycled plastics at a competitive cost of less than $0.50 per unit.

American Standard Brands

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Short-term Sanitary Improvement	RTTC Criteria
Project Title	Improved latrine pans for pour-flush systems	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	Contract	All
Project Start Date	03/2012	07/2011
Remaining time in funding cycle	9 months	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Fluid mechanics	N/A
Consumable		
• Water/user	1.5liters/use	For personal hygiene, no flushing
• Electricity/user	0	Off grid
• others	0	0
Limitations		Off grid
Waste to be processed off-site	0%	None
Waste dumped / infiltrated in soil	100%	None
Revenue stream		
Energy recovered produced/user (kw/h)	0	N/A
Water recovered/user	0	N/A
Nutrient/fertilizer recovered/user (g or L)	0	N/A
Estimated revenue/user/day ($)	0	N/A
Total revenue /user/day ($)	0	
Smell and odors control measures	Hygienic water seal	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	5	N/A
Estimated at end of funding Phase	8	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	12 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$200,000	N/A
Estimated capital cost of final toilet	$6.00 (with slab & rings)	N/A
Estimated lifetime	>3yrs	>5 years
Estimated total cost/user/day ($) (without revenue)	**$0.006**	**0.01 – 0.05**

Exhibitor 8

Loowatt Ltd. - An energy-producing, waterless toilet system



The team will present a fully functional Loowatt toilet, a model which explains how the Loowatt system works in Antananarivo, and a video documenting the construction of our pilot system.

The technology is estimated to be at TRL 6 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved within 1 month of commissioning the pilot. Data collected in the pilot may lead to further system refinements.

System Description

The Loowatt **toilet** seals waste into biodegradable film within a removable cartridge. The Loowatt **system** converts the biodegradable film and human waste into energy and fertilizer, and creates value at each stage of the process (toilet use, energy generation, fertilizer sale) to ensure that the toilets are financially, socially and environmentally sustainable. At present the Loowatt system uses mesophillic anaerobic digestion (AD), existing technology that our team has experience building and operating in the lab and in the field, to create energy and fertilizer.

Economic Analysis

- Based on a cost to the user of US$0.04/day, revenue streams from energy and fertilizer sales, and detailed operational costs, the system is estimated to generate $7.17/toilet/day gross profit (with 50 users/toilet). This amounts to $13,000 over a 5 year period. Energy units are estimated to cost as little as $1000 to construct, which can comfortably be financed with the aforementioned system profits, including the estimates of maintenance and depreciation.
- Water consumption across all of the processes, including AD and composting, amounts to 0.4 litres/user/day. Power consumption will be in the region of 95Wh/user/day in the context of Antananarivo, but will be effectively zero in hotter climates.
- System byproducts are biogas and fertiliser. The fertiliser is expected to be sold for between 250 – 750 USD/tonne. Energy-products can be made from the biogas, such as mobile phone charges, which we expect to sell for up to US$0.05/charge.

Loowatt Ltd.

Technology target	Reinvented Toilet, FS management	RTTC Criteria
Project Title	An energy-producing, waterless toilet system	Reinvent the Toilet Challenge
BMGF funding mechanism	GCE	All
Project Start Date	07/2011	07/2011
Remaining time in funding cycle	6 months	N/A
Processes and Technologies[1]		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Toilet	N/A
Consumable		
• Water/user	No	Personal hygiene, no flushing
• Electricity/user	No	Off grid
• Others	Biodegradable film, toilet paper	0
Limitations		Off grid
Waste to be processed off-site	Digestate to fertilizer[2]	None
Waste dumped / infiltrated in soil	None	None
Revenue stream[3]		
Energy recovered produced/user (kw/h)	0.23 kwh/user/day	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	530g	N/A
Estimated revenue/user/day ($)	$ 0.21 (USD)	N/A
Total revenue /user/day ($)	$ 0.21 (USD)	
Smell and odors control measures	Contained and odorless	No smell, no flies
Technology Readiness Level[4]		N/A
At time of RTT Fair	TRL 6	N/A
Estimated at end of funding Phase	TRL 7	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	1 month	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$700	N/A
Estimated capital cost of final toilet	$60[5]	N/A
Estimated lifetime	5 years +	>5 years
Estimated total cost/user/day ($) (without revenue)	**$0.04**[6]	**0.01 – 0.05**

[1] The toilet is mechanical and innovative. The team is designing and building anaerobic digesters with the toilet, but for the purposes of this form they are considering anaerobic digestion as a preexisting technology (which is both chemical and biological).

[2] Digestate is produced onsite with the toilet (with 90% pathogen reduction) and transported a short distance for further processing into marketable fertilizer.

[3] These values are produced by the Loowatt system.

[4] This level is applied to the toilet only.

[5] The toilet, at volume production (100K+) of internal components, with local manufacture and assembly of supporting components.

[6] The team is defining this cost as the price the user pays per toilet visit in our current financial model

Exhibitor 9

LIVVON LLC - A high-efficiency sanitary toilet with sewage treatment

Personal in-home toilet, sealed against vermin and odor

The technology is estimated to be at TRL 7 by the time of the Fair.

This fully functioning RTTC toilet meeting 100% of the requirements is ready now, including metal dies to mass produce 100,000 parts.

System Description

This personal, in-home toilet separates urine and feces. It is sealed against bugs and odor. Metabolic heat in the insulated feces chamber kills the disease-causing bacteria. Ammonia from fermented urine sterilizes the urine tank.

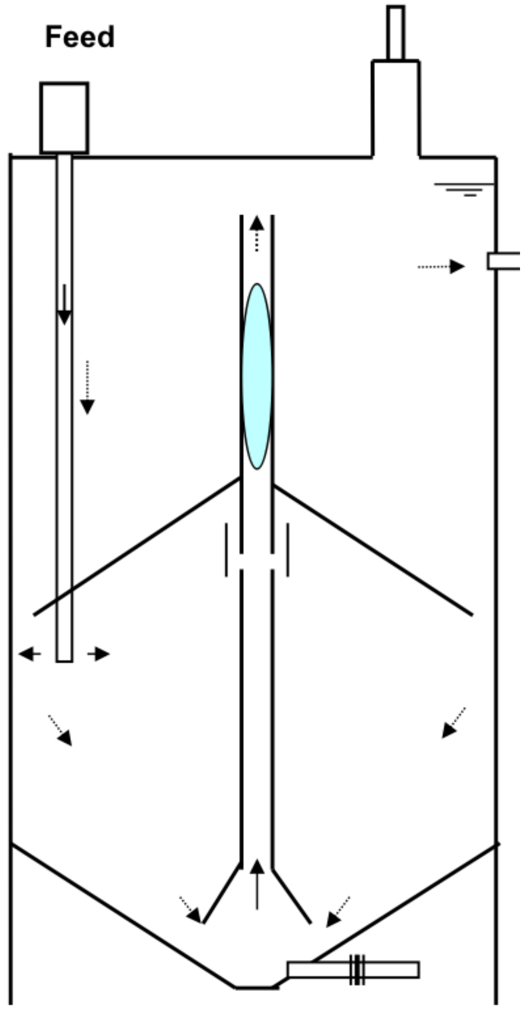
Economic Analysis

At less than $10 per toilet with a 20+ year expected life, the Livvon Toilet capital cost is less than $0.0014 per home per day. The value of the urine fertilizer and feces electricity at African prices is $0.16 per user per day. The collection labor and disposables are about $0.003 per user per day.

Technology target	Reinvented Toilet	RTTC Criteria
Project Title	A high-efficiency, sanitary toilet with sewage treatment	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	May 1, 2011	07/2011
Remaining time in funding cycle	0	N/A
Processes and Technologies		
Chemical engineering processes	Sterilization by Heat and Ammonia	Yes
Mechanical engineering	Structures, Fluid Mechanics, Heat transfer	Yes
Biological process	Metabolic Heat	No
Key technology component	Insulated Fece Chamber	N/A
Consumable		
• Water/user	0	Personal hygiene, no flushing
• Electricity/user	0	Off grid
• Others	0	0
Limitations	None	Off grid
Waste to be processed off-site	Feces & Urine	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kwh)	0.2 kwh/day	N/A
Water recovered/user	0.3 Liter/day	N/A
Nutrient/fertilizer recovered/user (g or L)	0.5 Liter/day	N/A
Estimated revenue/user/day ($)	0	N/A
Total revenue /user/day ($)	$0.16/day	
Smell and odors control measures	Toilet Seals and Ozone	No smell, no flies
Technology Readiness Level	7	N/A
At time of RTT Fair	7	N/A
Estimated at end of funding Phase	7	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	0	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	0	N/A
Estimated capital cost of final toilet	$10	N/A
Estimated lifetime	20 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**$0.0014**	**0.01 – 0.05**

Exhibitor 10

Frontier Environmental Technology - A self-mixing biogas generator



Operational sketch of Biogas Generator

The technology is estimated to be at TRL 3 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 12-18 months with $100,000.

System Description
Air injection simulates small bubble nucleation in bottom of the reactor and beads represent biomass/solids. Attendees can see the mixing function of the pump and disbursement of simulated solids within the reactor.

Economic Analysis
No estimated operational cost other than capital depreciation, which is $0.04/user/day and within the target goal for this endeavor. No power or water is needed for operation, but water may be needed to initially fill the reactor. Byproducts include methane at approximately 3 kWh/user/day and pathogen-free fertilizer at roughly 10 L/user/day.

Frontier Environmental Technology

Technology target	FS processing	RTTC Criteria
Project Title	A self-mixing biogas generator	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle	11 months	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Self-Actuating Mixer	N/A
Consumable		
• Water/user	None required for flushing; only start-up	For personal hygiene, no flushing
• Electricity/user	Net energy generator; none required	Off grid
• Others		0
Limitations	Temperature-dependent	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None; produces nutrient-rich, pathogen-free fertilizer	None
Revenue stream		
Energy recovered produced/user (kWh)	3 kWh/day	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	10 L	N/A
Estimated revenue/user/day ($)	0.35	N/A
Total revenue /user/day ($)	0.35	
Smell and odors control measures	None required	No smell, no flies
Technology Readiness Level		
At time of RTT Fair	3	N/A
Estimated at end of funding Phase	5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	12-18 months field testing; 30-45 days fabrication time	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$100,000	N/A
Estimated capital cost of final toilet/unit	$2000 – mass production	N/A
Estimated lifetime	30 years or more	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.04 – capital deprecation** **0 – operation cost**	**0.01 – 0.05**

Exhibitor 11

International Water Management Institute - Developing fortified fertilizer pellets from human waste

1

2

3

1) Locally fabricated equipment for pelletization;
2) workers in action; and 3) final product

The technology is estimated to be at <u>TRL 6</u> by the time of the Fair.

Estimated effort and time need to achieve a fully functioning RTTC toilet meeting 100% of the requirements: N/A

<u>System Description</u>

The process sanitizes and pelletizes feacal sludge.

To match the fertilizer requirements, which varies depending on the crop and the agro-ecological zone, blending with inorganic compounds is performed so that the final product can support different nutrient demands.

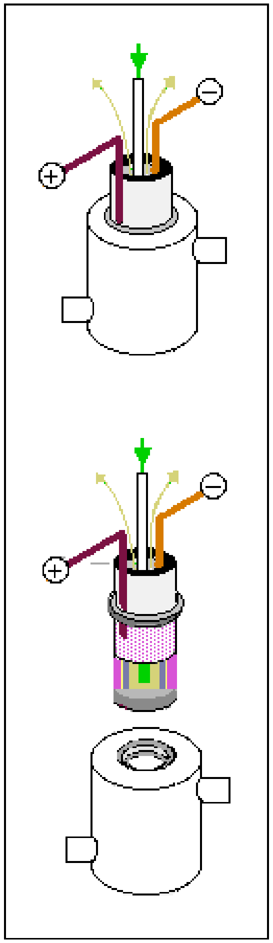
The pathogen free organo-mineral fertilizer is easier to handle and transport than conventional powdered products and can be sold. Targeting and scaling up potential is currently being analyzed.

International Water Management Institute

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	FS processing	RTTC Criteria
Project Title	Developing fortified fertilizer pellets from human waste	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	05/2011	07/2011
Remaining time in funding cycle	3 months	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Fertilizer (*Fortifert*); Pelletizer	N/A
Consumable		
• Water/user	N/A	For personal hygiene, no flushing
• Electricity/user	N/A	Off grid
• others	Cassava starch: 0.01-0.03 kg per kg of feacal fertilizer	0
Limitations		Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	N/A	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	6	N/A
Estimated at end of funding Phase	6	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	Variable	>5 years
Estimated total cost/user/day ($) (without revenue)	N/A	**0.01 – 0.05**

Exhibitor 12

Institute for Residential Innovation - Sewage Containment and Mineralization device (SeCoM)



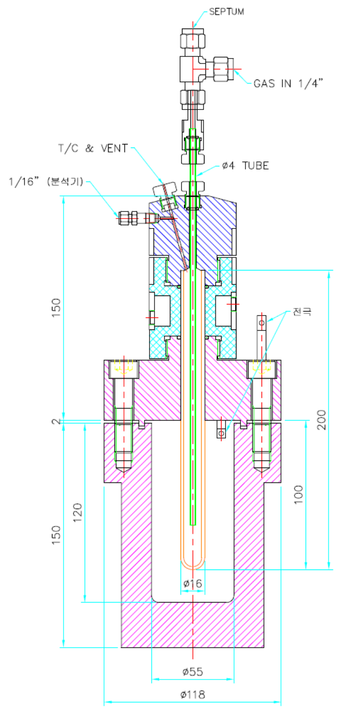


Figure showing the SOFC and PWR (LHS).
Schematic of the reactor used in this work (RHS).

The technology is estimated to be at TRL 3 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 1.5-2 years.

System Description

- Fabrication and testing of SOEC unit
- Models of laboratory version and mass-manufacturable prototype
- Presentation of unique benefits of SO-SCWFC -- speed and complete mineralization of biomass (target processing speed for RTTC prototype 6L/min); fuel versatility -- variety of carbonaceous materials; power generation
- Reduces/eliminates corrosive effect of oxygenated SCW on reactor material
- Introduction of "autonomous toilet" and speculation about re-envisioning the toilet

Economic Analysis

- Capital costs: comparable to 6x6x4 inch micro-fuel cell 'brick' - like the AIST version
- Operating Costs: less than zero; it creates value -- is autonomous, generates potable water and provides autonomy of water supply (i.e. it does not require additional water), and it generates sufficient power for its own operation
- Has potential for easy recovery of valuable salts, and capture of clean CO_2 for solar/wind powered regeneration of "green" fuel

Institute for Residential Innovation (IResI)

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Feasibility Study	RTTC Criteria
Project Title	Sewage Containment and Mineralization Device (SeCoM)	Reinventing the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	Nov 1, 2011	07/2011
Remaining time in funding cycle	9 months	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Solid Oxide - SuperCritical Water Fuel Cell	N/A
Consumable		
• Water/user	Zero -- autonomous device	For personal hygiene, no flushing
• Electricity/user	Zero -- autonomous device	Off grid
• others	Zero	0
Limitations	Will not process bones	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	~2,000kJ	N/A
Water recovered/user	Full recovery	N/A
Nutrient/fertilizer recovered/user (g or L)	Full recovery of mineral salts only	N/A
Estimated revenue/user/day ($)	n/a	N/A
Total revenue /user/day ($)	n/a	
Smell and odors control measures	None needed -- only CO_2/N_2 released	No smell, no flies
Technology Readiness Level	N/A	N/A
At time of RTT Fair	N/A	N/A
Estimated at end of funding Phase	5-6	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	10yrs, but with some replacement parts	>5 years
Estimated total cost/user/day ($) (without revenue)	**$ <0.01**	**0.01 – 0.05**

Exhibitor 13

London School of Hygiene and Tropical Medicine - Tiger Toilet

Model of installed Tiger system shown full size in vertical section

The technology is estimated to be at TRL 5 by the time of the Fair.

The team predicts that TRL 7 could be achieved in 2 years with $1M.

System Description

This illustrates what a production model of the Tiger system could look like, from squat plate through to the biofilter tank where worm-mediated solids removal takes place. It is much more compact than a septic tank and at least as efficient. The tank can be mass-produced in recycled plastic at low cost and there are very few components.

Economic Analysis

We are aiming to get the capital cost of this system below £150. At a more conservative estimate of $200 it still works out a cost/user/day of less than the RTT target in part because of the long expected lifetime. It only requires flush water. There is no revenue – the worms form a stable self regulating population.

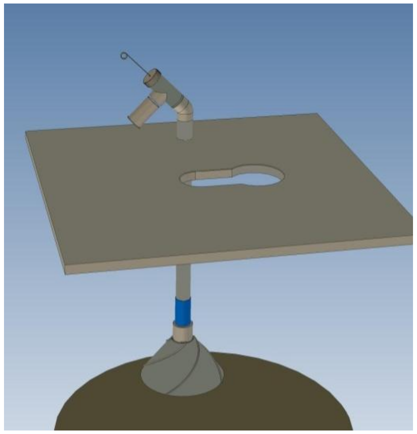
London School of Hygiene and Tropical Medicine

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Latrine replacement	RTTC Criteria
Project Title	Tiger Toilet	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	Other	All
Project Start Date	July 2009	07/2011
Remaining time in funding cycle	None	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Biofilter	N/A
Consumable		
• Water/user	Yes, flushing, 2l/user	For personal hygiene, no flushing
• Electricity/user	None	Off grid
• Others	Support matrix (eg coir)	0
Limitations	Excessive water influx	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	Treated effluent only	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	None	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	Lid on tank; water seal on pour flush toilet	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	5	N/A
Estimated at end of funding Phase	5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	2 years	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$1m	N/A
Estimated capital cost of final toilet (for family of 10)	$200	N/A
Estimated lifetime	> 10 yr	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.005**	**0.01 – 0.05**

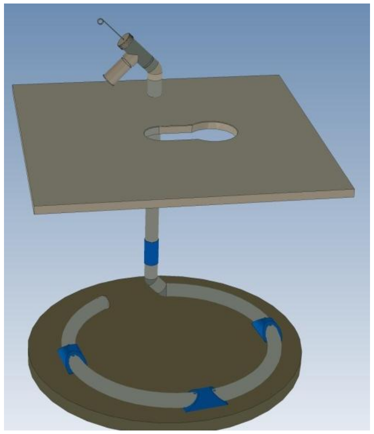
Exhibitor 13

London School of Hygiene and Tropical Medicine - Black Soldier Fly Larvae Collection System

The “Kone”



“Daisy Chain”



Illustrations showing an installed “Kone” (left) and “Daisy Chain” (right) larvae collection system with the main collection cone/pipe (bottom), retrieval pipe assembly and larvae collection pipe assembly holding the retrieval rod, plunger and collection jar (top)

The technologies are estimated to be at TRL 3 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 1 year with $100K.

System Description

The “Kone” and “Daisy Chain” are systems for retrieving Black Soldier Fly Larvae, used to digest sludge, from inside a pit latrine. They can be retrofitted with minimal adjustments to existing structures. A larvae collection cone rests at the sludge surface. Larvae migrate into the cone after feeding and are harvested through pipes extending to the surface by a retrieval rod and plunger into a collection jar. Larvae can be processed into high value products such as animal feed.

Economic Analysis

The system requires no power and only a small amount of water for cleaning. There is an estimated value of $14 per year per family as high grade animal feed and the estimated cost for the first year of $0.01 /day/user.

London School of Hygiene and Tropical Medicine

Technology target	Longer lasting pit latrines	RTTC Criteria
Project Title	Black soldier fly larvae collection system	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	Other	All
Project Start Date	July 2009	07/2011
Remaining time in funding cycle	None	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Larval retrieval mechanism	N/A
Consumable		
• Water/user	Only for cleaning	For personal hygiene, no flushing
• Electricity/user	None	Off grid
• Others	None	0
Limitations	None so far	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	None	N/A
Water recovered/user	None	N/A
Nutrient/fertilizer recovered/user (g or L)	None	N/A
High Grade Animal Feed (larval protein)	14kg /yr/family	
Estimated revenue/user/day ($)	$0.01	N/A
Total revenue /user/day ($)	$0.01	
Smell and odors control measures	No smell no flies (larvae suppress odours and egg laying by other flies)	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL 3	N/A
Estimated at end of funding Phase	TRL 3	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	1 year	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$100K	N/A
Estimated capital cost of final toilet	$15-20	N/A
Estimated lifetime	>10 year	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.01 (based on 1 year, 5 people per family)**	**0.01 – 0.05**

Exhibitor 14

University of Colorado Denver - Bioelectric Toilet

Converting two latrines to power-producing toilets in Uganda

The technology is estimated to be at TRL 3 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 2-3 years with $1M.

System Description

- Developed 3 bench scale prototype reactors for direct conversion of human waste to electricity
- One prototype also allows urine separation for nutrient recovery
- Encouraging results showed 80% of COD removal and of 1.1W/m2 power output
- Field implementation was performed in Uganda

Economic Analysis

As a GCE phase I grantee, the team has not conducted economical analysis on the technology. However, the reactors are the cheapest bioelectric systems reactor possible for now. The stainless steel is 50% cheaper than graphite material. The produced power and fertilizer can further reduce the total cost. We are confident to meet the US$0.05 per user per day in the next 2-3 years.

University of Colorado Denver

Technology target	Fecal Sludge processing	RTTC Criteria
Project Title	Bioelectric Toilet	Reinventing the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE phase I/round 7	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle		N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	No	Yes
Biological process	Yes	No
Key technology component	Microbial Electrochemistry	N/A
Consumable		
• Water/user	No water needed	For personal hygiene, no flushing
• Electricity/user	Produce electricity	Off grid
• Others	Stabilize sludge	0
Limitations	N/A	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	50 W/m3	N/A
Water recovered/user	Urine recovery	N/A
Nutrient/fertilizer recovered/user (g or L)	0.5 L/user	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	No smell, no flies	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	3	N/A
Estimated at end of funding Phase	4-5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	2-3 years	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	10-15 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**Less than 0.03, but not focused on this Phase I GCE study**	**0.01 – 0.05**

Exhibitor 15

American Environmental Systems, Inc. - Developing chemicals to self-clean and disinfect toilets

Toilet seat treated with self-cleaning & antibacterial agent

The technology is estimated to be at TRL 3 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 10 months.

System Description

The team applied recent advances in nanotechnology in the development of novel low-cost antimicrobial and self-cleaning surfaces in sanitary units based on silicone materials with embedded nanoparticles.

Economic Analysis

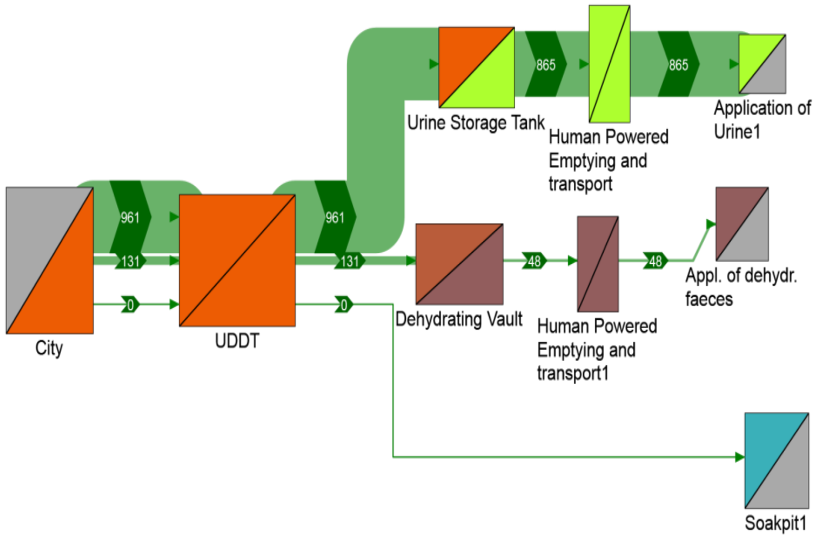
The capital and operational costs of the final unit will be less than US$0.0001 per user per day.

American Environmental Systems, Inc.

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Reinvented toilet	RTTC Criteria
Project Title:	Developing chemicals to self-clean and disinfect toilets	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle		N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering		Yes
Biological process	Yes	No
Key technology component	Hydrophobic coating	N/A
Consumable		
• Water/user	Minimum to clean	For personal hygiene, no flushing
• Electricity/user	No	Off grid
• others	0	0
Limitations	None	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)		
Smell and odors control measures	No smell, microbial free	No smell, no flies
Technology Readiness Level	3	N/A
At time of RTT Fair	3	N/A
Estimated at end of funding Phase	4	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	>2	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.001 – 0.01**	**0.01 – 0.05**

Exhibitor 16

University College London - Modeling the next generation of sanitation systems



Simulation of nutrient fluxes (shown here: Nitrogen) from household to final disposal – Sankey Diagram. Simulation done for a imaginary city of 100,000 people with 20,000 households using urine-diverting dry toilet (UDDT) assuming 1 toilet per household. The three component streams i.e. urine, faeces and anal cleansing water have been assumed. Number units: kg/day

The technology is estimated to be at TRL 4 by the time of the Fair.

System Description

NewSan is a computer-based simulator for current and new sanitation technologies. It serves for the selection of sanitation systems appropriate for the local conditions. Its flexibility allows to include sanitation technologies developed in the future. Significant cost-savings and improved utilization of resource streams, thus increasing revenue, are expected.

- NewSan is a computer-based simulation model to aid in decision-making, thus enabling sanitation systems to be implemented which are appropriate to the locally prevailing boundary conditions.
- NewSan simulates the whole sanitation chain from household to final disposal/reuse
- NewSan simulates new technologies such as dry toilets, UDDT, UDDT-flush toilet, vacuum, & low-flush toilet
- NewSan is highly flexible, therefore also sanitation systems developed in the future can be added to the model and, thus, be considered in the decision process.
- NewSan considers organic matter (BOD, COD) and has ability to simulate any nutrient flows such as N, P, K. For the preliminary prototype we focus on N and P as the main nutrients.
- NewSan simulates energy fluxes
- NewSan allows CAPEX and OPEX to be considered in technology selection.

University College London

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Computer simulation model	RTTC Criteria
Project Title	Modeling the next generation of sanitation systems [1]	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE (Round 7)	All
Project Start Date	01/11/2011	07/2011
Remaining time in funding cycle	10 months	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	No	Yes
Biological process	No	No
Key technology component	Simulation model	N/A
Consumable		
• Water/user	N/A	For personal hygiene, no flushing
• Electricity/user	Power supply for computer	Off grid
• others	N/A	0
Limitations	Need a computer	Off grid
Waste to be processed off-site	N/A	None
Waste dumped / infiltrated in soil	N/A	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	N/A	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL4	N/A
Estimated at end of funding Phase	TRL6	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	1 year	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	USD 100,000.00[2]	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	> 5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**N/A**	**0.01 – 0.05**

Notes:

(1) This project develops and demonstrates a simulation system which supports the selection of sanitation technologies appropriate to the locally prevailing boundary conditions. These also include Next-generation sanitation systems and help to promote them. Significant cost-savings and improved utilization of resource streams, thus increasing revenue, are expected from the appropriate selection of sanitation technologies which will be enabled by the simulator.

(2) Additional funds will be required for data sampling, field testing, and model refinement

Exhibitor 17

Delft University of Technology – A toilet that converts human waste to fuel gas

1. INDIA –
SQUAT SEPARATION TOILET, FOR ABLUTION BLOCKS

2. MOCK-UP OF INTEGRATED PLASMA-GASIFICATION SYSTEM

3. SOUTH AFRICA –
PEDESTAL TOILET, FOR HOUSEHOLDS

The three prototypes; mock up of the integrated technology in the middle, the applications of it for different settings on the left (India) and right (South Africa).

System Description
The integrated system for upgrading human waste to fuel gas with plasma gasification in the middle, with its applications for two different cases on both sides. Both applications (Durban/Delhi) split waste streams, and pre-dry feces to make it ready for gasification. The integrated system sizes the waste, gasifies it to create hydrogen, which is turned into electric energy.

The technology is estimated to be at TRL 4 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 2 years with high effort.

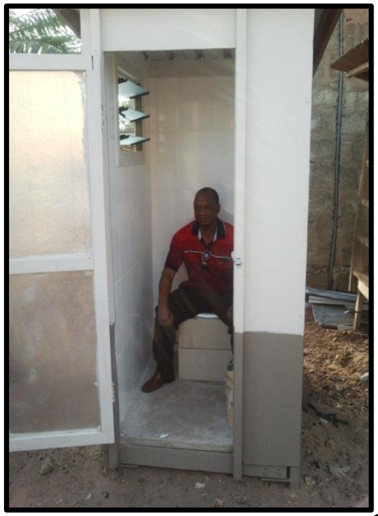
Economic Analysis
Estimated capital costs of the final unit: 18 dollars (will drop with the prices of solid oxide fuel cells).
Operational costs: based on E-production/efficiency
The final unit is expected to produce its own energy, making it truly off the grid. Water regaining can be integrated.

Delft University of Technology

Technology target	Reinvented toilet; plus conceptual overall sanitation system	RTTC Criteria
Project Title	A toilet that converts human waste to fuel gas	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	RTTC	All
Project Start Date	09/2011	07/2011
Remaining time in funding cycle	2 months	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Plasma gasification, SOFC	N/A
Consumable		
Water/user	For personal hygiene, cleaning	For personal hygiene, no flushing
Electricity/user	Off the grid	Off the grid
Others		0
Limitations	Enough input needed (700 persons)	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	0,035 India/0,05 SA	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	Reduced	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	4	N/A
Estimated at end of funding Phase	4,5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	2/3 years	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	< 10.000 euro	N/A
Estimated lifetime	10 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.05**	**0.01 – 0.05**

Exhibitor 18

Ghana Sustainable Aid Project - The Microflush Biofil Toilet



A recent visitor from the Foundation takes a test drive on a prototype Biofil/Microflush toilet in Pokuase Village in Ghana.

- √ Affordable
- √ No power
- √ Little water
- √ Useful output

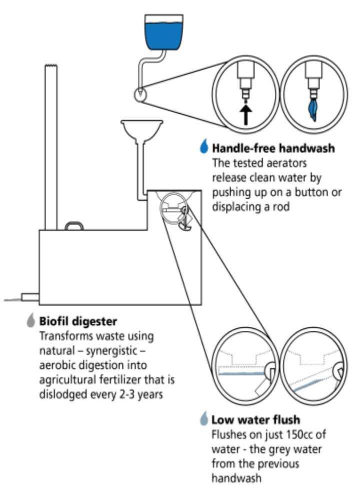
The technology is estimated to be at TRL 6-7 by the time of the Fair.

The team predicts that a Generation 2 system could be achieved in 2 years with > $1M of additional funding.

The Product

GSAP has prototyped the Biofil/Microflush toilet, a marriage of the Biofil digester, designed by Kweku Anno of Biofilcom, and the Microflush valve, designed by Stephen Mecca and Colin McDonagh at Providence College.

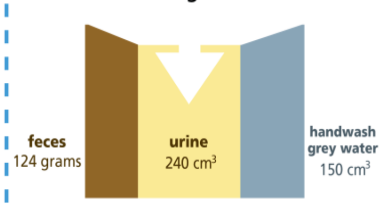
Biofil/Microflush Toilet



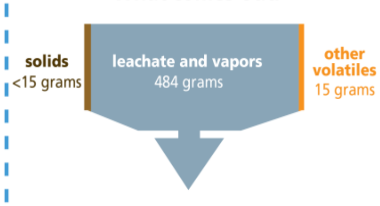
The Process

Human waste is isolated from human space by the Microflush valve. Waste input is dewatered and transformed in the Biofil digester through aerobic micro- and macro organism processes into useful compost.

What goes in:



What comes out:

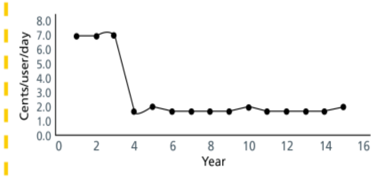


The Price

The prototype facilities have enjoyed user acceptance and appreciation. GSAP has tested a COOP loan program that promises accessible ownership opportunity for users. At less than 3 cents per user per day (most of which is for soap, tissue and towel), the prototype Generation 1 Biofil/Microflush toilet is an affordable sanitation solution. The Generation 2 system under consideration promises affordability even for the poorest individual households.

Life Span Costs
2.5 - 2.9 ¢ /user/day

Total User Costs



Ghana Sustainable Aid Project

Technology target	Reinvented Toilet	RTTC Criteria
Project Title	Microflush Biofil Toilet	RTTC
BMGF funding mechanism	GCE	All
Project Start Date	05/2011	07/2011
Remaining time in funding cycle		N/A
Processes and Technologies		
Chemical engineering processes	Yes, biochemical	Yes
Mechanical engineering	Yes, Microflush valve & Biofil digester	Yes
Biological process	Yes, Biofil digestion	No
Key technology component	Integrated systems	N/A
Consumable		
• Water/user	150 cc/use for hand washing and reuse for flushing	For personal hygiene, no flushing
• Electricity/user	Off grid	Off grid
• Others	N/A	0
Limitations	Off grid	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	Solids – none Liquid filtrate including urine & vapor – 484 cc/use	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	Hand wash water reused for 150 cc flush	N/A
Nutrient/fertilizer recovered/user (g or L)	15 g	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	No odor, no flies	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL 6 – TRL 7	N/A
Estimated at end of funding Phase	TRL 6 – TRL 7 (Phase I); TRL 8 – TRL 9 (if Phase II proposal is successful)	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	Generation 1 Biofil/Microflush prototypes have already been produced	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	Generation 1 prototype development ~$100,000 and now costs $1200/30 user facility Generation 2 development costs will exceed $1M	N/A
Estimated capital cost of final toilet	Generation 1 $1200 for 30 user toilet; Generation 2 target cost is < $500	N/A
Estimated lifetime	>10 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**Generation 1: Life span costs 0.025 – 0.029/user/day more than half of which is for soap, tissue and towel.**	**0.01 – 0.05**

Exhibitor 19

Swiss Federal Institute of Aquatic Science and Technology (EAWAG) - Diversion for safe sanitation

The *diversion* toilet

Portable source-separating toilet with on-site wash & flush water recovery. Can be retrofitted and used anywhere. Grid-free, without electricity, water and sewer.

The technology is estimated to be at TRL 5 by the time of the Fair.
Total sanitation is only conceptual (Resource Recovery Plant for 860 p), but included in estimated costs of total unit (cf. business model).

The team predicts that TRL 7 could be achieved in 15 months with $900,000. After TRL 7, investment costs for rotomoulding forms & new membrane production tool would cost $250,000. Larger costs for pilot projects with acceptance studies and setting up business model before going to scale.

System Description

- A diversion toilet with integrated water recovery
- Provides water for comfortable anal and menstrual hygiene and for toilet cleaning
- Diverts undiluted urine, feces and water in three different directions
- Foot pump assures hygienic, coupled pumping of soiled and clean water respectively
- Comfortable and hygienic collection of excreta in service system

Economic Analysis

- Estimated target investment costs (assuming high-volume production): $500 per toilet
- Total costs incurring for the user $0.05/day
- Sales of end-products of $0.02/user/day
- Profit of $0.016/user/day
- Energy consumption covered by 2-4W solar panels that are part of the toilet
- Water refilling required ~0.1 L per person /day

Swiss Federal Institute of Aquatic Science and Technology (EAWAG)

Technology target	Reinvented toilet; plus conceptual overall sanitation system	RTTC Criteria
Project Title	Diversion for safe sanitation	RTT Challenge
BMGF funding mechanism	RTTC	All
Project Start Date	07/2011	07/2011
Remaining time in funding cycle	Until end of July 2012	N/A
Processes and Technologies[1]…	*…in the toilet unit*	
Chemical engineering processes	Yes (electrolysis)	Yes
Mechanical engineering	Yes (ultrafiltration)	Yes
Biological process	Yes (passive process to prevent clogging & avoid maintenance)	No
Key technology component	Flushed dry toilet with source separation and on-site water recovery (ultrafiltration followed by electrolysis)	N/A
Consumable		
• Water/user	Water recovery requires refilling of 0.1L/user/day due to system losses. 6-8 L clean water/p/day is available	For personal hygiene, no flushing
• Electricity/user	Off grid; solar panels with 0.4-0.8 W/user (2-4W/toilet for aeration and electrolysis)	Off grid
• Others	Chlorine if desired	0
Limitations	Off grid	Off grid
Waste to be processed off-site	Dry feces and urine to be processed in a nearby Resource Recovery Plant (RRP)[2]. Logistics possible at $0.01/user/day	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	~ 0 (use energy from feces for urine treatment)	N/A
Water recovered/user	~1L of distilled water/user/day possible	N/A
Nutrient/fertilizer recovered/user	Max.: 8 gN/user/d; 1 gP/user/d; 4 gK/user/d	N/A
Estimated revenue/user/day ($)	$0.02/user/day (only the value of nutrients)	N/A
Total revenue /user/day ($)	Total profit: $0.016/user/day	
Smell and odors control measures	Toilet lid, normal improved ventilation; separated feces & urine reduce smell	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL 5	N/A
Estimated at end of funding Phase	TRL 5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce TRL 7	15 months is possible	N/A
Estimated cost to produce TRL 7	≈ 900,000 US$ (incl. own funding in kind)	N/A
Estimated capital cost of final toilet	$500 (mass production!)	N/A
Estimated capital cost of RRP (860 users)	$27500 (mass prod.!)	N/A
Estimated lifetime for toilet, resp. RRP	10 years, resp. 20 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**$0.05/user/day (only with mass production!)**	**0.01 – 0.05**

EAWAG - Promoting sanitation through urine source-separation

© Eawag

© KMU GmbH

Nitrification reactor at Eawag and distillation reactor to be installed in September 2012.

This technology is estimated to be at TRL 5 by the time of the Fair.

The team plans to install a fully functional urine treatment reactor in South Africa in less than 1 year.

System Description

The aim of the project is to promote sanitation and nutrient recovery through urine separation.

Collaboration partners

University of KwaZuluNatal (UKZN), eThekwini Water and Sanitation (EWS), Swiss Federal Institute of Science and Technology Zurich (ETHZ).

Economic Analysis

The current urine treatment setup (nitrification/distillation) requires ca. 220 Wh/p/d. The products are a highly concentrated nutrient solution and distilled water. A very small amount of excess biomass is produced. The current financial value of recovered nutrients (N,P,K,S,Mg) is 0.018 USD/p/d (based on Indian fertilizer prices).

Swiss Federal Institute of Aquatic Science and Technology (EAWAG)

Technology target	Management and processing of source-separated urine	RTTC Criteria
Project Title	Promoting sanitation and nutrient recovery through urine separation	RTTC
BMGF funding mechanism	Global development grant	All
Project Start Date	09/2010	07/2011
Remaining time in funding cycle	2 years	N/A
Processes and Technologies		
Chemical engineering processes	Evaporation, mineral precipitation, electrolysis	Yes
Mechanical engineering	Urine collection and transport	Yes
Biological process	Nitrification	No
Key technology component	Nutrient recovery as a highly concentrated solution (nitrification/evaporation)	N/A
Consumable		
• Water/user	No	For personal hygiene, no flushing
• Electricity/user	Ca. 220 Wh/p/d (only nitrification/distillation)	Off grid
• others	Optional for complete ammonia oxidation: limestone (30 g/pers/d) (nitrification/distillation)	0
Limitations	Requires collection scheme and semi-decentralized treatment facilities.	Off grid
Waste to be processed off-site	A very small amount of excess sludge and possibly distilled water are waste products	None
Waste dumped / infiltrated in soil	Excess sludge and distilled water	None
Revenue stream		
Energy recovered produced/user (kWh)	None from urine	N/A
Water recovered/user	Nearly all water in urine: about 1.25 L/p/d (Udert *et al.* 2006)	N/A
Nutrient/fertilizer recovered/user (g or L)	With nitrification/evaporation nearly all nutrients in urine. If all urine per person is collection, no losses occur during collection and the person is well-nourished: 10 gN/p/d, 1 gP/p/d, 2.5 gK/p/d, 1.5 gS/p/d, 0.13 gMg/p/d (Udert *et al.* 2006)	N/A
Estimated revenue/user/day ($)	Based on fertilizer values in India (N,P,K,S,Mg) Sakthivel *et al.* 2012): 0.018 USD/p/d (without possible revenue for distilled water and Ca)	N/A
Total revenue /user/day ($)	Selling fertilizer and distilled water is unlikely to cover the costs of collection and treatment.	
Smell and odors control measures	The smell of stored urine is not a problem, if the storage tank is properly closed. If UDDT is properly operated: feces will dry quickly and not smell.	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL 5	N/A
Estimated at end of funding Phase	TRL 7	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	1.5 years	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	for about 200 people: 80,000 USD	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	>10 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**N/A**	**0.01 – 0.05**

Exhibitor 20

University of KwaZulu Natal - A community bathroom block that recovers clean water, nutrients, and energy

Washwater diversion and odour seal mechanism on three-way split pedestal

The technology is estimated to be at <u>TRL 2</u> by the time of the Fair.

The following stages are required to achieve a fully functioning RTTC toilet meeting 100% of the requirements: <u>generation of design data from community ablution blocks, modeling of integrated system alongside development of unit process prototypes; integration of unit process prototypes.</u>

<u>System Description</u>

- *Source separation of influent streams*: 3-way split (urine, faeces, washwater) pedestal with odour seal prototyped.
- *Faeces and solids processing*: Extrusion/separation, drying and combustion processes. First stage prototype of extruder. Rheological, chemical and thermal analysis of human excreta carried out to generate required data for design of prototypes.
- *Urine processing*: Three-stage membrane process. Experimental work to establish feasibility of process for treating faeces-contaminated urine and to generate flux, fouling and water and urea recovery rate data for design of prototype system.

<u>Economic Analysis</u>

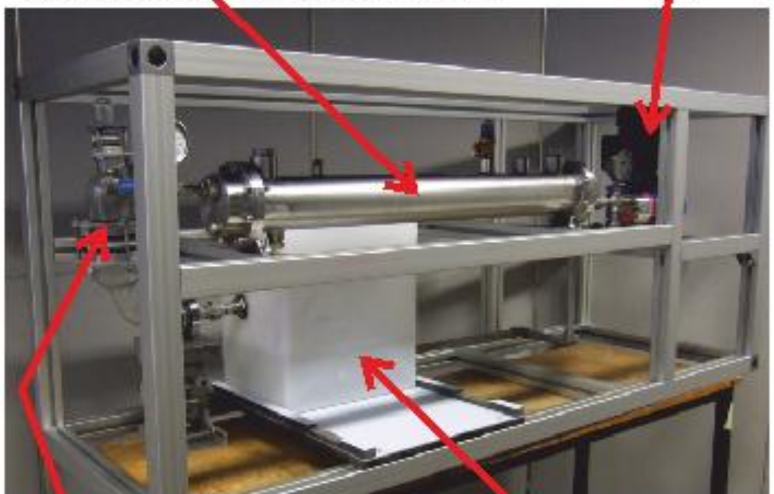
- Modeling work required to establish if/how the system can be energy self-sufficient. Heat energy from the combustor will be recovered for drying and part of the membrane system.
- Water recovered and recycled within system, limited input required to replace losses.
- Solids product streams from combustor (ash containing phosphorus and potassium) and urine processing (urea-rich concentrate) will have potential economic value, particularly at community ablution block scale of production.

University of KwaZulu-Natal

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Reinvented Toilet	RTTC Criteria
Project Title	A community bathroom block that recovers clean water, nutrients, and energy	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	RTTC	All
Project Start Date	20/06/2011	07/2011
Remaining time in funding cycle	Phase 1 end 30/09/2012	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	N/A	N/A
Consumable		
• Water/user	Handwash water diverted for toilet bowl cleaning; no water seal requirement	For personal hygiene, no flushing
• Electricity/user	External electricity supply still required to power unit processes	Off grid
• others	Membrane cleaning agents or replacement cartridges	0
Limitations	Conceptual integrated system is off grid, has no requirement for off-site processing of waste or dumping to soil. Project is several stages back from this, producing data required for design of the individual unit processes.	Off grid
Waste to be processed off-site	See above	None
Waste dumped / infiltrated in soil	See above	None
Revenue stream		
Energy recovered produced/user (kw/h)		N/A
Water recovered/user		N/A
Nutrient/fertilizer recovered/user (g or L)		N/A
Estimated revenue/user/day ($)		N/A
Total revenue /user/day ($)		
Smell and odour control measures	Bowl seal underneath pedestal (when pedestal not in use) together with airflow from pedestal towards combustor. Rapid movement of faecal material away from pedestal area to processing.	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	1	N/A
Estimated at end of funding Phase	1	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)		N/A
Estimated cost to produce fully functioning prototype (TRL 7)		N/A
Estimated capital cost of final toilet		N/A
Estimated lifetime	> 5 years, in a community ablution block environment	>5 years
Estimated total cost/user/day ($) (without revenue)		**0.01 – 0.05**

Exhibitor 21

Loughborough University - A toilet that produces biological charcoal, minerals, and clean water



Continuous Hydrothermal Carbonization Rig: an un-lagged prototype to show detail of reactor (a three pass plug flow shell and tube system), a glass 3-phase (gas liquid and solid) flash tank and sedimentation tank; the demonstration system is capable of treating between 100 and 1000 people per day (smaller numbers are possible) whilst operating continuously, with energy recovery (not included here).

The subsystem (continuous hydrothermal carbonization) is estimated to be at TRL 5 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in approximately 18 months.

System Description

The reactor conditions ensure complete pathogen destruction and render the solids easily separable. Pressure is reduced in the Flash Tank; steam is generated (energy in the form of electricity can be recovered). The project has also investigated dewatering the solids after carbonization and sedimentation by means of slotted metal microfilters.

Economic Analysis

A modular process system is anticipated, with a capital cost estimate of $10k to $20k for ~1000-100 users (aim to 30-100). Maximum recycle of energy and water is provided within the system, with phosphate, urea and salt products recovered and ~$0.05/user/day costs. Clean (thermally treated) water is also produced: 0.15 kg/day/person.

Loughborough University

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Reinvented Toilet	**RTTC Criteria**
Project Title	A toilet that produces biological charcoal, minerals, and clean water	Reinvent the Toilet
BMGF funding mechanism (RTTC, GCE, Contract, other)	RTTC	All
Project Start Date	07/2011	07/2011
Remaining time in funding cycle	N/A	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Continuous Hydrothermal Carbonization	N/A
Consumable		
• Water/user	Recycled	For personal hygiene, no flushing
• Electricity/user	Minimal, off grid	Off grid
• others	none	0
Limitations		Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	0.7 kJ/h per person	N/A
Water recovered/user	0.15 kg per day per person	N/A
Nutrient/fertilizer recovered/user (g or L)	10 grams per person per day	N/A
Estimated revenue/user/day ($)	TBD	N/A
Total revenue /user/day ($)	TBD	
Smell and odors control measures	No smell, no flies	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	5	N/A
Estimated at end of funding Phase	5 (At the end of phase 1) 7 (October 2013) 8 (May 2014) 9(End of 2014)	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	12 months(from November 2012)	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$650k	N/A
Estimated capital cost of final toilet	$10-20k	N/A
Estimated lifetime	>5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**~0.05**	**0.01 – 0.05**

Exhibitor 22

Oklahoma State University - A device that sterilizes fecal sludge

Fecal treatment chamber housing (inverted). The 10 cm, tapered section is the reactor rotating core (left) and the shell (right).

The technology is estimated to be at TRL 5 by the time of the Fair.

The team predicts that 6-12 months are required to optimize the geometry and performance of the system.

System Description
The technology uses viscous heating of feces through an extruder. Temperature, shear stress and pressure goals have been exceeded. Simulant achieves 200°C without added heat. A device the size of a fist could treat the solid waste for a small community. Easy integration with other processes.

Economic Analysis
Geometries for different scales are possible. A device that treats feces from 10-12 people would cost ~$150 and operate at US$0.04 per user per day. Water input must be minimal. Power to rotate a core in a tube is required from any source, perhaps by hand. Byproducts are disinfected solid (possible soil additive) and recoverable water vapor.

Oklahoma State University

Technology target	Reinvented toilet	RTTC Criteria
Project Title	A device that sterilizes fecal sludge	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	05/2011	07/2011
Remaining time in funding cycle	11/2012	N/A
Processes and Technologies		
Chemical engineering processes	Reactor Design Methods	Yes
Mechanical engineering	Friction Viscous Heating	Yes
Biological process	No	No
Key technology component	Auger rotation in a shell	N/A
Consumable		
• Water/user	None	For personal hygiene, no flushing
• Electricity/user	Maybe some, but off grid	Off grid
• Others		0
Limitations	Screening if grit/sand	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	Dry solid possible	None
Revenue stream		
Energy recovered produced/user (kw/h)	Possible, burning residue	N/A
Water recovered/user	Possible, not measured	N/A
Nutrient/fertilizer recovered/user (g or L)	All solid recovered	N/A
Estimated revenue/user/day ($)	Not yet known	N/A
Total revenue /user/day ($)	Not yet known	
Smell and odors control measures	Dried solid should help	No smell, no flies
	But benefit unconfirmed	
Technology Readiness Level		N/A
At time of RTT Fair	TRL 5	N/A
Estimated at end of funding Phase	TRL 6	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	6-9 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	With solar panel & car battery - $150-180/unit	N/A
Estimated capital cost of final toilet	$170-200/unit	N/A
Estimated lifetime	>5 for parts; ~3 battery	>5 years
Estimated total cost/user/day ($) (without revenue)	**10-12 people to achieve $0.04/user/day**	**0.01 – 0.05**

Exhibitor 23

Fundación In Terris - The Earth Auger Toilet: Innovation in waterless sanitation (el taladro de la tierra)

GRAN TALADRO set on a exhibition structure

Economic Analysis

- Capital & operating cost: $0.07
- Nearly dry compost is harvested (requires more storage time (4 months) to ensure pathogens die off)
- Urine can be harvested or infiltrated

The technology is estimated to be at TRL 5 by the time of the Fair.

The concept is already functional, but additional time and budget (8-18 months, $250 - 500K) are needed for final testing towards a commercial version and for developing a scale-up strategy for reducing unit costs. Budget & time listed for GRAN and MINI.

System Description

- Large capacity unit
- Dry flushing system
- Pedal-operated
- No water or electricity required
- No odors or flies

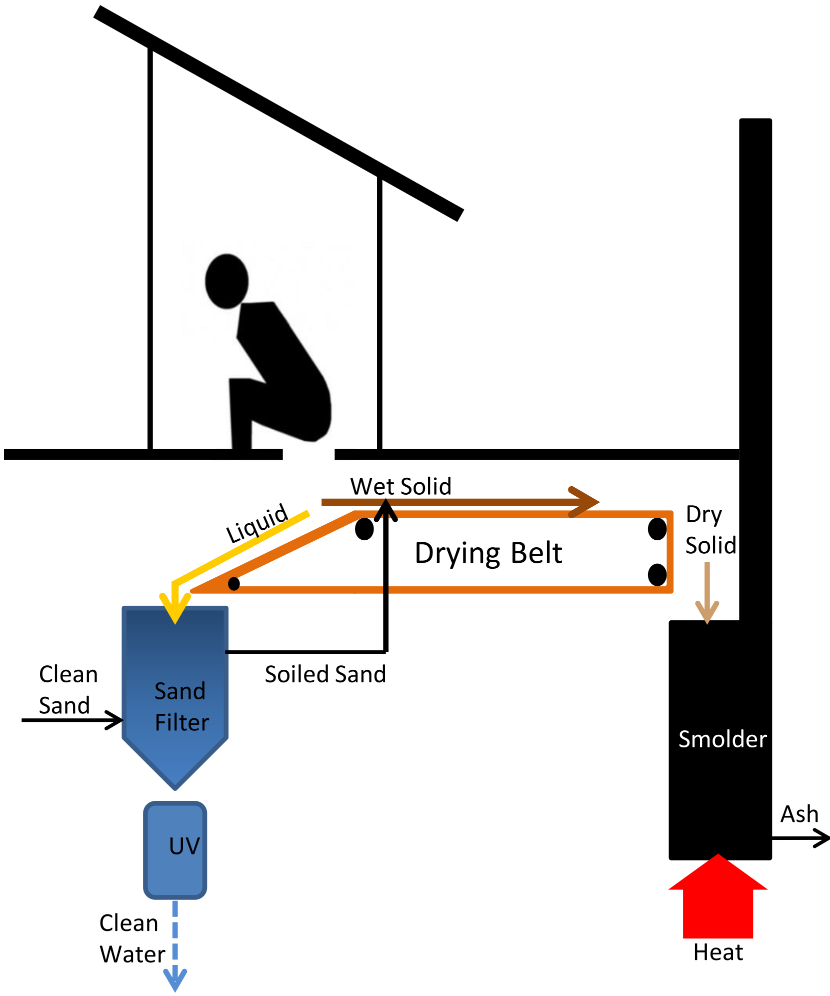
When the pedal is pushed, the excreta moves to the processing chamber and sawdust (or simple dry material) is released. An auger system mixes and aerates the material, and thereby accelerates the composting process.

Fundacion in Terris

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Reinvented Toilet	RTTC Criteria
Project Title	The Earth Auger Toilet: Innovation in waterless sanitation	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	Grand Challenges Explorations	All
Project Start Date	05/2011	07/2011
Remaining time in funding cycle	4 months (untill 11/2012)	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Yes	N/A
Consumable		
• Water/user	No flushing.	For personal hygiene, no flushing
• Electricity/user	Off grid	Off grid
• others	Compost producing	0
Limitations	Off grid	Off grid
Waste to be processed off-site	Not waste, compost production	None
Waste dumped / infiltrated in soil	Both possible with urine: infiltration or storage	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	120 g /user /day	N/A
Estimated revenue/user/day ($)	0,02 US $ /user /day	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	No smell, no flies	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	5	N/A
Estimated at end of funding Phase	6	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	18 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$ 500K	N/A
Estimated capital cost of final toilet	$150	N/A
Estimated lifetime	>5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.07 – 0.10**	**0.01 – 0.05**

Exhibitor 24

University of Toronto - A toilet that sanitizes feces and urine to recover resources and energy



Chemical plant with filtration, UV, drying, and smoldering unit operations.

The technology is estimated to be at TRL 3 by the time of the Fair.

The team predicts that TRL 7 could be achieved in 15 months with team of faculty advisors and 5 full time research staff. Estimate 1.5 years additional field testing.

System Description

- Solid and liquid waste are passively separated.
- Solid is dried and smoldered; rollers to flatten feces and smolder reactor will be shown.
- Liquid with solid contaminant is fed to sand filter with countercurrent sand and liquid flow.
- Solid retentate cake is skimmed with top layer of contaminated sand and fed to smoldering reactor.
- Liquid filtrate is disinfected in thin film UV reactor.

Economic Analysis

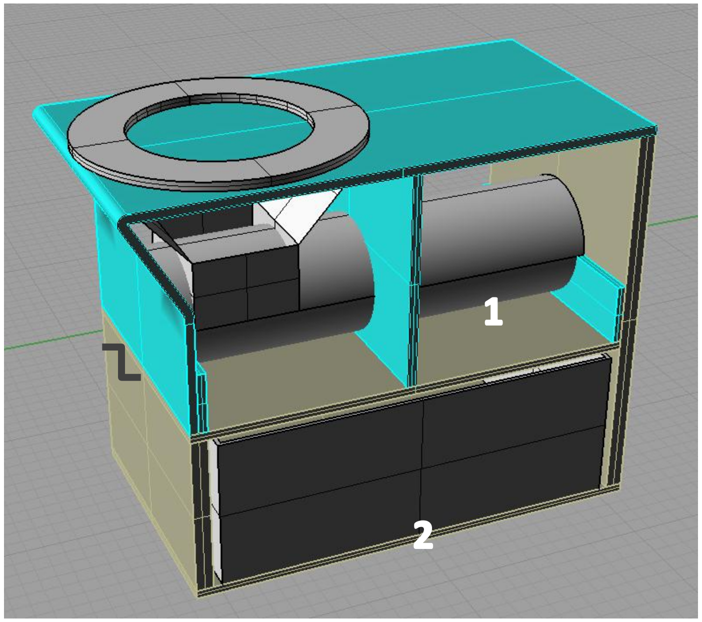
- $1,000 capital cost or $0.04 pp/pd for 6% interest amortized over 10 years.
- Operating cost expected to be low since consumables are inexpensive.
- US$0.05 pp/pd target at commercial scale achievable.
- <20 watts (UV, fan) at 10 person scale, and fuel for smoldering ignition are the only energy requirements. No added water required.
- Energy capture not considered yet.

University of Toronto

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Reinvented toilet	RTTC Criteria
Project Title	A toilet that sanitizes feces and urine to recover resources and energy	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	RTTC	All
Project Start Date	07/2011	07/2011
Remaining time in funding cycle	1 month in Phase 1; 15 months in Phase 2	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Drying/crusting, smoldering, sand filtration, UV disinfection	N/A
Consumable		
• Water/user	Estimated 2 L/user per day wash water for personal hygiene – accounted for in technology, but not essential for technology function.	For personal hygiene, no flushing
• Electricity/user	1.5 Watts/user (15 W UV lamp for 10 users). Anticipate using off grid power such as solar.	Off grid
• Others	Fuel for ignition of smoldering reaction	0
Limitations	Off grid.	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	Have not tried to capture yet.	N/A
Water recovered/user	UV disinfected liquid can be recovered if needed. Estimate 2L /user per day.	N/A
Nutrient/fertilizer recovered/user (g or L)	Have not considered possible ash recovery yet.	N/A
Estimated revenue/user/day ($)	Not considered yet.	N/A
Total revenue /user/day ($)	Not considered yet.	
Smell and odors control measures	Preliminary work with smoldering unit shows promise for controlling odor and visible smoke.	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL 3	
Estimated at end of funding Phase	TRL 3 at end of phase 1; TRL 7 at end of phase 2.	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	15 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$750,000 (current estimate, pending final phase 2 proposal)	N/A
Estimated capital cost of final toilet	$1,000	N/A
Estimated lifetime	5 to 10 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**Expect < $0.05 when manufactured at scale**	**0.01 – 0.05**

Exhibitor 25

University of California Berkeley - Safe sludge project



Pathogen Free Loo (pHreeLoo): (1) Auger with hand crank to mix urine and feces; (2) Collection bin with liquid to raise pH of urine and feces to 12 (to enable disinfection by ammonia). The system can also be designed as a squatting toilet.

The technology is estimated to be at TRL 2 by the time of the Fair.

The team predicts that is would take approximately 2 years to fully test the system in the field and develop final design(s).

System Description

The pHreeLoo has two main components: auger and collection bin. The auger mixes urine and feces, provides ~ 2 hour storage (for ammonium to be released from urine by urease in feces), and transfers the material to the collection bin. The bin has a liquid with lime ($Ca(OH)_2$ to raise pH to 12), perfume, and oil layer to minimize volatilization. During storage, Safe Sludge is produced as pathogens are disinfected by ammonia (NH_3).

Economic Analysis

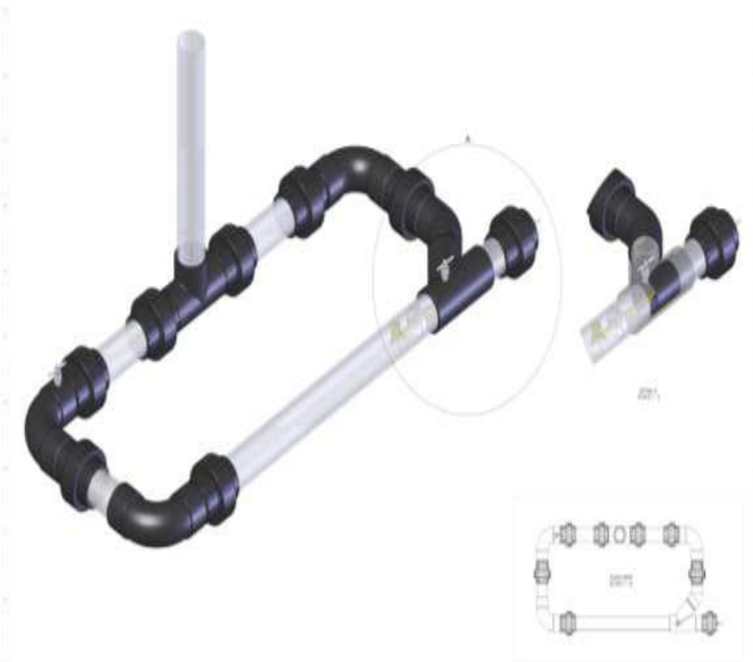
The pHreeLoo concept can be incorporated into other toilet technologies to provide onsite disinfection. The disinfectant solution has an estimated cost of < $0.01/user/day; total cost depends on specific toilet design. The Safe Sludge can be collected and used for energy production or resource recovery with minimal public health risk.

University of California Berkeley

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	FS processing	RTTC Criteria
Project Title	Safe Sludge Project	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	05/2011	07/2011
Remaining time in funding cycle	05/2013	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Auger	N/A
Consumable		
• Water/user	Minimal	For personal hygiene, no flushing
• Electricity/user	Off grid	Off grid
• others	Lime ($Ca(OH)_2$), perfume, oil barrier	0
Limitations	Off grid	Off grid
Waste to be processed off-site	Partially on-site	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	Perfume, oil barrier	No smell, no flies
Technology Readiness Level	2	N/A
At time of RTT Fair	2	N/A
Estimated at end of funding Phase	3	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	N/A	>5 years
Estimated total cost/user/day ($) (without revenue)	**< $0.01/user/day for disinfectant solution**	**0.01 – 0.05**

Exhibitor 26

Plymouth Marine Laboratory - A vortex bioreactor that processes fecal sludge and wastewater



Pathogen-rich water and buoyant anti-microbial beads are mixed and then separated by means of vortex flow.

The technology is estimated to be at TRL 5 by the time of the Fair.

The team predicts that TRL 7 could be achieved in 18 months with $1M.

System Description
The vortex bioreactor is a small, hand or bicycle-driven device for the rapid sterilization of water. It is intended for use in decentralized waste water treatment facilities (DEWATS) as a means of neutralizing the water that must be drained / squeezed out of fecal sludge before it can be used for energy generation.

Economic Analysis
Vortex bioreactors have only one internal moving part and can be constructed with standard plumbing fabrications. At approximately $200 per unit, a vortex bioreactor can safely sterilize water at block and district level whilst in the process generating water suitable for domestic and commercial use at less than $0.002/litre.

Plymouth Marine Laboratory

Technology target	FS energy recovery	RTTC Criteria
Project Title	A vortex bioreactor that processes fecal sludge and waste water	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE Round 7	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle	1 month	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Anti-microbial beads in vortex flow	N/A
Consumable		
• Water/user	None	For personal hygiene
• Electricity/user	None	Off grid
• Others	None	0
Limitations	None	Off grid
Waste to be processed off-site	Dewatered FS	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	Complete recovery of water	N/A
Nutrient/fertilizer recovered/user (g or L)	Not known	N/A
Estimated revenue/user/day ($)	Not known	N/A
Total revenue /user/day ($)	Not known	
Smell and odors control measures	No smells	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL5	N/A
Estimated at end of funding Phase	TRL5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	12-18 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$1m	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	5-8 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**Not yet known**	**0.01 – 0.05**

Exhibitor 27

North Carolina State University - A device to improve pit latrine emptying

Pit Latrine Extraction Auger lifting simulant waste from a 5 foot deep pit.

The technology is estimated to be at TRL 7 by the time of the Fair.

The team expects to complete field testing (TRL 8) in a developing country during the Phase I GCE grant.

System Description

The key function of the prototype is the screw conveying motion of a plastic auger (screw) within a stationary PVC pipe. The auger bit is rotated by a small gasoline powered motor which lifts the waste up the pipe and out through a tee fitting and hose, discharging the fecal sludge into a 210 L (55 gal) drum for offsite disposal. The technology dates back to the Archimedean Screw and is currently used to transport grain, select foods, and soil. The prototype has produced flows over 50 liter/min (13 gal/min) and should be able to pump out a typical pit in 15-30 minutes.

Economic Analysis

The final unit is estimated to cost between USD $750 - $1000 depending on the engine size and needed attachments. A complete business including the machine, rickshaw, drums and hand tools would cost approximately $2500. The main operating cost is 1 L of petrol per 2 hrs operation. Two men should be able to empty a pit in a remote location in 30-60 min.

North Carolina State University

Technology target	Pit Extraction	RTTC Criteria
Project Title	A device to improve pit latrine emptying	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	10/2011	07/2011
Remaining time in funding cycle	10 months	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Auger (Screw Conveyor)	N/A
Consumable		
• Water/user	Only for Clean-up (does not need to be potable)	For personal hygiene, no flushing
• Electricity/user	None	Off grid
• Others	Gas (petrol) for engine (small amount)	0
Limitations		Off grid
Waste to be processed off-site	Yes (only designed for pit extraction not treatment)	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	N/A	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	N/A	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	7	N/A
Estimated at end of funding Phase	8	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	Completed by fair (11 months)	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	~$900 for one Prototype and all attachments	N/A
Estimated capital cost of final toilet	$750 - $1000 (depending on size)	N/A
Estimated lifetime	>5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**~ $1/d for equipment + $1-2/d for petrol. Can empty 5-10 pits/d**	**0.01 – 0.05**

Exhibitor 28

National University of Singapore - A urine-diverting combustion toilet

Sustainable Low-cost Decentralized Sanitary System For Treatment, Water and Resources Recovery

Prototype Components:
1. Urine Compartment; 2. Feces Compartment; 3. Urine Transfer Line; 4. Urine Boiling Chamber; 5. Auxiliary Heaters (for demonstration purpose only); 6. Hand-Operated Vacuum Pump; 7. Feces Combustion Chamber (upper slot); 8. Biochar Burning Chamber (lower slot); 9. Condenser; 10. Condenser Cooling Water Holding Tank; 11. Solar Dryer; 12. Condenser Return Cooling Water Tank; 13. Vapor Transfer Line; 14. Hand-Operated Water Pump; and 15. Condensed Water Purification Tank.

The technology is estimated to be at TRL 4-5 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 1 year.

System Description

- Urine and feces are collected separately through a Urine Diversion Dehydration Toilet system (1 and 2 in the figure).
- Urine is channeled by gravity to the boiling chamber (4) and the fecal liquid collected underneath the feces collection tray (underneath 2) is manually poured into the boiling chamber (4).
- Feces collection tray (underneath 2) is slid into the solar dryer (11) for drying.
- Once the feces is substantially dried, the feces tray is slid underneath the boiling chamber (4) and biochar is placed in the burning chamber (8).
- Condenser (9) and boiling chamber (4) are depressurized to a desired vacuum level using a hand-operated vacuum pump (6).
- Biochar in the burning chamber (8) is ignited to dry and burn the feces, and to produce water vapor at low temperature heat input. Vapor is condensed in the condenser (9) and the condensed water is filtered through the purification tank (15) to produce highly purified water.

Economic Analysis (Note: each system is designed for 20 persons):

Capital Cost	= $ 325
Annual Operational Cost	= $ 150 (activated carbon & exchange resin)
Annual Maintenance Cost	= $ 30
Per day cost/person	*= $ 0.047 < $ 0.050*

Electrical Power Consumption = NIL (stand alone system)

Water Consumption = 150 Liters (groundwater; river water or tap water; reusable over multiple batches)

Expected by-products:

Concentrated Urine	: Use as natural fertilizer
Purified Water from Urine	: Can be used for hand wash, etc.

National University of Singapore

Technology target	Reinvented Novel Toilet system including feces processing, concentration of urine and water recovery	RTTC Criteria
Project Title	A urine-diverting combustion toilet	RTTC
BMGF funding mechanism	RTTC	All
Project Start Date	6 June 2011	07/2011
Remaining time in funding cycle	2 ½ months (until 30 September 2012)	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Urine Diversion Dehydration Toilet Bowl; Urine Boiling Chamber; Biochar Combustion Chamber; Feces Combustion Chamber; Gravity Driven Condenser; Solar Dryer; Hand-Operated Pump; and Hand-Operated Vacuum Pump	N/A
Consumables		
• Water/user	Yes (Groundwater, river water or tap Water)	For personal hygiene, no flushing
• Electricity/user	No (for real prototype; but required for demonstration of prototype at the Fair)	Off grid
• Others	Biochar for drying and burning of feces, and heating of urine and fecal liquid; Activated carbon and exchange resin (if highly purified water is desired)	0
Limitations		Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None (Note: ash will be produced from the burning of feces and biochar)	None
Revenue stream		
Energy recovered produced/user	Nil	N/A
Water recovered/user	0.4 L/user/per day	N/A
Nutrient/fertilizer recovered/user (g or L)	Concentrated urine as fertilizer for agriculture application; Ash from combustion of feces and biochar.	N/A
Estimated revenue/user/day ($)	Nil (if not considering monetary equivalent gained from recovered water and fertilizer)	N/A
Total revenue /user/day ($)	Nil (if not considering monetary equivalent gained from recovered water and fertilizer)	
Smell and odors control measures	May emit minor odor from urine and feces before and during processing	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	4 to 5	N/A
Estimated at end of funding Phase	4 to 5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	1 year (About 1 year is required to optimize urea removal from product water, fine tune and optimize the 1st prototype particularly the combustion stove and purified water production; biochar production from feces will be explored)	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	US$6,000.00	N/A
Est. capital cost of final toilet	US$325 (for mass production)	N/A
Estimated lifetime	6 Years	>5 years
Estimated total cost/user/day ($) (without revenue)	**US$0.047 per person per day (based on 20 persons for each system and includes O&M cost)**	**0.01 – 0.05**

Exhibitor 29

Fontes Foundation - Urban sanitation solutions for high-use, flooded, and difficult-to-serve areas

5-toilet array with composting structure below and ventilation plenum above

The technology is estimated to be at TRL 6-7 by the time of the Fair.

The team predicts that TRL 8 could be achieved in November 2012.

System Description

- Enhanced natural ventilation for odour control.
- Compost bin below the array produces compost *in situ*.
- No excreta contact with the ground.
- Serves high-density populations with the 5-toilet array.

Economic Analysis

- Capital cost per unit is $290 per toilet in the 5 -toilet array.
- Operational cost varies according to the situation.
- For rural communities the cost will be <0.05 USD/p/d; in urban communities this will be higher.
- This assumes 40 people per toilet.
- No power or water consumption.
- Compost is the principal by-product.

Fontes Foundation

Technology target		RTTC Criteria
Project Title	Urban sanitation solutions for high-use, flooded, and difficult to serve areas	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	May 1st 2011	07/2011
Remaining time in funding cycle	3 months	N/A
Processes and Technologies		
Chemical engineering processes		Yes
Mechanical engineering	Ventilation and air flow	Yes
Biological process	Thermophilic composting	No
Key technology component	Enhanced ventilation and low-cost structure	N/A
Consumable	Sugarcane bagasse or other	
1. Water/user	No water	For personal hygiene, no flushing
• Electricity/user	No electricity	Off grid
• Others	Carbon material for composting	0
Limitations	None	Off grid
Waste to be processed off-site	No	None
Waste dumped / infiltrated in soil	No	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A	N/A
Water recovered/user	N/A	N/A
Nutrient/fertilizer recovered/user (g or L)	To be determined	N/A
Estimated revenue/user/day ($)		N/A
Total revenue /user/day ($)	To be determined	
Smell and odors control measures	Enhanced passive ventilation	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	TRL 6/7	N/A
Estimated at end of funding Phase	TRL 8/9	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	In operation	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	In operation, actual costs	N/A
Estimated capital cost of final toilet	$1,450 USD/five-toilet array	N/A
Estimated lifetime	3 years, could be extended	>5 years
Estimated total cost/user/day ($) (without revenue)	**N/A**	**0.01 – 0.05**

Exhibitor 30

California Institute of Technology – A solar-powered toilet that generates hydrogen and electricity

The Caltech RTTC Solar Toilet
First-Phase Demonstration System

The technology is estimated to be at TRL 5 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 3 years.

System Description

The Caltech PV-powered electrochemical waste treatment system demonstration system is shown to the left. On the ground level (elevated to display the working system) are two toilets and one water-less urinal. The waste products are sent to a septic holding tank; the tank effluent is treated and disinfected in the electrochemical reactor.

Economic Analysis

Excluding the amortization of capital costs, the team estimates that they will achieve the target operational cost economics of the fully operational unit of less than USD 0.05 per user per day. The byproducts generated include H_2 gas for cooking or for PEM fuel cell power generation, nitrate, phosphate and ammonia for local use as fertilizer.

California Institute of Technology

Technology target	Reinvented toilet; plus conceptual overall sanitation system	RTTC Criteria
Project Title	A solar-powered toilet that generates hydrogen and electricity	Reinvent the Toilet Challenge
BMGF funding mechanism GCE,	RTTC	All
Project Start Date	1 July 2011	07/2011
Remaining time in funding cycle	2 months	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes, septic tank	No
Key technology component	PV-powered electrochemical reactor.	N/A
Consumable	None	
• Water/user	Water recycled through waste treatment system	For personal hygiene, no flushing
• Electricity/user	No	Off grid
• Others		0
Limitations	Processing time (6 hours)	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	Water and Sediment Recycle through system.	None
Revenue stream		
Energy recovered produced/user (kw-h) H2 $0.012 per day per capita (includes the cost of separation)	Hydrogen recovery and use for hot water heating and PEM power generation, 0.024 kW-h/person/day (86 kJ/day)	N/A
Water recovered/user	Yes, 90%	N/A
Nutrient/fertilizer recovered/user (g or L) N $0.0014 per day per capita P $0.03 per day per capita (includes the cost of separation)	Yes, compost, nitrate, ammonia, urea (2.8 g/L total N) from urine & feces, phosphorus, 9.5 g/day.	N/A
Estimated revenue/user/day ($)		N/A
Total revenue /user/day ($)		
Smell and odors control measures	Self-contained with Disinfection, Self-cleaning toilet sea	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	5	N/A
Estimated at end of funding Phase	5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	15 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$50,000 including variations in design and construction	N/A
Estimated capital cost of final toilet facility	$1500 - $2000	N/A
Estimated lifetime	15 – 20 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**$0.03 per user per day**	**0.01 – 0.05**

Exhibitor 31

re: char - Converting human waste to biological charcoal

Waste collection system and production factory

The technology is estimated to be at TRL 4 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 6-12 months.

System Description

Small-scale, distributed systems to sanitize and convert human excreta to biochar and energy. Localized and rapid manufacture of components and toilet infrastructure via mobile, shipping container-based factory.

Economic Analysis

- $.045 opex/capex/user/day due to low manufacturing/transport costs and use of recycled materials.
- Recoverable products include sanitized biochar, combustible syngas (for power generation) and stabilized urine for agricultural nitrogen supplementation.

re:char

Technology target	Reinvented Toilet	RTTC Criteria
Project Title	Converting human waste to biological charcoal	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle	3 months	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	No	N/A
Consumable		
• Water/user	None	For personal hygiene, no flushing
• Electricity/user	Off grid	Off grid
• Others	Waste biomass	0
Limitations	Off-grid	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)		N/A
Water recovered/user	1-2 kg biochar	N/A
Nutrient/fertilizer recovered/user (g or L)	1-2 L stabilized urine	N/A
Estimated revenue/user/day ($)	$.50	N/A
Total revenue /user/day ($)	$2-4	
Smell and odors control measures	No smell, no flies	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	4	N/A
Estimated at end of funding Phase	7	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	3-6 months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$200,000	N/A
Estimated capital cost of final toilet	$100	N/A
Estimated lifetime	>5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**$.045**	**0.01 – 0.05**

Exhibitor 32

Southern Illinois University - A wind-driven sanitation system

Windmill ATAD now Operating (for six months) on a High Concentration Sludge.

Current date--July-3-2012

The technology is estimated to be at TRL 6 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 18 months. Several technical issues must be solved before deployment:

1) How do you mix pure excreta at 55 C without electricity?
2) How does oxygen transfer do?
3) What biodegradation effects occur at 55 C?
4) What happens to the 2 phase product in separation?
5) How do solids with stools act over the 10 hot day run and others?

System Description

- The basic thermal input of oxygen used (14.2 Mj/kg) will heat the system to over 65 C.
- Superior pathogen reduction is gained if the temperature is held for 10 days.
- Air comes from the windmill.
- The system works without power, water or chemicals.

Economic Analysis

The system built handles about 100 gallons of excreta. It is estimated to serve 15-20 people. With optimization and other manufacturing factors, it would cost $2,000. With 17 people using it, the distributed capital would be $0.032/person/day. Maintenance (10% of capital) would be $0.0032. The combined cost would be $0.035 /person day.

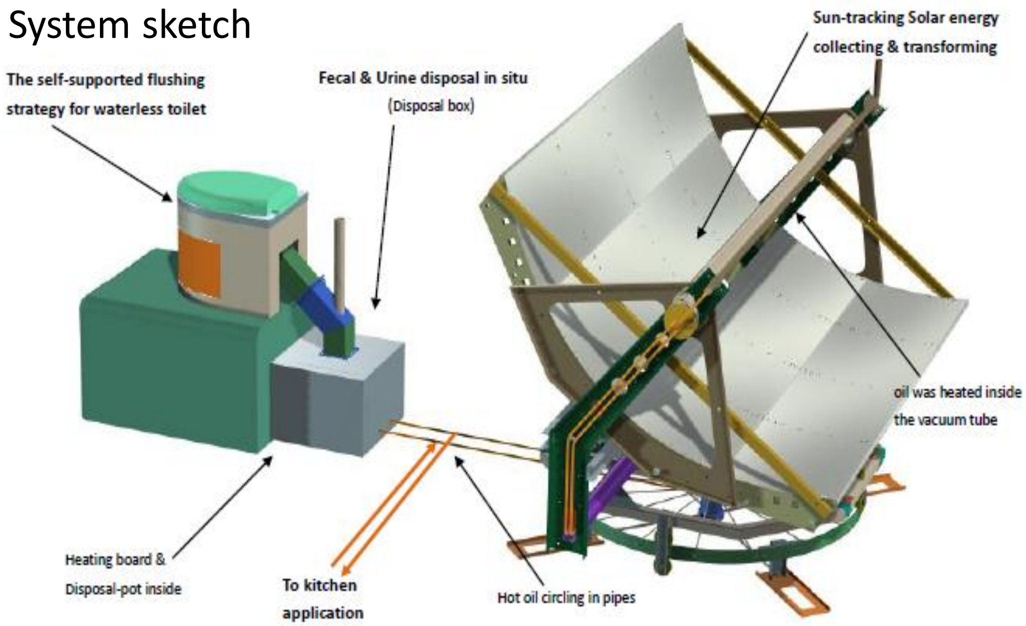
Southern Illinois University

Technology target	Reinvented toilet	RTTC Crit.
Project Title	A wind-driven sanitation system	RTTC
BMGF funding mechanism	GCE6	All
Project Start Date	05/2011	07/2011
Remaining time in funding cycle	5 months	N/A
Processes & Technology		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	Yes	No
Key technology component	Performance of Windmill ATAD To Human Excreta in the system to real weather conditions.	N/A
Consumable		
• Water/user	A drop to keep system clean, generating gallons/day of sanitized treated, low pathogen water. With the manpower to use a hand pump, it can be recycled to make the flush toilet a "green technology."	For personal hygiene, no flushing
• Electricity/user	None	Off grid
• others	None	0
Limitations	The lack of literature discussing aerobic systems with very high densities and ability to mix and degrade the excreta without dilution -Ph 2 studies.	Off grid
Waste to be processed off-site	No. Products Water and Solids will be virtually void of pathogens, allowing many farm and agricultural uses	None
Waste dumped / infiltrated in soil	High temps and residence times of system make this a valued product; device sanitizes water & solids which are usable for any agricultural purpose according to the USEPA.	None
Revenue stream		
Energy recovered produced/user(kw/h)	Hot water at 140 degrees. Est. total biological energy for the current pilot (100 gal) is 2.05 kw/hr. Total system excreta heat produced is near zero. Most generated heat from system with aqueous stream and hot, off gas air.	N/A
Water recovered/user	A "clean" supplement possible ability to use flush toilets and irrigation; ideal for future studies in converting to potable water	N/A
Nutrient/fertilizer recovered/user(g or L)	Calculation based on 15 individuals.10 gal/day (37.9 l, or2.5 l/person) at pilot plant is estimated to generate 20% total solids or 0.5 l	N/A
Estimated revenue/user/day($)	If this water has a value of $0.1/l and the solids may have a value of $.1/l The revenue pp/day would be $ 0.25.	N/A
Total revenue/user/day($)	For 15 users, the revenue is $0.25/user/day	
Smell and odors control measures	No smell or foam at pilot plant, the technology has increased ammonia. USEPA technology produces a product with no vectors.	No smell, no flies
TRLs		N/A
At time of RTT Fair	5	N/A
Est. at end of funding Phase	8	5 to 6
Cost		
Est. time to produce fully functioning prototype	(TRL 7) Running in the field since January, 2010	N/A
Estimated cost to produce fully functioning prototype	(TRL 7)Parts have not been used on direct excreta, need one yr of research. Design, build and deploy in a year. Designed as a production unit, not a prototype	N/A
Estimated capital cost of final toilet	With an experiment tested information, an engineering analysis making close evaluations, look for cheaper parts and designs and the economies of scale of materials needed, and assuming that it will become competitive, Est. at $1500/ unit. A unit will serve from 15-25 people and the per capita cost is $100.	N/A
Estimated lifetime	10 years	>5 years
Est. total cost/user/day ($) (without revenue)	**First cost=$1500/Cost per year=$150/365 days Per Year=$0.4/15 users= $0.027**	**0.01 – 0.05**

Exhibitor 33

Shijiazhuang University of Economics - On-site fecal sludge extraction and disposal system

System sketch



Economic Analysis
- Solar Toilet can serve a six-member family as long as 10 years
- Total cost = $800 (capital) + $200 (lifetime maintains) = $1000
- Meet RTT standard: (US$0.05/user/day) =6*365*10*0.05=$1059
- Consumption: power and water = 0
- Expected revenue: lunch cooking, clean water, organic fertilizer -- - Free!

The technology is estimated to be at TRL 5-6 by the time of the Fair.

The team predicts TRL 9 could be achieved in 8-12 months.

System Description

Highlights
- Removes 100% of pathogens
- Totally off grid
- Resource recovery
- Inexpensive
- Multifunction

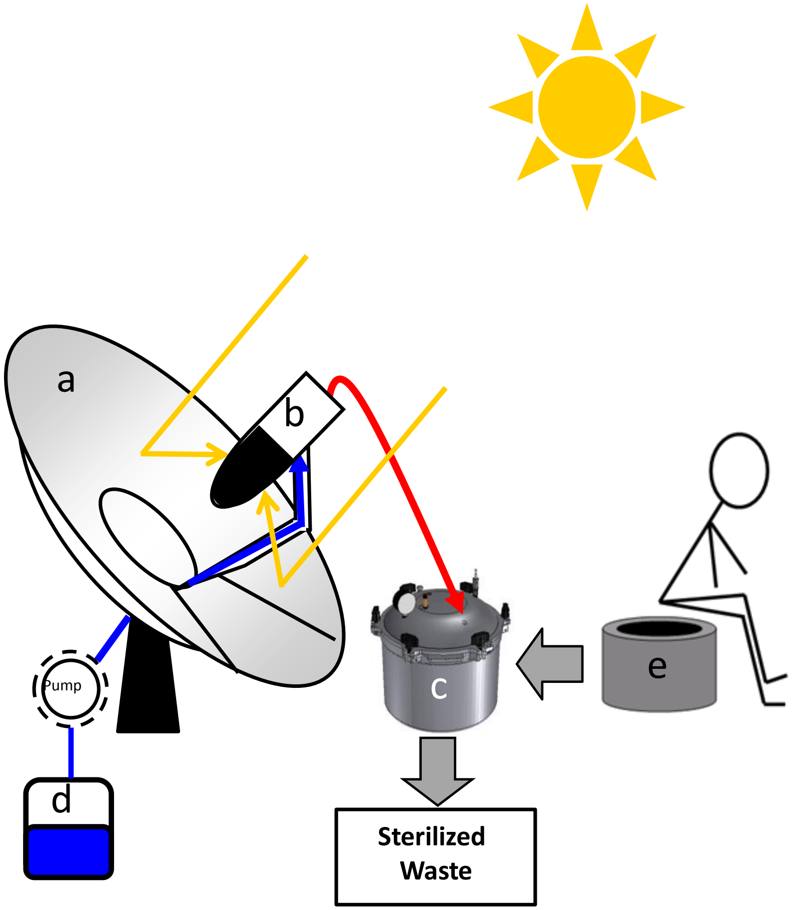
Key processes
- Sun-tracking solar energy collecting & transforming
- The self-support flushing for waterless toilet
- Fecal sludge disposal in situ

Shijiazhuang University of Economics

Technology target	Reinvented Toilet	RTTC Criteria
Project Title	On-site fecal sludge extraction and disposal system	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE-7	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle	4 Months	N/A
Processes and Technologies		
Chemical engineering processes	No	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component		N/A
Consumable		
• Water/user	0	For personal hygiene, no flushing
• Electricity/user	0/ (~15w, by self supported solar cell)	Off grid
• Others	0	0
Limitations	Totally off grid	Off grid
Waste to be processed off-site	Waste processed in situ	None
Waste dumped / infiltrated in soil	No	None
Revenue stream		
Energy recovered produced/user (kw/h)	1~2 kw/h (from solar energy)	N/A
Water recovered/user	1~2 liter	N/A
Nutrient/fertilizer recovered/user (g or L)	200g fertilizer user/day	N/A
Estimated revenue/user/day ($)	＞0.1 per user/day	N/A
Total revenue /user/day ($)	＞0.1	
Smell and odors control measures	No files	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	5 to 6	N/A
Estimated at end of funding Phase	6 to 7	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	3~6Month	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	300K~700K(700K Include some tooling & mold etc)	N/A
Estimated capital cost of final toilet	~700$ (mass production)	N/A
Estimated lifetime	7~10 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.01~0.02**	**0.01 – 0.05**

Exhibitor 34

Rice University - A solar steam sterilizer to treat human waste



Schematic of compact, particle-based solar autoclave human waste system showing: (a) solar concentrator , (b) steam generation module, and (c) human waste sterilization module, (d) water reservoir for steam generation (need not be clean water), (e) human waste collection.

The technology is estimated to be at TRL 4 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved in 4-6 months.

System Description

Conventional steam-based sterilization is a highly effective, well-established approach for waste remediation in the developed world, but is limited due to its extensive energy consumption and cost. We have developed a breakthrough solar steam-generation technology that directly converts solar energy to steam at an efficiency of ~80%. Our unique, particle-based approach enables us to produce high-temperature steam without boiling a large fluid volume: this enables the sterilization process to be completed in a matter of minutes with no external fuel consumption. This same technology can be applied to distillation for water purification and other uses.

Economic Analysis

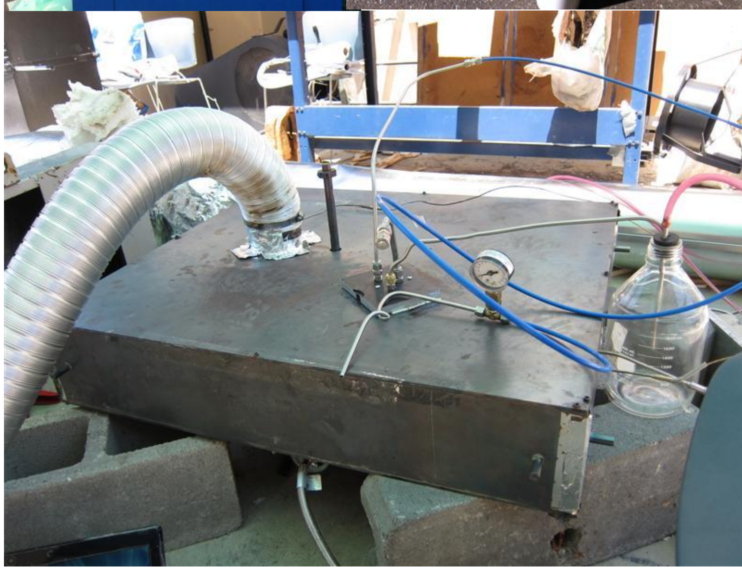
The only consumable is water; the volume required is approximately 1-2 liter/day, and does not need to be clean prior to use. Current electrical usage is 0.02 cents per user per day but the electric pump can be replaced by a system of hand-powered pumps for waste transport, making the system completely solar powered. The byproduct after sterilization can be used as fertilizer.

Rice University

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	FS treatment	RTTC Criteria
Project Title	A solar steam sterilizer to treat human waste	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	GCE	All
Project Start Date	11/2011	07/2011
Remaining time in funding cycle	Until 04/2013	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	Yes	Yes
Consumable		
• Water/user	For steam production	For personal hygiene, no flushing
• Electricity/user	To operate pump (ultimately hand pump may be used)	Off grid
• others		0
Limitations	None	Off grid
Waste to be processed off-site	No	None
Waste dumped / infiltrated in soil	Byproduct may be used for fertilization	None
Revenue stream		
Energy recovered produced/user (kw/h)	Possibly	N/A
Water recovered/user	Possibly	N/A
Nutrient/fertilizer recovered/user (g or L)	Yes	N/A
Estimated revenue/user/day ($)	N/A	N/A
Total revenue /user/day ($)	N/A	
Smell and odors control measures	Enclosed processing system	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	3	N/A
Estimated at end of funding Phase	5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	N/A	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	>5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**0.02**	**0.01 – 0.05**

Exhibitor 35

Stanford University - A sanitation system that converts human waste into biological charcoal



Conversion of solid waste into biochar using pyrolysis at community-scale facility

The technology is estimated to be at TRL 5 by the time of the Fair.

The team predicts that a fully functioning RTTC toilet meeting 100% of the requirements could be achieved by 2013 with Phase 2 program funding.

System Description

The biochar reactor reforms incoming solid waste in a rich combustion environment to biochar. Syngas is generated, which fuels the reaction in a lean burn environment. The lean burn environment also reduces odors and processes partial combustion products. Sterile biochar is produced as a result of the process, suitable for application as a fertilizer substrate in agriculture. The insulated system conserves thermal energy, while a recuperative counterflow heat exchanger captures heat in the exhaust and provides it to the incoming air, improving reactor efficiency.

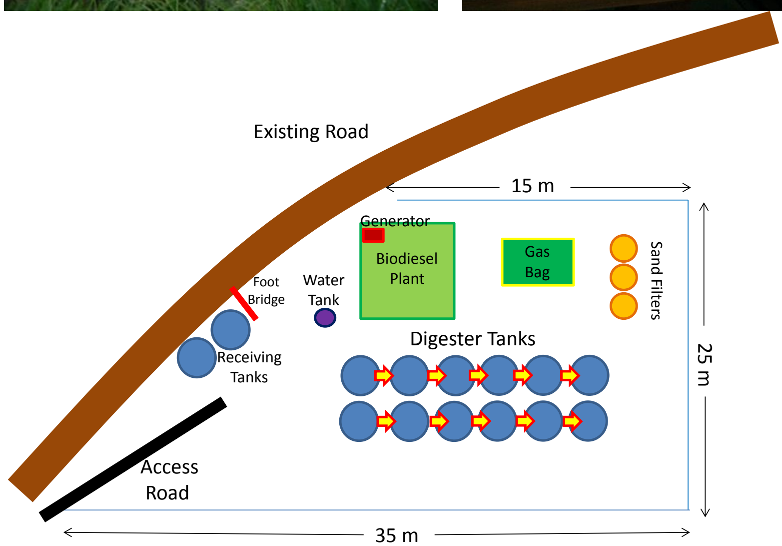
Economic Analysis

Economics of the final unit: Capital Cost: $350/yr/100 users: $.01/person/day
Operational costs: $.04/person/day
System uses no water or grid power
Byproducts: biochar, averted methane
Expected value: $1,314/yr in biochar, and $4,600/yr in averted methane at $20/t CO_2e

Stanford University

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	Stanford / Climate Foundation	RTTC Criteria
Project Title	A sanitation system that converts human waste into biological charcoal	Reinventing the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	RTTC	All
Project Start Date	07/2011	07/2011
Remaining time in funding cycle		N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering	Yes	Yes
Biological process	No	No
Key technology component	N/A	N/A
Consumable		
• Water/user	None	Personal hygiene, no flush
• Electricity/user	Off grid	Off grid
• Others	0	0
Limitations	Off grid	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	Up to 1 MJ/day/person	N/A
Water recovered/user		N/A
Nutrient/fertilizer recovered/user (g or L)	36 gram/day/person	N/A
Estimated revenue/user/day ($)	0.036	N/A
Total revenue /user/day ($)	0.05	
Smell and odors control measures	No smell, no flies	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair		N/A
Estimated at end of funding Phase	TRL-5	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)		N/A
Estimated cost to produce fully functioning prototype (TRL 7)		N/A
Estimated capital cost of final toilet		N/A
Estimated lifetime	>5 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**.05**	**0.01 – 0.05**

Columbia University – Fecal Sludge to Biodiesel



Integrated biochemical conversion of fecal sludge to biodiesel

The technology is estimated to be at TRL 4 by the time of the Fair.

The team predicts to be producing a biodiesel at pilot-scale (10 m^3 FS/d) in 1 year.

System Description

The overarching goal of this pilot-scale project (10 m^3/d) is to develop an integrated biological and chemical process technology to convert fecal sludge primarily into biodiesel. Value added products include methane, methanol and fertilizer.

Economic Analysis

- Current operating cost : $0.68 /person /day.
  - *Note: The process is being optimized to minimize these costs*
- Final products : Biodiesel, Nitrogen, Phosphorous, Methane energy
- Cost recovered : $0.04/person/day

Technology target (e.g. Reinvented Toilet, FS processing, Pit Extraction)	FS processing	RTTC Criteria
Project Title	Fecal sludge fed biodiesel plants – the next generation urban sanitation facility	Reinvent the Toilet Challenge
BMGF funding mechanism (RTTC, GCE, Contract, other)	Other, Global Development	All
Project Start Date	6/2011	07/2011
Remaining time in funding cycle	12 months	N/A
Processes and Technologies		
Chemical engineering processes	Yes	Yes
Mechanical engineering		Yes
Biological process	Yes	No
Key technology component	Chemical biodiesel production with biological fermentation and methanogenesis	N/A
Consumable		
• Water/user	For chemical washing	For personal hygiene, no flushing
• Electricity/user	For running the chemical and biological process reactors	Off grid
• others	Chemicals for biodiesel production and extraction	0
Limitations	Chemical costs	Off grid
Waste to be processed off-site	None	None
Waste dumped / infiltrated in soil	None	None
Revenue stream		
Energy recovered produced/user (kw/h)	N/A – biodiesel recovery	N/A
Water recovered/user	2 L/user/d	N/A
Nutrient/fertilizer recovered/user (g or L)	25 kg N/d, 1.5kg P/d	N/A
Estimated revenue/user/day ($)	$0.04	N/A
Total revenue /user/day ($)	$0.04	
Smell and odors control measures	No smell or odor	No smell, no flies
Technology Readiness Level		N/A
At time of RTT Fair	4	N/A
Estimated at end of funding Phase	8	5 to 6 (not in original RFP)
Cost		
Estimated time to produce fully functioning prototype (TRL 7)	Twelve months	N/A
Estimated cost to produce fully functioning prototype (TRL 7)	$500,000 Not for the toilet but for the reactor system	N/A
Estimated capital cost of final toilet	N/A	N/A
Estimated lifetime	> 10-15 years	>5 years
Estimated total cost/user/day ($) (without revenue)	**$0.68 Not for toilet but for the reactor system producing biodiesel**	**0.01 – 0.05**