CULTURALLY AND FINANCIALLY SUSTAINABLE APPLICATIONS OF LOOWATT TECHNOLOGY IN ANTANANARIVO, MADAGASCAR – EARLY FEEDBACK

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ABSTRACT

Loowatt is piloting a faecal sludge management system in Antananarivo, Madagascar. The Loowatt system creates biogas and fertiliser from human waste. Understanding how to create desirable and affordable products from human waste is critical in ensuring that the Loowatt system will be culturally and financially sustainable.

Between June and August 2012, Loowatt conducted a detailed survey of local residents and farmers to better understand the cultural landscape, collect socio-economic data, and gauge responses to human-waste-derived (HWD) products. The results of this work helped Loowatt to customize the physical implementation, modify assumptions about the system operation, and reevaluate the system's projected economics.

There was ample local interest in HWD energy products, with most locals willing to use biogas for cooking (53%), heating water (60%), and making electricity (85%). For foods or flowers grown with HWD fertiliser, 79% of residents expressed willingness to purchase vegetables, 83% to purchase fruit from trees, and 93% to purchase cut flowers. Of the local farmers surveyed, 100% expressed willingness to use Loowatt fertiliser after seeing a representative sample, at an average price of $0.83USD/kg.

Newly acquired demand and price point data has increased estimates of net system profit by 79%, greatly improving the confidence of the economic case. Cultural findings tend to support the chosen implementation strategy and toilet design for Loowatt's 2012 pilot. The results suggest that Loowatt's toilet, FSM technology, and system products are scalable in this context.

Key words: SANITATION TECHNOLOGIES; ANAEROBIC DIGESTION; VERMICOMPOSTING; WASTE TO VALUE

INTRODUCTION

Loowatt Ltd. is a for-profit company based in London, England, that has developed a waterless toilet and faecal sludge management (FSM) system. The Loowatt system produces energy and fertiliser products by way of waterless toilets linked to anaerobic digesters, and further post treatment to upgrade digestate into marketable compost. A pilot project is underway in FAAMI, a densely populated neighbourhood of Antananarivo, Madagascar, to trial the Loowatt system.

Pilot Project Objectives

- O1: Understand local culture, preferences, and need surrounding sanitation, and deliver a solution that ensures community acceptance and continued use.

- O2: Gather feedback on the Loowatt toilet, system, and commodity products.
- O3: Validate Loowatt's financial model of the Loowatt system in this context.
- O4: Measure the value potential of the commodities produced by the system.
- O5: Position the system for scaling in Antananarivo.

The system implementation is informed by a detailed financial model constructed by Loowatt. This model is based on assumptions derived from preliminary research. The purpose of objectives O2, O3 and O4 is to improve these assumptions and therefore the confidence in the economic case for the system at scale. This paper presents Loowatt's FSM technology along with the results of market research and business modeling.

FSM Technology and Structure of Implementation

The main functions of Loowatt's FSM technology are to add value and destroy pathogens. There are four stages to the process, which are physically distributed between two types of facility. The facilities and FSM stages are:

Energy Unit Facilities

Energy units consist of a Loowatt toilet and anaerobic digester, of which many are distributed throughout the community. An owner sells toilet visits and energy products such as mobile phone charges, earning a living and return on investment. The first two FSM stages are situated at each energy unit:

FSM Stage 0 – The Loowatt Toilet (capture and storage)

Loowatt has developed and tested a waterless toilet that packages human waste within biodegradable polymer film. A patented sealing mechanism separates liquids and solids, provides an odour-free user experience, and creates a barrier to disease vectors. An example of a Loowatt toilet produced in Antananarivo is shown in Figure 1 below.

Figure 1: Loowatt Toilet

FSM Stage 1 - Mesophillic Anaerobic Digestion (AD)

Mesophillic AD is a long established low or zero-energy process (depending on local climate), which converts organic material into biogas and a nutrient-rich liquid, digestate. In the pilot system, AD happens in close proximity to the toilet, to create a distributed gas source and to pre-treat the waste before transport, as the process reduces faecal bacteria and enterovirus content of raw sewage by approximately 90% (Carrington et al. 1991).

Compost Factory Facility

A single compost factory serves many energy units, collecting digestate and providing support and consumables. The digestate is upgraded into highly valuable compost, marketed locally to create revenue. The final two FSM stages take place at the compost factory.

FSM Stage 2 - Aerobic Composting

Aerobic Composting is a naturally occurring process that uses autothermal aerobic bacteria to convert raw waste into compost. A well-managed thermophillic composting process can create a class-A product from biosolids as defined by the United States Environmental Protection Agency (1994). This step ensures pathogen destruction by way of subjecting the waste to an appropriate time-temperature treatment. Digestate from the Energy Unit Facilities is combined with locally sourced dry organic material, such as straw, before composting.

FSM Stage 3 - Vermicomposting

Vermicomposting makes use of Eisenia Foetida worms to process organic material. As discussed by Arancon et al. (2005), vermicomposting increases microbial activity, nutrient availability, water retention, mineral content and plant-pathogen suppression, and increases marketable crop yields. The value of this step is to upgrade typical compost to a higher value vermicompost, increasing revenue potential for the system.

SURVEY AND RESULTS

The results generated as of 25th September 2012 are presented below.

<u>Local Cultural, Financial, and Waste Survey</u>

To assess cultural preferences and desires surrounding toilets, collect socio-economic data, and gauge response to human-waste-derived products, Mattens (2012) surveyed 40 local residents, 5 waste collectors, and 27 farmers from in around Antananarivo.

Figure 2 below shows where, when using a toilet, residents mostly relieve themselves.

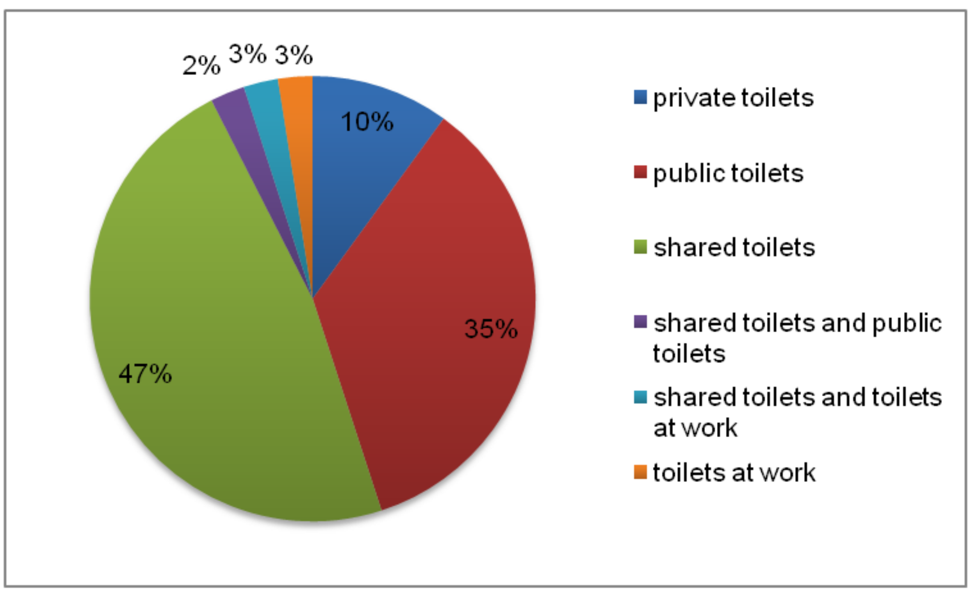

Figure 2: ‘Relieving places’ Mattens (2012)

In addition to this, 83% of residents also relieve themselves in buckets at night for security and convenience and often dispose of the waste unsafely.

The most common type of toilet locally is a pit toilet with a squat platform. Most inhabitants wipe (72%), wash, or do both after defecation, and 98% wash their hands. Locals expressed a significant preference for sit toilets (93%), despite most toilets in the area being squat. Mattens (2012) identified that 'cleanliness, running water, tiled walls and good ventilation' were all key desirable features in a toilet. Most inhabitants were willing to use mixed-gender sit-toilet facilities.

Results relating to the demand for toilet services, Loowatt energy-products, fertiliser-products and food grown from Loowatt compost are summarized in Table 1, below.

Table 1: Local consumers' response to Loowatt system products

System product	**Surveyees**	**Willingness to buy (%)**	**Preference over alternative**	**Price willing to pay ($)**	**Comments**
Toilet					
Public sit toilet	Residents	63%	93%	-	Preference over squat toilet (of those who had experience with sit toilets)
Toilet use (defecate)	Residents	91%	-	$0.045	Willingness to pay for public toilet use. Modal average price
Toilet use (urinate)	Residents	86%	-	$0.022	Willingness to pay for public toilet use. Modal average price.
Energy-products					
Cooking	Residents	53%	-	-	
Hot water	Residents	60%	-	$0.055	For a 10l bucket
Electricity	Residents	85%	-	$0.091	For a single mobile phone charge
Products grown with Loowatt vermicompost					
Vegetables	Residents	79%	-	-	50% before seeing a fertiliser sample
Fruit trees	Residents	83%	-	-	67% before seeing a fertiliser sample
Flowers	Residents	93%	-	-	93% before seeing a fertiliser sample
Fertiliser					
Loowatt vermicompost	Farmers	100%	-	$0.83 / kg	100% preference after seeing sample, 78% before. Av. $0.83 price.
Organic fertilisers	Farmers	-	64%	-	Preference over imported inorganics

Waste collectors and residents were questioned as to the volume and composition of household waste. The resulting estimated volume of suitable organic waste available in the community was between 5.4 and 10 cubic meters per day. Taking into account local minimum wage, and using estimates from waste collectors for sorting time, the cost of acquiring separated organic waste is between $4.8 and $21 per cubic meter. Of the 27 famers interviewed by Mattens (2012), two sold straw or rice husks mainly for the purposes of brick firing. The cost of this material is $\$0.2/m^3$ in summer and $\$0.9/m^3$ in winter, not including transportation.

Many results collected in the survey have an impact on the financial case for scaling Loowatt technology in this context. See Table 2 below for updated financial assumptions related to the anticipated demand and price points for various system products, alongside Loowatt's original assumptions for comparison.

Table 2: Comparison of financial assumptions before and after detailed survey

System Product or Cost	Assumed Value (preliminary research)	Assumed Value (following detailed survey)
Products		
Visit to defecate	100 MGA (~$0.04)	100MGA ($0.04)
Visit to urinate	50 MGA (~$0.02)	50MGA (~$0.02)
Mobile phone charge	50 MGA / charge ($0.02)	200 MGA / charge ($0.09)
Demand for mobile charges	13 charges / day / unit (at a scale of 55 units)	5 charges / day / unit (at a scale of 55 units)
Hot water	9 MGA / l *	12 MGA / L
Demand for hot water	-	23 buckets / day
Loowatt compost	$0.25 / kg	> 0.5 $/kg
Major running costs		
Additional waste for digestion	$1.58 / m^3 **	$4.8 – 21 / m^3
Additional waste for composting (including transportation)	$0.86 / m^3	$0.68 – 1.38 / m^3 (seasonal)
Transportation (in general)	$0.16 / km	$0.16 / km
Staff	$2 – 8 / day ***	$2 – 10 / day

* Originally based on the price of hot showers locally. New price based on take-home heated water product
** Originally based on Water Hyacinth, now based on local food waste
*** Ranging from basic labourer to low-level management

DISCUSSION

This discussion is structured to reflect the impact of the results on the key pilot objectives listed in the introduction.

<u>Objectives O1: Understand local culture, preferences, and need surrounding sanitation, and to deliver a solution that ensures community acceptance and continued use; and O2: Gather feedback on the Loowatt toilet, system, and commodity products</u>

The survey results support the decision to create a public, sit version of Loowatt's toilet, with 93% of residents preferring sit toilets, and 84% using shared facilities. The preference for sit toilets may be rooted in aspiration; sit toilets are often only used by the wealthy in Madagascar, and are of course widely used in wealthy nations. Therefore a sit toilet is likely to be well received.

Loowatt has informed the design of the cubicle and services to reflect the key desirable features identified in the cultural survey; matching local aspirations helps to ensure user acceptance. Also, Loowatt will provide toilet paper, as 72% of locals are accustomed to using it.

Opinions toward foods and flowers grown using Loowatt compost are very positive (see Table 1), which demonstrates that the cultural barrier to adoption of human-waste-derived products is low. Surveyees' opinions improved upon seeing a sample of compost, which indicates that the quality and appearance of the compost must be high, and must be understood by the end consumer to ensure uptake. A positive correlation exists between residents' willingness to purchase a crop and the crop's abstraction from the fertiliser, i.e. vegetables that will certainly come in contact with soil received the worst result (79%); flowers which don't get eaten received the best (93%); and fruit from trees, which probably won't come in contact but are eaten, received a result in between (83%). Nonetheless, the results are still promising and suggest uptake will not pose a problem.

Farmers' responses to Loowatt compost were positive. Willingness to try the product was common (78% of farmers), and increased to 100% upon seeing a sample, indicating that key potential customers for Loowatt compost are likely to purchase the product once it goes on sale. In this case, product quality also proved instrumental to shaping opinion.

Objectives O3: Validate Loowatt's financial model of the Loowatt system in this context; and O4: Measure the value potential of the commodities produced by the system

Loowatt's original and updated economic assumptions are presented in Table 2 in the Survey and Results section.

Revenue Streams

Perhaps most importantly, the majority of local residents were willing to pay 4.4US cents to defecate and 2.2US cents to urinate, which is in line with other public sanitation facilities in Antananarivo. This is a crucial result which shows that paying for sanitation is culturally acceptable in the area.

Mattens (2012) found that the demand for phone charges is approximately 5 per day per energy unit (at a scale of 55 energy units locally). However, the price point was much higher at 200Ar compared to the originally assumed 50Ar. Interestingly, 68% of residents expressed willingness to purchase hot water to take home. Originally this was not considered, and is now a product included in the economic proposal for the energy unit. Overall, the change in the predicted revenue stream from energy products represents an increase of 148%. This is largely due to the introduction of the take-home hot water product.

The updated assumption for the value of Loowatt compost is $0.5 / kg ($500 / tonne). This a conservative figure, based on survey results and the price of similar products available locally. It is important not to overestimate the value of Loowatt compost as it has the biggest impact on system revenue and financial sustainability. The change in the predicted revenue stream for Loowatt compost is a 100% increase over the original model assumption.

Running Costs

The most significant contextual system costs are the supply of additional organic waste, labour costs, and transportation. Two types of additional organic waste are required, food waste and dry organic matter such as straw. Collection and separation incur cost when acquiring food waste. For straw, price per unit volume is combined with additional transportation cost.

Taking into account the change in assumed cost of organic waste, as well as a 300% increase in the predicted transportation distance (which is informed by our experience in the field), the assumed cost of additional organic waste has increased by 470%. This is a significant increase but not prohibitive, especially in light of the increased predicted sale value of Loowatt compost.

Most importantly, the overall impact on the net profit of the proposed system needs further examination. Taking into account changes in predicted revenues and costs, the change in predicted net profit represents an increase of 79%, from $2430/week to $4360/week. This can largely be attributed to the increase in predicted compost value, with increased costs having a less significant impact on net system profit.

O5: Position the system for scaling in Antananarivo following the pilot implementation

All of the previously discussed results have an impact on the scalability of the system. Increased net profit is extremely promising, as larger capital expenditures, higher maintenance costs and/or faster depreciations can be supported.

Cultural barriers to adoption are also crucial, which as previously discussed seem low enough so as not to pose a problem for the proliferation of toilets and HWD products. Also, locals are willing and able to pay for public sanitation facilities, as well as HWD energy and compost. The results gathered so far generally support the cultural and economic case for scaling Loowatt technology and system products in the context of Antananarivo.

CONCLUSION

There is a multitude of options for creating value from human waste. While the use of new sanitation technologies is important, a thorough understanding of the cultural and economic context of waste-to-value systems is critical to making sensible choices about the creation and marketing of products. This knowledge should help to reduce the risk of cultural rejection of toilet facilities or HWD products.

So far, Loowatt has discovered that cultural barriers to the FSM technology and HWD products are lower than expected. An example of this is the willingness of locals to buy products such as electrical energy from biogas (85%), or vegetables grown with Loowatt compost (79%). Suggested price points are also promising at $0.045 for a toilet visit, $0.09 for a mobile phone charge, and $0.83/kg for Loowatt compost. The predicted net system profits have increased by 79% over Loowatt's original estimate, a strong indication that the system can be scaled and become sustainable.

ACKNOWLEDGMENTS

Loowatt would like to thank the Bill & Melinda Gates Foundation for funding this work through the Grand Challenges Explorations Initiative. We also wish to thank Water and Sanitation for the Urban Poor in London and Antananarivo for their support, guidance, and additional funding provided for construction work as part of the USAID African Cities for the Future fund. Lastly, this work would not have been possible without the hard work and dedication of Marie Mattens.

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