

# Self Contained Waste Treatment System for the Urban Poor: Technical and Social Challenges



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# Reinvent the Toilet Project Update



## The RTI Team

Duke University  
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## Technical Advisors

NASA Ames  
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# Overview: Toilet Technology



**Solids** – Converted into burnable fuel

**Liquids** – Electrochemical disinfection

**Energy** – Thermoelectric conversion

# Prototype System: Toilet Technology

## Solid Waste Gasification Unit



Converts feces into burnable fuel  
(10-50 persons)

# Prototype System: Toilet Technology



Liquid Processing Unit



Converts urine into mixed oxidants /  
flush water (10-50 persons)

# Prototype System: Toilet Technology



Toilet Interior



Custom RTT squat plate (Roca)  
(1.5 L per flush)

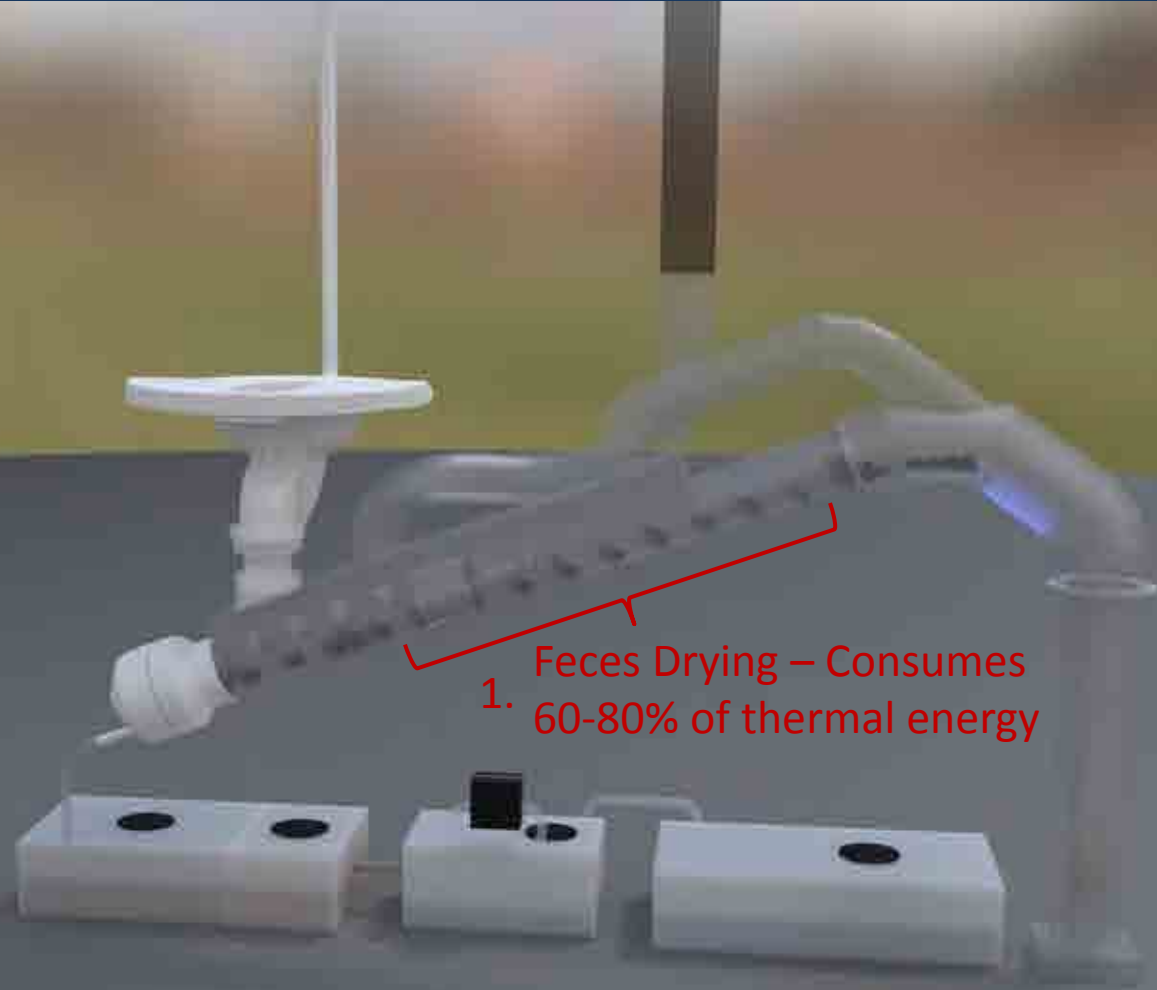
# How it Works: Toilet Animation



See Animation at:

<http://abettertoilet.org/toilet-technologies/>

# Technical Challenges

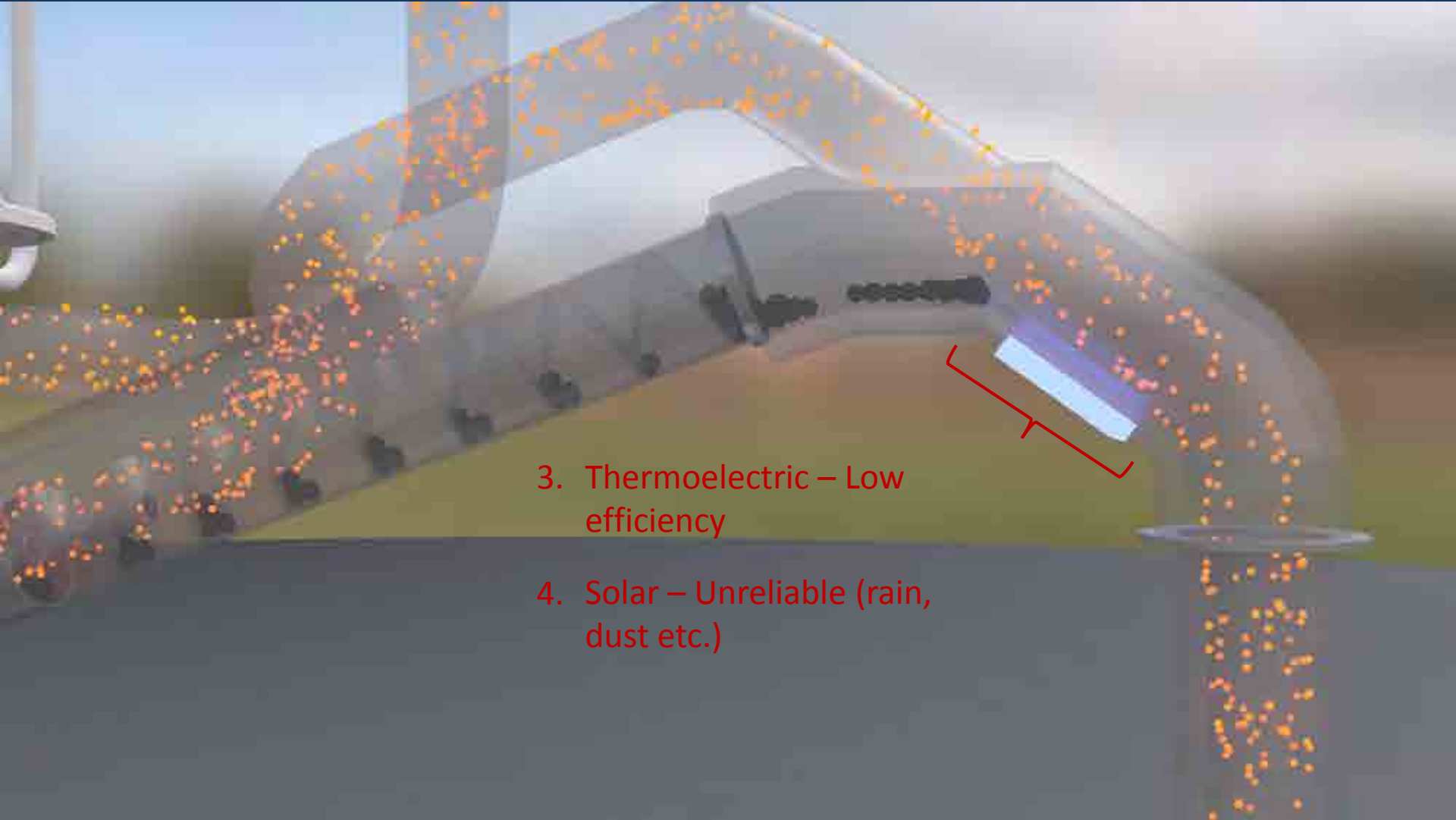




# Technical Challenges

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2. Liquid Disinfection – Consumes 60-80% of electrical energy

# Technical Challenges



- 3. Thermoelectric – Low efficiency
- 4. Solar – Unreliable (rain, dust etc.)

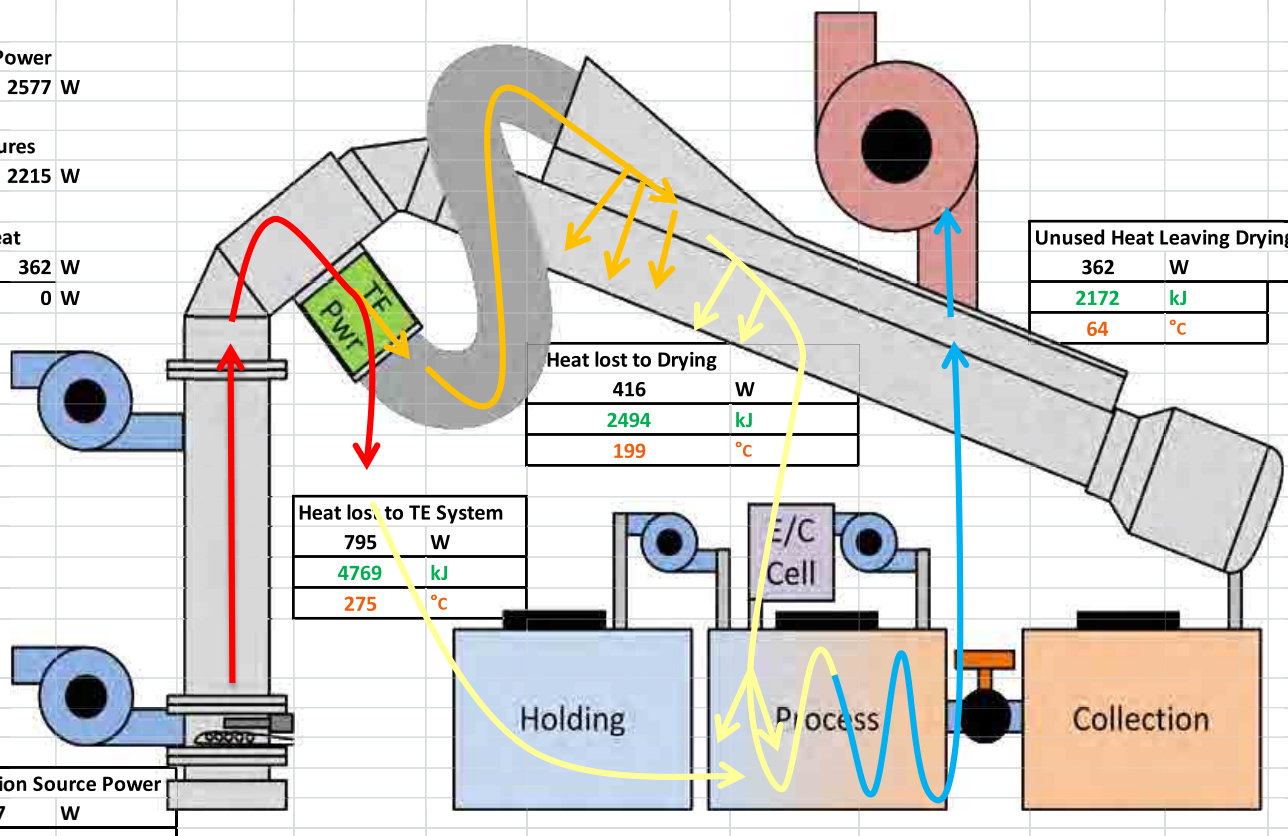
# Technical Challenges



5. Solid / Liquid Separation:
- Mechanical System
  - Load Variability ?
  - Corrosion ?

# Energy Balance Analysis

Starting Power	2577 W
- Expenditures	2215 W
- Waste Heat	362 W
=	0 W



Combustion Source Power	2577 W
	15460 kJ
	600-800 °C

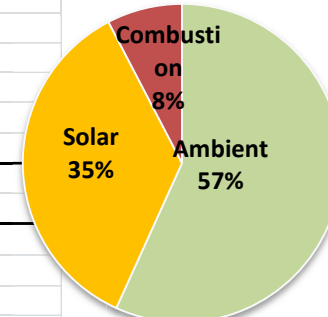
Heat lost to TE System	795 W
	4769 kJ
	275 °C

Heat lost to Drying	416 W
	2494 kJ
	199 °C

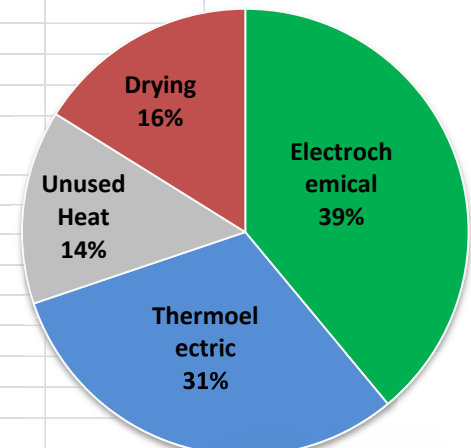
Heat lost to E/C System	1004 W
	6025 kJ
	160 °C

Unused Heat Leaving Drying System	362 W
	2172 kJ
	64 °C

## Drying Heat Sources

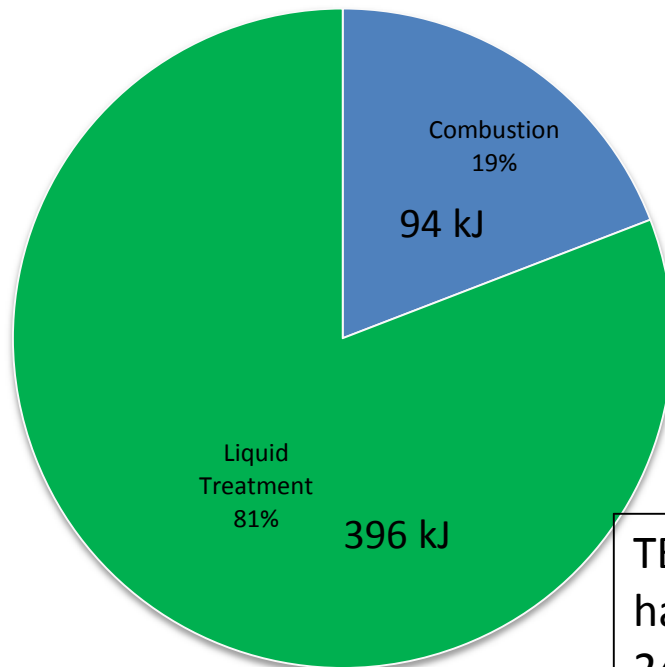


## Combustion Thermal Energy

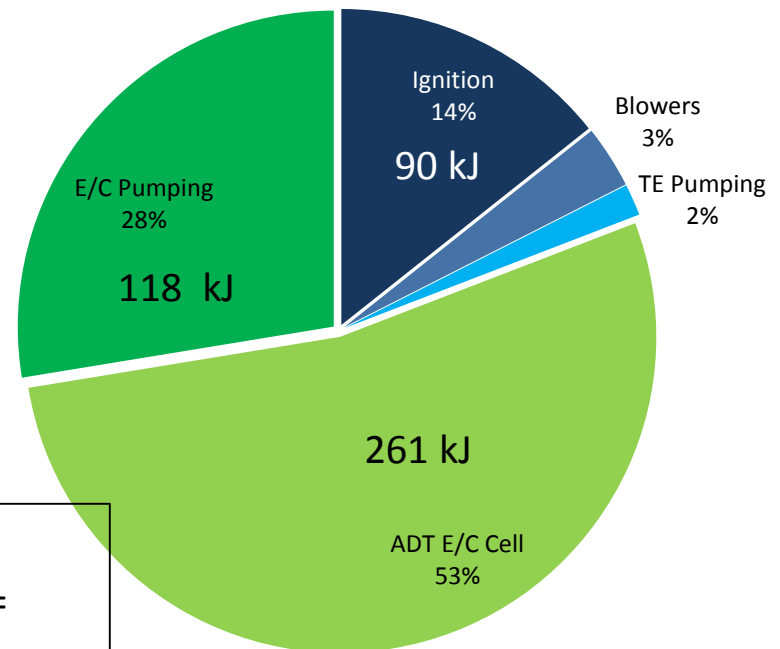


# Electrical Energy Balance

## Electrical Energy Use



## Electrical Energy Breakdown



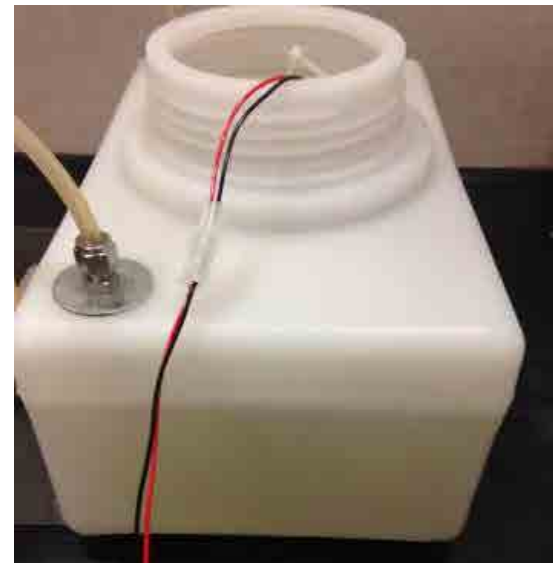
TE energy harvesting = 243 kJ

# Liquid Waste Processing Overview

- Liquid treated using electrochemical disinfection
  - Electrochemical cell to generate pathogen-killing oxidative species
  - Uses salt found in urine as source of chlorine
- Treatment time: 40 – 60 seconds/L
- Energy: 4-8 kJ/L
- Treatment volume: 60 L
- Users per day: 10 – 50
- Power supply: 12 VDC automotive battery



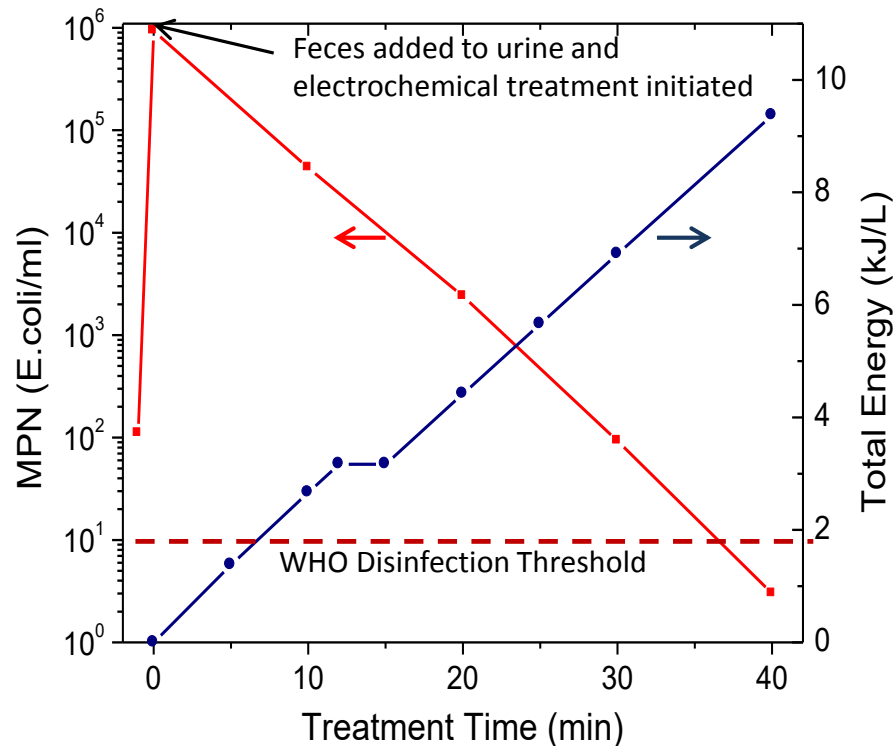
Tank of urine and feces prior to electrochemical treatment



Tank after electrochemical treatment

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# Non-Technical Risks: User Preference



**Stairs** – Represent significant adoption risks for old, young, and limited mobility



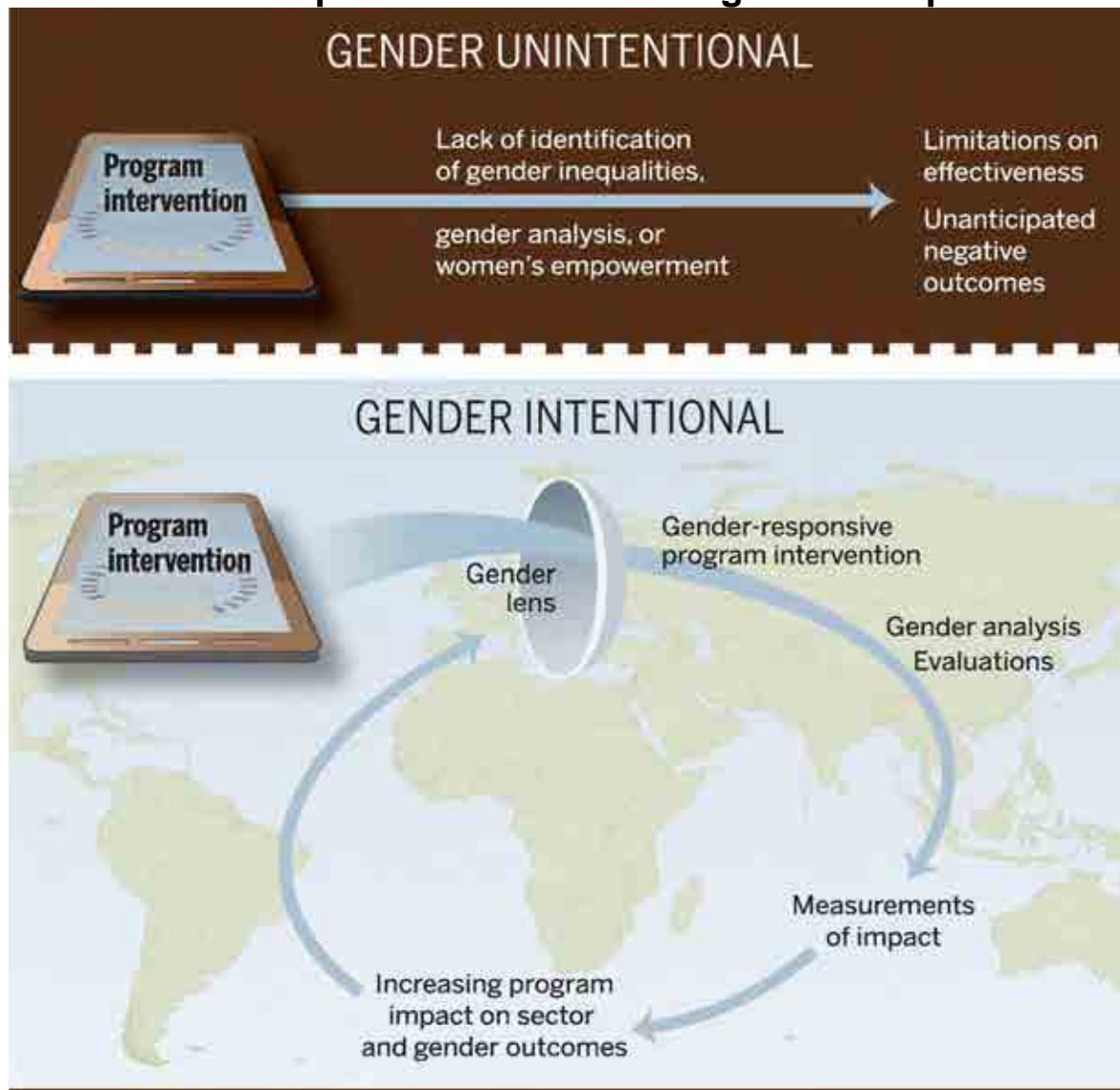
# Non-Technical Risks: User Preference



# Women and young girls

- **Freedom from imprisonment by daylight**  
In many cultures, the only time available for women or girls to defecate is after dark.
- **School enrolment and attendance**  
The lack of safe, separate and private sanitation and washing facilities during menstruation.
- **Reduce the burden of caring for the sick**  
Caring for sick children adds to the already heavy workload.
- **Protect pregnant women from diseases**  
About 44 million pregnant women have sanitation-related hookworm infections that pose a considerable health burden in developing societies.

**Fig. 1 Gender Unintentional.**The upper scenario depicts interventions (for example, a family planning program) to improve outcomes (for example, modern contraceptive prevalence rate) without explicit consideration of gender inequalities.



# Addressing the Needs of Women and Girls

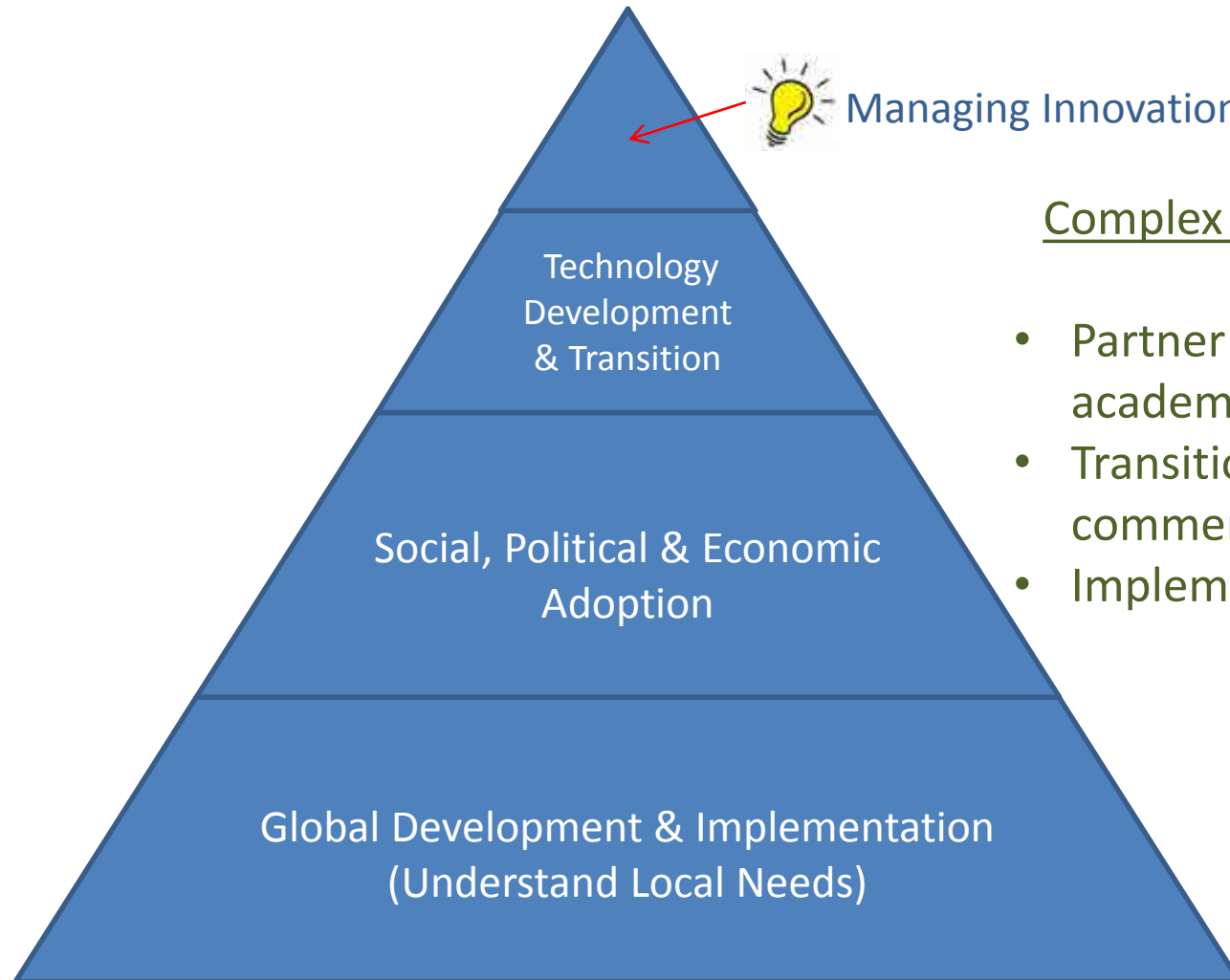


## Considering the Needs of Women

- Menstrual Management
- Safety
- Privacy

# Solving Global Challenges

## Complex Problems Require a Multidisciplinary Approach



### Complex Multidisciplinary Programs

- Partner with NGOs, industry and academia
- Transition technologies from lab to commercial scale
- Implement them globally



# Reinvent the Toilet Fair - India



Thank you