Reinvent the toilet challenge

The proposal of plasma gasification as an off the grid sanitation solution for urban slums
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Introduction

Delft University of Technology
The reinvented toilet

Our view on sanitation
Approach

PLASMA GASIFICATION RESULTS (top-down)

USER DEMAND (bottom-up)
Integration

Parts
**Process**

**Initial calculations**

*Calculation Basis*

100g of sewage sludge

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**Critical residence time:**

10.2 min

**Energy content:**

100g – 1700 kJ

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**Energy Inlet:**

1000 W

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**ASH 30g**

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**SOFC**

**Electrical Energy:**

612 kJ

**Thermal Exit Gas:**

52 kJ

**Gas flow:**

10 L/min

**H₂, CO, CO₂, N₂, O₂**

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**36% efficiency**

Integration
HUMAN CENTERED DESIGN FRAMEWORK

NOW

PEOPLE
- Culture
- Religion
- Type of cleaning
- Economical situation
- Type of person
- Sanitary situation now

SETTING
- Rural/urban/peri-urban
- Type of housing / space
- Water available
- Slum characteristics
- Climate
- Government influence

STAKES
- Phosphate
- Water
- Energy
- Health / disease prevention

IF

SERVICE / DESIGN
- Aspirational
- Clean
- Affordable
- Accessible

TECHNOLOGY
- INPUT / OUTPUT
- Separation
- Pre-drying
- Smell reduction
- Volume reduction
- Local processing
- Distribution

TOOLING

THEN

(Future scenarios)

OWNERSHIP
LOCATION
LOGISTICS
USE OF OUTPUT
PROCESSING

SCENARIO 1

SCENARIO 2

Challenge the future 11
India - Delhi
Research
South Africa - Durban

Prototype testing
India - Delhi

Results
India - Delhi
South Africa - Durban

Results
South Africa - Durban
Phase 2

**Track 1: Process and Energy**
- Design reactor, gas cleaning, plasma optimization
- SOFC
- Control system
- Suboptimal integrated system - for further optimization
- Gasification - SOFC integration
- Internal integration/optimization
- Changes in system, documentation, advising off the shelf parts integration
- Integration - prototype building
- Modular designs:
  - West (festivals)
  - Shared - Urban slums (Delhi/Durban)
  - Household - Urban slums (Delhi/Durban)

**Track 2: Industrial Design**
- Implementation plan: service design, business models
- Intermediate prototype + feedback users
- (partial) prototype building
- Intermediate prototype tests: Lowlands
- Prototype building
- Intermediate field tests MD5: Delhi, Durban & reporting
- Integrating the system - pre-treatment, auxiliary appliance, urine/water filtration
- Off the shelf - translating to reality
- (partial) prototype building
- Prototype building

**Track 3: Technology/design integration**
- Testing and changing
- Off the shelf - design for realistic use
- Building model/testing
- User tests with full setup

**TU Delft**

Challenge the future