Kohler CLASS:
Challenges and Insights

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Martha's Vineyard Innovative Alternative Conference

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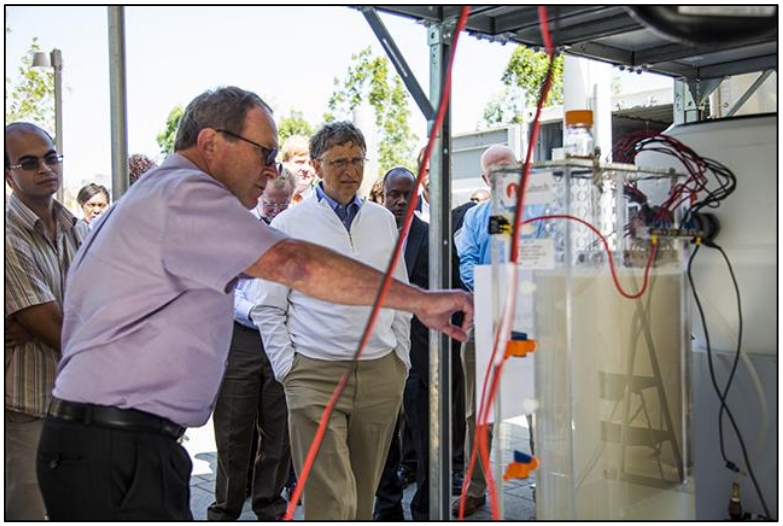
Project Background

BILL & MELINDA GATES foundation

Our Goal:
To enable universal access to sustainable sanitation services by supporting the development of radically new sanitation technologies and markets for new sanitation products and services.

- Hygienic and sustainable for the world's poorest populations
- Operational cost of $0.05 per user, per day
- Does not require sewer, water, nor electricity
- No discharge of pollutants

Caltech Team Approach – Electrolysis of Wastewater



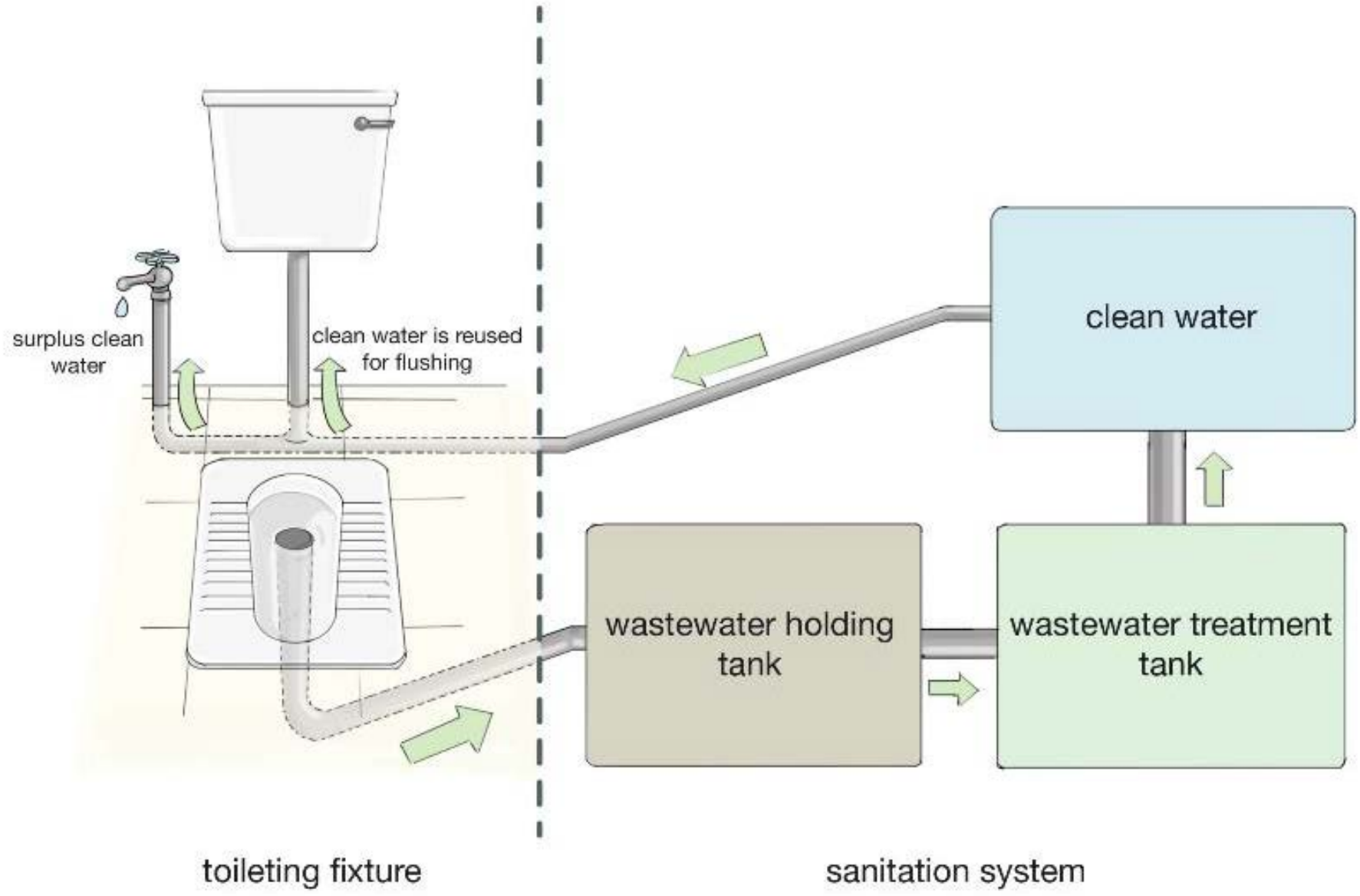
Main reactions:

at the anode: chlorine generation
$2Cl^- \longrightarrow Cl_2 + 2e^-$

at the cathode: hydrogen evolution and hydroxide formation
$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

chemical reaction: chlorine and hydroxide ions react in the electrolyzer to form hypochlorite
$Cl_2 + 2OH^- \longrightarrow Cl^- + ClO^- + H_2O$

overall mass balance: production of hypochlorite
$NaCl + H_2O = NaClO + H_2$

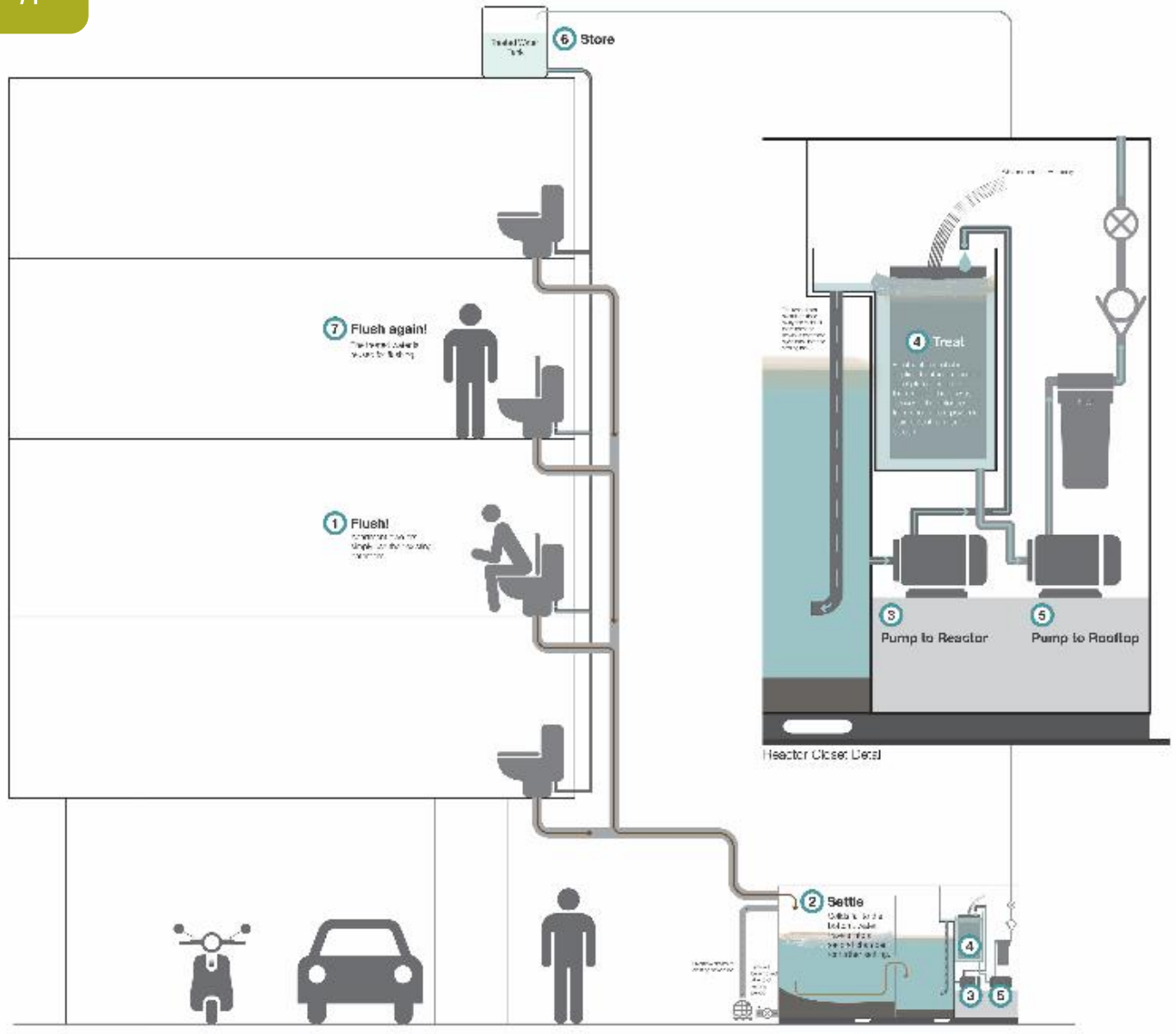

surplus clean water
clean water is reused for flushing
clean water
wastewater holding tank
wastewater treatment tank
toileting fixture
sanitation system

Collaboration

- Caltech conducts basic and applied research
- Kohler designs and manufactures test systems
- RTI conducts field testing of system performance

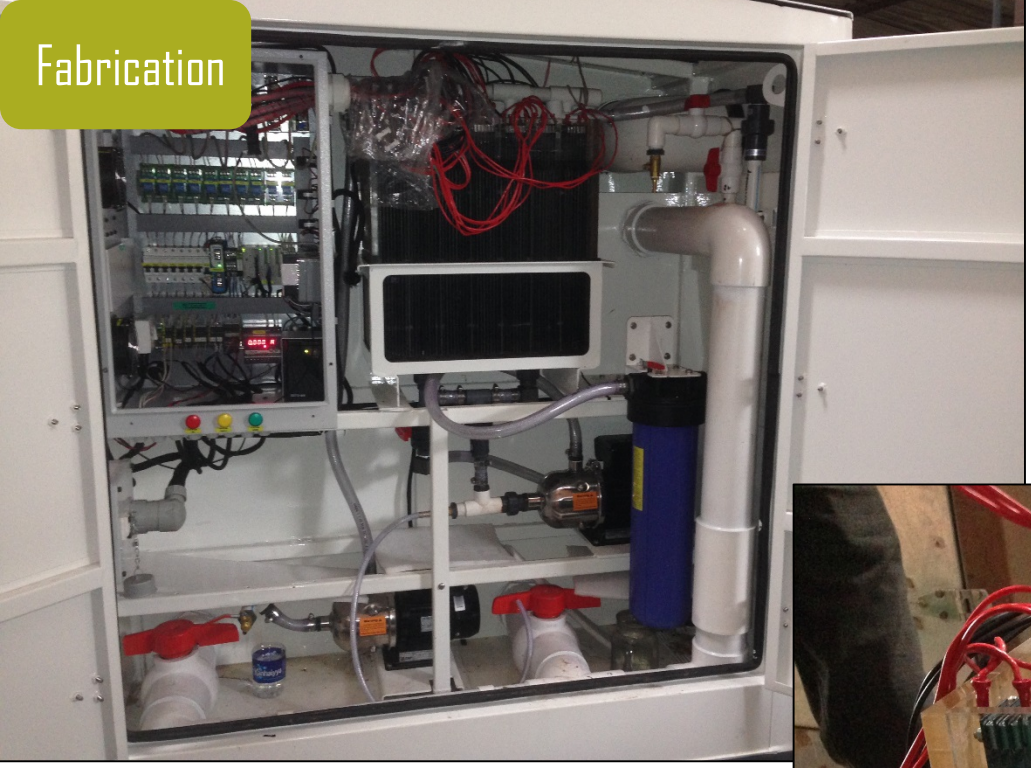
The Beta Prototype

The Beta Prototype



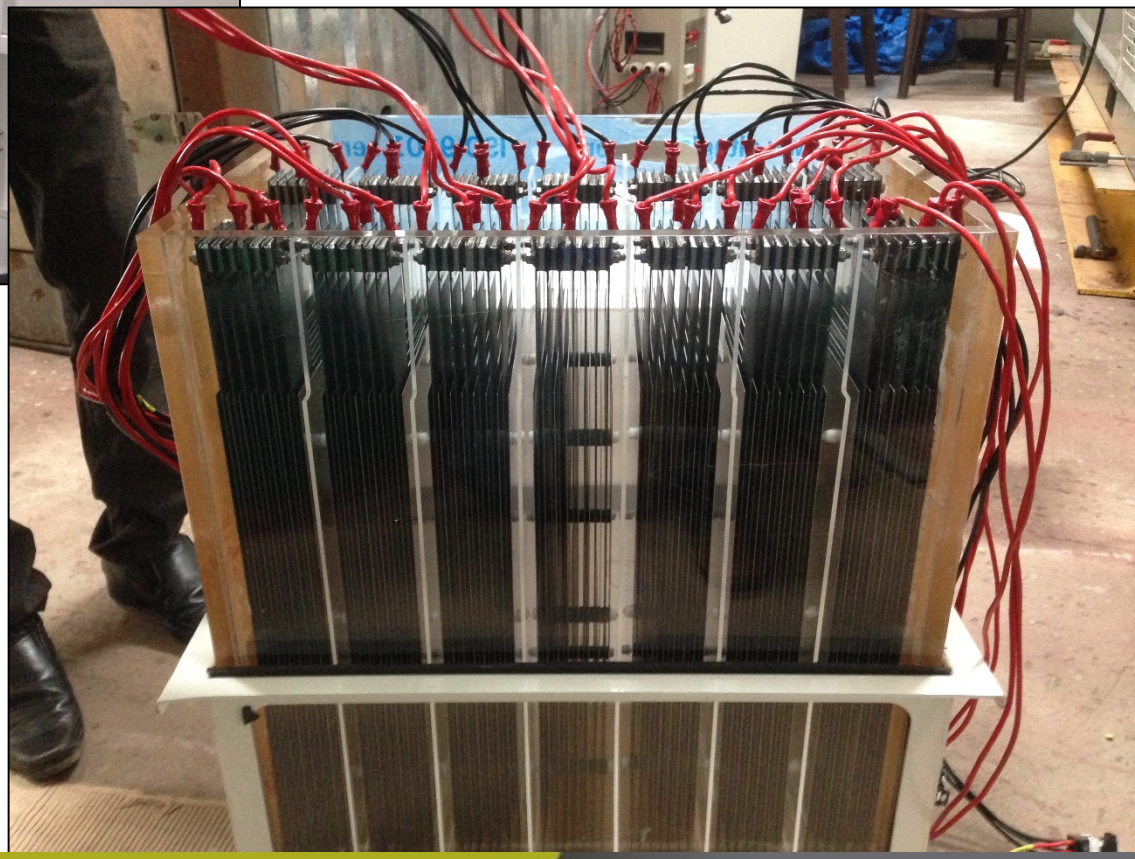
First unit ready for field test site installation in India in September 2015.

Fabrication



Mechanical cabinet

Electrode set



Field Testing

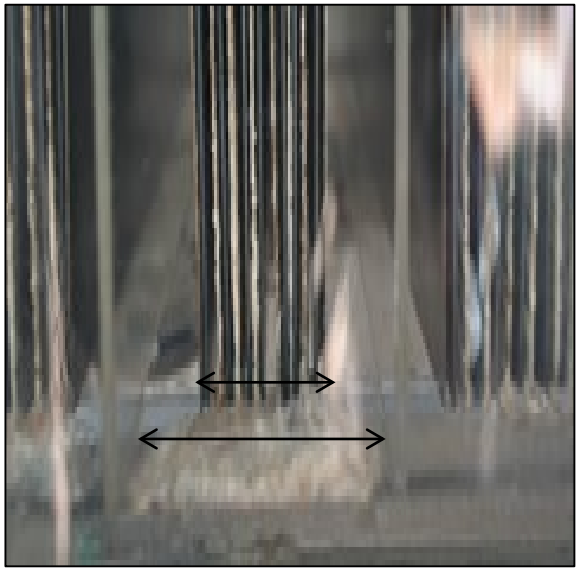
- Worked with the Gates Foundation and the Indian government to identify acceptable test sites.
- Several test units are currently operating in Coimbatore.
- Purpose of testing is to identify technical issues and user acceptance.

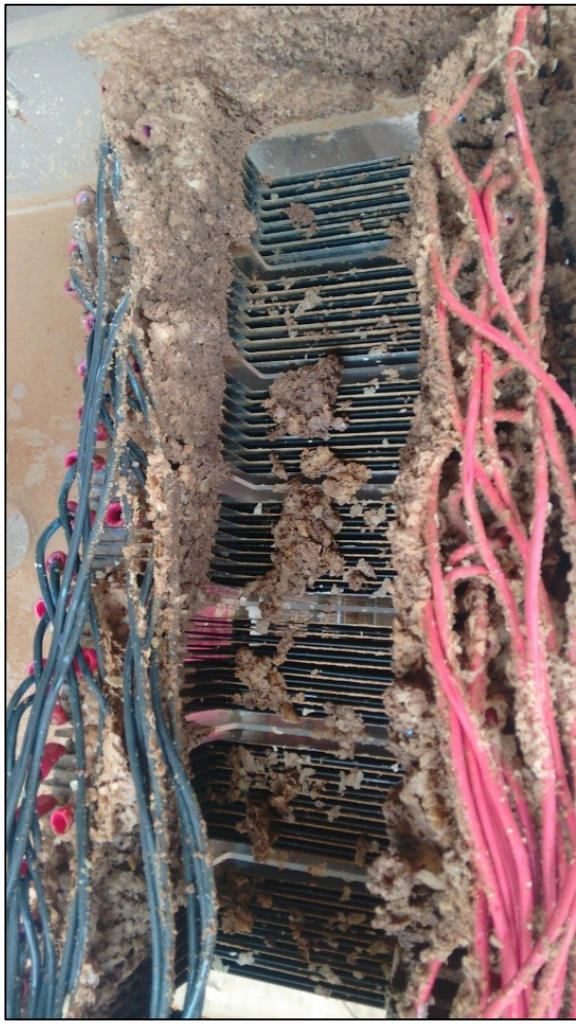
Apartment test site, Coimbatore, India

Performance

- Good water quality
  - Clear
  - Colorless
  - Disinfected
- Steep learning curve associated with the project and technology.
- Water quality greatly impacts system performance
- Mechanical, electrical issues

Some Learnings





- Rapid dissolution of dissolved minerals
- Reduction of space between electrodes, and short circuits
- Accumulation of gelatinous precipitate on electrodes

Summary

- Operating costs higher than expected, but could be offset with solar panels.
- Electrode technology is young and manufacturing costs are expected to come down over time.
- User acceptance of water for flushing toilets has been good.
- Testing will continue for several more months; and learning will continue.

Septic Pre-Treatment Challenges

- Source separation—requires change in user behavior and dedicated plumbing and fixtures
- Nitrogen removal—electrode design not optimized for this application
- Incoming water chemistry
- Effects on receiving systems
- Performance verification and monitoring
- Field testing—volunteers, experimental design

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Thank You!

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