

WATER, SANITATION & HYGIENE: REINVENT THE TOILET CHALLENGE

FACT SHEET

SUMMARY AND ANALYSIS

The Water, Sanitation & Hygiene program of the Bill & Melinda Gates Foundation recently challenged 22 universities to submit proposals for how to invent a waterless, hygienic toilet that is safe and affordable for people in the developing world and doesn't have to be connected to a sewer. Eight universities were awarded grants to "reinvent the toilet."

The Water, Sanitation & Hygiene program initiated the Reinvent the Toilet Challenge to leverage advances in science and technology and create a new toilet that will transform waste into energy, clean water, and nutrients.

The Reinvent the Toilet Challenge aims to achieve the following goals:

- Address the failures of the 18th-century toilet, which is not meeting the current needs of 2.6 billion people who lack access to sanitation
- Devote funding and attention to the need for a new toilet
- Generate innovation among a wider research and development community
- Support upstream research and development of a toilet that:
 - » Is hygienic and sustainable for the world's poorest populations
 - » Has an operational cost of \$0.05 per user, per day
 - » Does not discharge pollutants, but instead generates energy and recovers salt, water and other nutrients
 - » Is designed for use in a single family home
- Create a toilet that does not rely on water to flush waste or a septic system to process and store waste
- Create a toilet that is the basis for a sanitation business that can be easily adopted by local entrepreneurs living in poor urban settings

- Raise awareness about this research by publishing scientific papers in journals and articles in various media outlets

REINVENT THE TOILET CHALLENGE GRANTS

Upstream Innovation

1. A toilet that produces biological charcoal, minerals, and clean water

Professor M. Sohail of Loughborough University and his team propose to develop a toilet to transform feces into a highly energetic combustible through a process combining hydrothermal carbonization of fecal sludge followed by combustion. The process will be powered by the heat generated during the combustion phase and will recover water and salt from feces and urine.

2. Turning the toilet into an electricity generator for local use

Professor Georgios Stefanidis and his team at Delft University of Technology propose to develop a toilet system that will apply microwave technology to transform human waste into electricity. The waste will be gasified using plasma, which is created by microwaves in tailor-made equipment. This process will yield syngas, a mixture of carbon monoxide (CO) and hydrogen (H₂). The syngas will then be fed to a solid oxide fuel cell stack for electricity generation. This toilet system will be able to serve single households or groups of households.

3. A urine-diverting toilet that recovers clean water on site

Dr. Tove Larsen of the Swiss Federal Institute of Aquatic Science and Technology and Dr. Harald Gründl of the industrial design company EOOS propose to design and construct a functional model of a urine-diverting toilet that recovers water and is user-friendly, attractive, hygienic, and provides water for cleansing.

4. A community bathroom block that mineralizes human waste and recovers clean water, nutrients, and energy

Professor Christopher Buckley and his team at the University of Kwazulu-Natal propose to design, prototype, and evaluate a toilet system that can safely dispose of pollutants and recover valuable materials such as water and carbon dioxide from urine in community bathroom blocks.

5. A community scale biochar production plant fed by human waste

Brian Von Herzen of the Climate Foundation and Professor Reginald Mitchell of Stanford University in Palo Alto, California, propose to design, build, and test a self-contained system that pyrolyzes (decomposes organic material at high temperatures without oxygen) human waste into a type of biological charcoal (biochar) that is used for carbon capture and storage. The system will be able to process two tons of human waste daily at a facility located in the slums of Nairobi.

6. A toilet that uses mechanical dehydration and smoldering of feces to recover resources and energy

Professor Yu-Ling Cheng and her team from the University of Toronto Department of Chemical Engineering and Applied Chemistry propose to develop a technology for treating solid waste streams through mechanical dehydration and smoldering that will sanitize feces within 24 hours. They also intend to develop a method for sanitizing urine through membrane filtration and ultra-violet disinfection. Their third area of research will be on user-centric design to determine a preferred interface that creates demand to use the toilet technology.

7. A solar-powered toilet that generates hydrogen and electricity for local use

Professor Michael Hoffman of the California Institute of Technology proposes to design a self-contained, solar-powered domestic toilet and wastewater treatment system. The solar panel will convert the sun's rays into enough energy to power an electrochemical reactor that Hoffmann designed to break down water and human waste into hydrogen gas. The gas can then be stored in hydrogen fuel cells to provide a backup energy source for nighttime operation or for use under low-sunlight conditions.

8. A pneumatic flushing urine-diversion dehydration toilet

Professor How Yong Ng and his team at the National University of Singapore propose to research the development of a decentralized modified pneumatic flushing urine-diversion dehydration community toilet block for five to six households with separate collection and treatment of urine and feces to recover water and nutrients. The toilet system will recover energy from feces combustion and clean water from advance adsorption desalination.

Water, Sanitation & Hygiene

The Bill & Melinda Gates Foundation works with a wide range of partners through its Water, Sanitation & Hygiene program to reduce the burden of water-borne disease and improve the lives of the poor. Our approach aims to expand the use of sanitation that does not connect to a sewer, as this is by far the most common type used by the poor. We invest in effective approaches that help end open defecation and unsafe sanitation in rural communities, and we help develop the tools and technologies that will allow the urban poor access to sustainable non-piped sanitation.

Guided by the belief that every life has equal value, the Bill & Melinda Gates Foundation works to help all people lead healthy, productive lives. In developing countries, it focuses on improving people's health and giving them the chance to lift themselves out of hunger and extreme poverty. In the United States, it seeks to ensure that all people—especially those with the fewest resources—have access to the opportunities they need to succeed in school and life. Based in Seattle, Washington, the foundation is led by CEO Jeff Raikes and Co-chair William H. Gates Sr., under the direction of Bill and Melinda Gates and Warren Buffett.

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