# Pushing the limits of pump design for small farmers in India

May 19 2015, by Ben Miller

After a few days of observation, and without explicit training, farmers in India began setting up an MIT Tata Center-designed irrigation system themselves. Credit: Katherine Taylor

The Ganges River basin of eastern India is some of the most fertile farmland in the world. With shallow groundwater and rich soil, the area is instrumental in India's agricultural ecosystem. However, all is not well for the roughly 480 million people who rely on the basin for their livelihood.

"Eastern India is one of the lowest agricultural productivity areas in the country, and it should be much higher, because it has excellent water resources," says Katherine Taylor, graduate student in mechanical engineering and a fellow at the Tata Center for Technology and Design, part of the MIT Energy Initiative.

Taylor is part of an MIT team developing a solar-powered pump designed to the specifications of small-acreage farmers in eastern India, many of whom currently use costly, inefficient diesel pumps to irrigate their crops, or have no pumping capacity at all.

The project grew out of the MIT course 2.760 (Global Engineering), where Taylor met Kevin Simon, another Tata Fellow and a graduate student in systems engineering, and Marcos Esparza, a senior in mechanical engineering. Led by Assistant Professor Amos Winter, "we explored pump design, and a good idea emerged. In true Tata Center spirit, we ran with it."

At a time when Indian agriculture is edging toward crisis, Taylor, Simon, and Esparza believe their pump can contribute to higher yields and greater profits for these small farmers.

## The pump problem

"Lots of people ask us why this pump hasn't been made," Simon explains, noting that an estimated 23 million small-acreage farmers in eastern India use diesel pumps (often improperly-sized for individual fields) or rely on the annual monsoon. "There are very few people who have the technical know-how to design a pump from scratch, and who also understand the context of these farmers."

As Tata Fellows, Simon and Taylor have each traveled to India six times since 2013, researching the country's agriculture systems, talking to farmers and industry experts, and learning the design constraints they would need to meet in order to create an efficient, affordable, solar-powered pump. One important discovery was that a very small portion of the land is used during the dry season, possibly less than 5 percent. In fact, it is so rarely used that there is no dedicated Hindi word for it as a growing season. "This is all fertile land that could be used year-round with proper irrigation. It's very profitable to cultivate in the dry season."

Despite a water table frequently less than 10 meters below the surface, lack of access to the electrical grid means farmers are dependent on diesel pumps that operate between 10-20 percent efficiency, making fuel costs prohibitive. Solar power, on the other hand, is reliable, clean, and cheap to generate—but no solar pumpset had ever been created with these farmers in mind.

It was an exquisite engineering problem: designing a pump that would exceed the performance standards of current models while being affordable, robust, and entirely solar-powered. Guidance came from Winter, who heads up MIT's GEAR Lab; Olivier de Weck, professor of engineering systems; and Alexander Slocum, professor of mechanical engineering.

Today, the team's pump is hitting a mark of 30-35 percent efficiency. "It's definitely higher efficiency than any other pump at this performance point," Taylor says. Simon adds, "We're pushing the limits of what you can do with a centrifugal pump."

## "In-the-field engineering"

In February and March of this year, the people of Chakradharpur, in the eastern state of Jharkhand, were treated to the daily spectacle of the MIT team lugging hardshell suitcases "packed to the gills with tools and replacement parts and pumps" out to their worksite.

In a series of field trials aided by their partner, PRADAN, an non-governmental organization co-founded by Deep Joshi SM '77, the team assembled and tested their pumps, later training farmers to use them.

"It was really in-the-field engineering," Taylor says. "We came up with a lot of creative solutions."

"We turned one of our hotel rooms into an entire lab," adds Simon. "We had tools, we had an electronics station. The hotel staff would stand there watching us as we stripped wires."

PRADAN's regional knowledge was crucial in locating suitable test sites and connecting with the community. "If we were to try this in a community that didn't have diesel pumps, that wasn't familiar with year-round cultivation, that wasn't organized, we could have failed for a wide variety of reasons. But instead we were able to work with a community that PRADAN had hand-picked."

The team will return to Jharkhand and continue their pilot in July, just as the dry season is ending and the monsoon begins. "We'll use tape measures to see exactly how much land they cultivated [in the dry season]. That's the holy grail of questions, and it's going to be really critical to understanding our value proposition."

Taylor and Esparza will graduate from MIT this spring, while Simon plans to pursue his PhD and continue to stretch the boundaries of pump design. All three agree that the project is far from over.

"We're dedicated to following through," Taylor says. "We want to do whatever it takes to get this technology into the hands of the people it can help."

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Provided by Massachusetts Institute of Technology

Citation: Pushing the limits of pump design for small farmers in India (2015, May 19) retrieved 2 May 2024 from https://phys.org/news/2015-05-limits-small-farmers-india.html