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Energy

Microgrids: Why some fail, and how others can succeed in providing electricity to rural India

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A village within three hours drive from Lucknow, the capital city of Uttar Pradesh (UP), received its first electrical line in January 2012. This was through Mera Gao Power's microgrid, which provided service of four hours lighting and cell phone charging in the evening from 6pm-10pm.

This village in Reusa district was one of more than 400 villages around UP that Mera Gao was serving through their microgrid business. These villages are 10-15 minutes by motorcycle from town centers, which do have state grid connections. In many of the villages, there are even poles and electrical lines for grid services, but no electricity.

This is the situation in more than 10,000 villages across UP and Bihar – two of the poorest and least electrified states in India. Our MIT team visited new potential sites where Mera Gao was planning to build microgrids. People were enthusiastic and even said they were willing to pay more than what was being charged for other Mera Gao customers, which is $2 per month.

Along with the excitement of getting electricity for the first time, we also heard a few other things – at least 40% of the community would have to buy in to justify installation of a solar microgrid. That means in a village of 100 homes, at least 40 homes had to sign up saying they would pay for the service, otherwise the number was too small to justify putting in a central solar microgrid business. We also heard people asking if they could have more power than just light and cell phone charging. How about television? Would there be enough power to run an agricultural pump? *(cont. inside)*

“Community buy-in needed to set up microgrids”

And there was another issue that Mera Gao was avoiding – interaction with government. Having a regional office in one of the town centers, people knew Mera Gao as the electricity provider. We heard from shop owners who wanted Mera Gao’s service, because it was more reliable than the state grid, which provided limited service. When their were failures in the grid, like a transformer explosion, it could take months for someone from the state utility to come and fix it. Mera Gao did not provide service for the people in town at the time (2012), because they did not want to interact with the grid; they wanted a stand-alone system that they could operate on their own.

There is one benefit to that philosophy since India currently does not have any regulation for electricity provision for rural communities in small scale - there is no bureaucracy and things could move at a much faster pace than having to involve government officials. But a big drawback of not including government into your plan, especially in a country like India, is what Greenpeace saw happen in Bihar, where they set up a microgrid and within a few months much cheaper state grid came in to supply electricity, making Greenpeace’s microgrid irrelevant.

There are two distinct sets of problems that we saw in this one visit. One, for a bottom-up approach to electricity access, a lot of community buy-in is needed to set up a microgrid. Apart from expensive solar home systems and solar lanterns, there are no other solutions that can provide electricity on an individual scale. Within this bottom-up approach, there is also the issue of how technology addresses demand growth within a community. Currently, most off-grid solutions (microgrids) come with fixed generation assets and distribution network where you can probably add another battery and panel to support demand growth, but not for one and two individuals.

The second problem is with the interaction, or lack of, with government and utilities. In India’s context particularly, there are lots of organizations and government entities that do want to provide access, either through grid extension or an off-grid solution. But there is a lack of cohesive planning. If an independent microgrid operator does not know where the grid extension is happening, how can they plan to have a successful business?

People in India still consider grid the optimal solution to getting electricity, and with huge subsidies, it is very cheap (4-6 cents/kWh). How can any alternative solution compete in this distorted market? Within the Tata Center at MIT, faculty and researchers have been looking to tackle these issues.

An innovative new approach for electricity distribution is being considered, with an ad-hoc microgrid that can support multiple loads, and focuses on generation and demand management with state-of-the art control algorithms that will make the operation of the network autonomous. Modular architecture can help with scaling the system with demand growth. With embedded billing and payment capabilities, the system can be a lot cheaper than a solar home system but more flexible than the current version of a central microgrid system.

Another project in development is a comprehensive planning tool kit that would enable a common platform for electricity planning across a large-scale geographic region, i.e. district, state or national levels. Such a tool would allow planners to make an

“42% of demand will be met with microgrids”

effective decision based on least-cost optimization to choose an appropriate solution between grid extension or off-grid solution for a particular area.

Private entrepreneurs or distribution companies could evaluate the economic benefits of different electrification solutions based on tariff or subsidy structure in a country. Combining this top-down and bottom-up approach is also a research focus for a team at MIT that looks at grid-compatibility of microgrids, and how large number of microgrids could be interconnected and/or connected with the national grid. Since the IEA said in their 2010 World Energy Outlook that 42% of the off-grid electricity demand will be met with microgrids, the Tata Center is looking at precise questions of what those microgrids could look like, how they could fit into the national electricity planning scheme.

Energy, development, and a forum for MIT students

Varun Mehra
Tata Fellow and Co-President, e4Dev

In India, it’s estimated that 300-400 million don’t have access to electricity; millions more connected to the grid receive unreliable electricity service due to an insufficient supply of energy generation, bankrupt distribution utilities, and a host of other reasons. For those living off-grid, most rely on kerosene and solid fuels as primary energy sources for lighting and cooking -- both of which have respiratory health implications. And from a policy perspective, India has aggressive renewable energy targets outlined in initiatives such as the National Solar Mission, but its power system is currently (and expected to be in the near-term) dominated by coal-fired generation. This is just a tiny snapshot of the complex energy landscape in India -- let alone the rest of the developing world.

A few years ago, a couple of MIT graduate students started a student group called Energy for Human Development (e4Dev) to create a forum where interested students could learn about and discuss topics ranging from renewable energy policy design in India to business model innovation for off-grid energy service providers. e4Dev’s goal is to explore the interdisciplinary intersection of energy access and development, highlighting the numerous research projects and wide-ranging opportunities at MIT and beyond. As a second year master’s student, I have the privilege of leading e4Dev this year, alongside a number of awesome graduate students.

As many development indicators show, access to affordable energy and increased standards of living are inextricably related. Being a Tata Center Fellow has allowed me, along with many others I’m sure, to go beyond the statistics and develop a first-hand understanding of what access to electricity actually means for people living without it. And e4Dev serves as a great outlet for me to share my experience while being able to learn from others working on different energy-related challenges in different cultures, countries, and geographies. If you’d like to join these conversations, I’d encourage anyone interested to check out our website (e4dev.mitenergy.org) and join us at one of our weekly e4Dev meetings.

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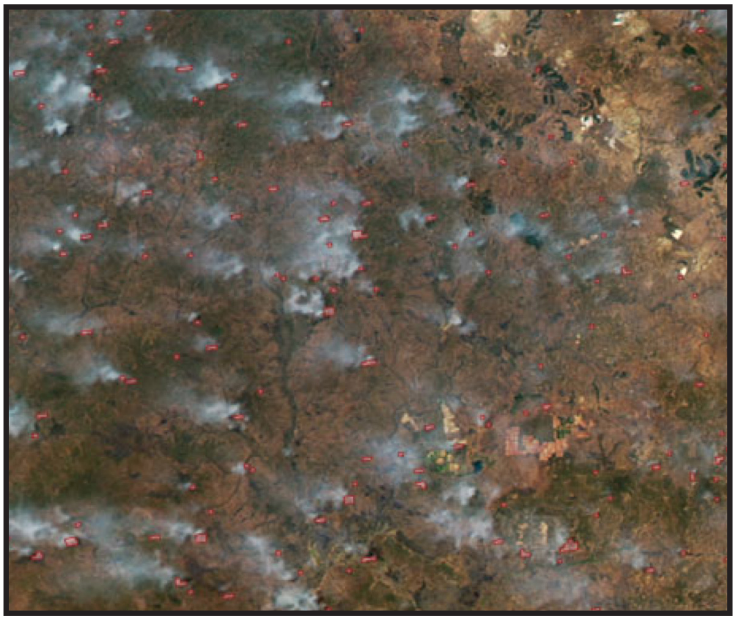
The dirty secret of biomass energy

Kevin Kung
Tata Fellow



Since 2011, my main interest has revolved around biomass waste. Different people have defined biomass variously. In the discussion below, I refer mainly to plant-based residues, such as post-harvest farm and agricultural waste, and/or forestry waste.

Initially, I saw tons and tons of rice husks, sugarcane bagasse, and other types of biomass being burned. The problem, I thought, was that there was no good technology to turn this waste into fuel. So I started a company in Kenya focused on providing the technical process for turning this hitherto unharnessed waste into a low-cost, safe, and high-quality cooking fuel. Households, by buying such fuel, would save 20% on their cooking expenditures. By replacing traditional charcoal, this biomass-derived fuel would also save forests and mitigate greenhouse emissions.

Through the years, as I progressed on my company, and interacted with many more people in the biomass energy conversion sector, something gradually dawned on me. There are plenty of biomass energy conversion technologies out there—for example, biomass boilers (heat or electricity production), pelleting machines (solid fuel production), gasification (electricity production), and pyrolysis (liquid fuel). The possibilities are endless, and so are the biomass energy companies. What I gradually realized is that what is missing, in this case, is not the crucial conversion technology. Rather, it is the challenge of moving biomass waste from point A to point B.

Biomass is available mostly in rural, dispersed locations in small batches. After harvest, the farm waste does not always present itself in the right form to be economically transported. If a batch of biomass is wet, then we are effectively paying freight to transport water. Likewise, if a batch of biomass is loose, then we cannot squeeze too much biomass mass (and thus energy content) into a truckload. Ironically, most biomass waste conversion facilities, on the other hand, are immensely centralized and capital-intensive installations. They often require at least tons and tons of biomass every hour to run themselves. Because collecting tons of biomass from rural areas is very expensive, most of these large conversion facilities can often only be co-located with existing agricultural processing mills. The city of Muzaffarnagar, in Uttar Pradesh, India, for example, has the nearby fiber-rich agricultural residue go to paper-making and/or boilers. Likewise, a biomass pelleting mill in the United States only collects the biomass waste from about a 50 km radius, and even so, transportation accounts for 90% of their production cost. These conversion processes are therefore, by and large, economically uninteresting in remote areas, where most of the biomass waste from the small-holder farmers still do not have a significant economic value. If there is no significant value to the farmers, then farmers, anxious to clear their land for the next planting season, may simply choose to burn their biomass on-site in the open air.

In a satellite image taken by NASA in 2013 (above), we can see plumes of smoke rising from fields in Punjab. At certain times of year, this smoke covers much of northern India, including Delhi -- a severe public health concern. A 2014 Stanford study (Jacobson, 2014) shows that burning biomass may contribute to up to 18% of global anthropogenic CO_2 emissions. What's more, by burning biomass in their field rural farmers are burning an equivalent of US$120 billion/year in cash that they could have potentially earned, if they had the chance to economically convert and sell their biomass waste as a valuable product.

This is one reason why I decided to dedicate my PhD research at the Tata Center to looking at a thermochemical process called torrefaction for densifying biomass waste on-site before transportation. Imagine a mobile, low-cost, and easy-to-operate unit that can travel from farm to farm after a harvest season, converting the biomass waste into a form with a much longer shelf life and less moisture. This then becomes a product that can be much more easily transported and processed. The biomass energy producers can now source their input feedstock at a lower cost. This value chain may even expand to rural areas whose biomass waste was previously burned in open air, creating an additional source of income for millions of remote farmers.