India microgrid control

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In India, roughly one-fifth of the population has no access to electricity. Solar direct-current microgrids can provide reliable, affordable electricity to areas not served by the traditional grid.

Then, too, roughly a quarter of a billion Indians, or one-fifth of the population, live without access to any electricity at all, according to the International Energy Agency. For a country where science and technology has otherwise advanced at a breathtaking pace, this sorry state of electrification is a disgrace.

In recent years, the Indian government has invested heavily in electricity generation (including solar- and wind-power plants), state-of-the-art high-voltage transmission lines, and a multitude of household electrification projects. And yet these efforts have made only a modest dent in the problem. A government Web portal that tracks rural electrification efforts shows that in only four of the country"s 29 states do all of the households have access to electricity.

The problem is this: The Indian government has taken a traditional approach to electrification, which focuses on building up generation, transmission, and distribution. But there"s a better way that"s more affordable, more efficient, and much faster and easier to deploy. It can also address all aspects of the electrification problem at once, reducing the gap between demand and supply, bringing down electricity costs, and providing reliable, always available electricity to everyone.

This strategy, developed by my group at the Indian Institute of Technology (IIT) Madras in conjunction with industrial partners, relies on solar-powered direct-current (DC) microgrids. For homes not connected to the grid, a 125-watt microgrid can serve as the sole source of electricity. For connected households, the microgrid acts as a backup power supply to let lighting, fans, TV sets, and cellphone chargers continue operating even during brownouts.

In 2014, we began field-testing our DC microgrid systems in dozens of homes, offices, and dormitories at IIT Madras. The following year, we expanded deployments to about a thousand homes in three cities and multiple villages. Now, with funding from India"s Ministry of Power, we have two large-scale projects under way that will eventually reach more than 100,000 households.

By Western standards, the 125-W load provided by our microgrids is quite modest--an ordinary household vacuum cleaner uses anywhere from 500 to 3,000 W. Indeed, in the typical northern California home, the "idle" load [PDF]--that is, the electricity used by devices that are plugged in but turned off--far exceeds 125 W. And yet, in every place we"ve deployed our system, the recipients have been immensely satisfied because they now have electricity around the clock. They appreciate having lights to prepare a meal or study at night,

watching an entire TV program without having it interrupted by a power outage, sleeping through a hot night under the cooling breeze of a fan.

And while India faces a unique challenge in the sheer number of homes that lack electricity, our technology could find uses far beyond India. In fact, we believe every household in the world, whether in Cincinnati or S?o Paulo, could benefit from having a solar DC microgrid. Here"s why.

Let"s first consider how to shore up the power supply to households that already have a grid connection. As in the rest of the world, India"s main power grid is based on alternating current (AC). Our system, by contrast, relies on DC because PV panels and batteries as well as consumer electronics, LED lighting, and a growing range of appliances all work with direct current, and we thus avoid the losses that come with converting back and forth between AC and DC. Each conversion incurs a power loss of 5 to 20 percent, so for the sake of efficiency, you want to minimize the conversions.

We start by running an additional power line in the home. It is a 48-volt DC line and provides about 10 percent of the typical household load. LED lightbulbs, electronics, or small appliances that have been designed to run on DC can be fed directly by this line. We also replace the traditional electricity meter with what we call an uninterrupted direct-current (UDC) power meter, which has the same control and communications capabilities of a smart meter, along with an AC-to-DC converter for converting a portion of the incoming AC to DC.

Since 2015, we"ve been collaborating with the Hyderabad-based solar power company Cygni Energy to roll out UDC systems in the city of Sasaram, in the northeastern state of Bihar. There, up to 100,000 households will soon receive DC microgrids. Although these homes are connected to the existing AC power grid, the reliability is poor, and residents are desperate for an alternative. Bihar has the largest deficit between peak demand and supply of any Indian state and the lowest per capita electricity consumption. Eventually, Sasaram could become the first city in the world to have a DC power line installed in every home.