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ISLANDS OF LIGHT

More than a billion people lack electricity, but now microgrids are powering up rural areas.

BY JEFF TOLLEFSON

In Haiti, the least-electrified country in the Western Hemisphere, some residents spend US$10 a month on candles and kerosene just to light their homes — roughly 125 times what those in the United States typically pay for the equivalent light. In India, many pay a premium to charge their mobile phones from car batteries at the local market. The Sun still dictates life for millions of Africans, and diesel generators burn through budgets on small Pacific islands. Around the world, nearly 1.3 billion people live without access to electricity, many of them far from the ever-expanding electric grid.

The quest is on to find the best way to bring clean power to rural areas. Mixing local development work with Silicon-Valley-style entrepreneurship, engineers, scientists and economists are setting up independent 'microgrids' that can be deployed quickly and cheaply one community at a time. Those leading such electrification schemes aim to create small-scale renewable-energy systems, building an archipelago of light across the developing world and helping remote communities to kick their dependence on fossil fuels.

Such efforts have often failed in the past, as subsidies lapsed or infrastructure collapsed. But today's entrepreneurs are better placed to succeed. A new generation of cheaper photovoltaic panels and wind turbines can be managed with simple smart-grid devices. The price of fossil fuels has soared over the past decade, making renewable energy more competitive. And the United Nations has set a goal of achieving universal access to electricity by 2030, providing political impetus.

"The ambition is there, and the economics are making a lot more sense now than they were a few years ago," says Richenda Van Leeuwen, executive director for energy access at the United Nations Foundation. But the challenge remains extreme. A 2012 analysis by the International Energy Agency projects that, on the basis of current plans, the percentage of people without access to electricity will fall from 19% in 2010 to 12% in 2030 — leaving nearly 1 billion people still in the dark. Achieving universal energy access would mean increasing investments from a projected $14 billion to $49 billion a year, the agency says. Centralized grids are expected to provide only about 30% of the solution in rural areas.

Among the projects already on the go are a few bright spots with lessons to teach about technologies and business models that could help to light the world.

TAMKUHA, INDIA

When a pair of young Indian entrepreneurs flipped the switch to electrify the remote agricultural village of Tamkuha in 2007, the power flowed from rice husks. Gyanesh Pandey and Ratnesh Yadav knew that photovoltaic panels were too expensive for their plans, and there wasn't a lot of wind blowing through this town of roughly 2,000 people. But their home state

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of Bihar has rice in abundance.

Trained in electrical engineering at Rensselaer Polytechnic Institute in Troy, New York, Pandey sketched out a plan with his long-time friend Yadav. Working with a grant of roughly $12,000 from the Indian Ministry of New and Renewable Energy, the duo invested more than $40,000 of their own money to purchase and modify a gasifier to turn rice husks into biofuel, buy a 32-kilowatt generator, and run power lines through the village.

Within five months, the residents of Tamkuha had enough electricity to charge their mobile phones and fend off darkness with two compact fluorescent light bulbs per household for 6–8 hours a night. Pandey and Yadav formed Husk Power Systems with Manoj Sinha, who studied business at the University of Virginia in Charlottesville, and the company now has more than 80 mini-power plants serving some 200,000 people in India, Uganda and Tanzania.

Success in Tamkuha proved that even poor customers will pay 100 rupees ($1.60) per month or more for minimal power, in a country where rural households often survive on $15–80 a month. The rates are higher than in urban centres, but customers typically save overall because they purchase less kerosene. In 2007, says company president Sinha, nobody believed that Husk Power could create a viable business."But when we scaled up to more than 300 villages, people started believing in the model."

The opportunities in India are huge. Although the percentage of people without access to electricity in 2011 was only 25% — much lower than the 80–90% rates seen in some African countries — that still left a record 300 million people without power in a single country. The government has invested money and attention in the problem, and those efforts have slashed the number of people without a connection to the main grid by more than half in the past decade. But the country is struggling to supply enough power to feed all those lines, and to hook up the most remote communities.

Husk Power has become one of the world's largest microgrid developers. And it is dreaming big, targeting 5 million customers within five years in India and east Africa. With the cost of photovoltaic panels falling, the company is building solar microgrids and pairing them with storage batteries to meet evening demand. And it is experimenting with a solar–biomass hybrid power plant intended to provide power around the clock.

"Where Husk is going is very positive," says Daniel Kammen, an energy researcher at the University of California, Berkeley. "It is not fixating on one technology, it is fixating on solutions."

But problems may lie ahead. In some areas, small providers such as Husk Power compete with the expanding central grid, leaving some villages with two suppliers. The microgrids tend to be more reliable, but are also more expensive, because subsidies usually go into capital construction costs rather than towards keeping electricity rates low. Kammen says governments and companies should agree on some basic industry standards for regulation and finance, so that investment in microgrids — the only solution for some areas — expands rather than being undermined.

TOKELAU, SOUTH PACIFIC

The Sun shone brightly on Tokelau as a cargo ship pulled into harbour in June 2012, bringing the tiny trio of South Pacific islands their largest delivery ever. On board were more than 4,000 solar panels and 1,000 storage batteries, as well as innumerable nails and screws. "We thought the island was going to sink," jokes energy minister Foua Toloa. The cargo gave Tokelau the moral high ground in the battle to halt global warming: it has been widely billed as the first nation to accomplish a sweeping shift from fossil fuels to renewable energy.

Tokelau, like almost all small island nations, used to rely on diesel-powered generators to meet the needs of its 1,400 residents. In its first full year of operation, the new 1-megawatt solar system met roughly 93% of the nation's electricity demand. Today, Tokelau has reduced its annual fuel bill by about $800,000, which more than covers payments on the loan it received from the government of New Zealand for the microgrid. "We're very proud," Toloa says. "We are challenging the world and the big emitters of greenhouse gases to equal or better what Tokelau has done."

A handful of Caribbean islands has signed up to that challenge with the help of the Carbon War Room, a Washington DC-based advocacy group founded by British entrepreneur Richard Branson. The Caribbean island of Aruba, where wind power currently provides 12% of demand, led the way in March 2012 with a commitment to eliminate fossil-fuel use by 2020. But with 109,000 residents and regular demand for roughly 100 megawatts of power, Aruba's challenge is much bigger than Tokelau's. "This is actually a very interesting proving ground to test out ambitious levels of renewables and energy efficiency," says Amory Lovins, co-founder of the Rocky Mountain Institute in Snowmass, Colorado, which co-hosted a clean-energy summit for Caribbean nations with the Carbon War Room in February. Lovins notes that the lessons learned about balancing energy supply and demand could help with the management of mainland power, too. Some US states, including New York, are exploring ways to divide the main grid into electricity 'islands' that could be isolated in the face of large-scale outages. And, Lovins adds, island projects such as that on Aruba may help to convince the world that reliable power systems can be built almost entirely from renewables.

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Tokelau has not yet achieved its goal of going 100% renewable. The old diesel generators still occasionally kick in to charge batteries during the rainy season, and many residents rely on imported gas for cooking. The nation's government is planning to help residents to purchase more efficient appliances or make the switch to electric cookers. Air conditioners, considered an unnecessary luxury on the island, have already been banned for government use. And if the economics work out, as early as next year the country hopes to begin producing coconut oil to power the generators when the Sun doesn't shine. "We've got plenty of extra coconuts," Toloa says.

SINE MOUSSA ABDOU, SENEGAL

Residents in the village of Sine Moussa Abdou once had to trek ten kilometres to a neighbouring village to charge their mobile phones, paying fees as high as $110 per kilowatt hour — the average US rate is 12 cents. Those with televisions hauled a car battery to be recharged. The village's 900 residents now pay about $1.40 per kilowatt hour for power delivered to their homes through a microgrid built in 2009. The company in charge of supplying the power — a combination of wind, solar and diesel — says all of the students in the village school passed their annual exam for the first time one year after electrification, thanks to having enough light at night to study by.

The project is just one of many seeking to solve the massive energy problem in sub-Saharan Africa, where nearly 600 million people — more than two-thirds of the population — lack access to electricity (see 'In the dark'). But it is an innovative example of public–private partnership that many observers are watching closely.

The project, a partnership of Inensus in Goslar, Germany, and Matforce, based in Dakar, Senegal, was divided into two parts: international grants were used to wire up the village, but the power generation and supply is entirely unsubsidized. Inensus uses smart meters to track customers' usage, and asks users to pay for weeks' worth of power in advance, offering a discounted rate to those who predict and commit six months ahead. That information helps to keep costs and emissions down by ensuring that the wind and solar systems can cope, and that the diesel generators are not leaned on too heavily; they typically mop up the last 10–20% of demand.

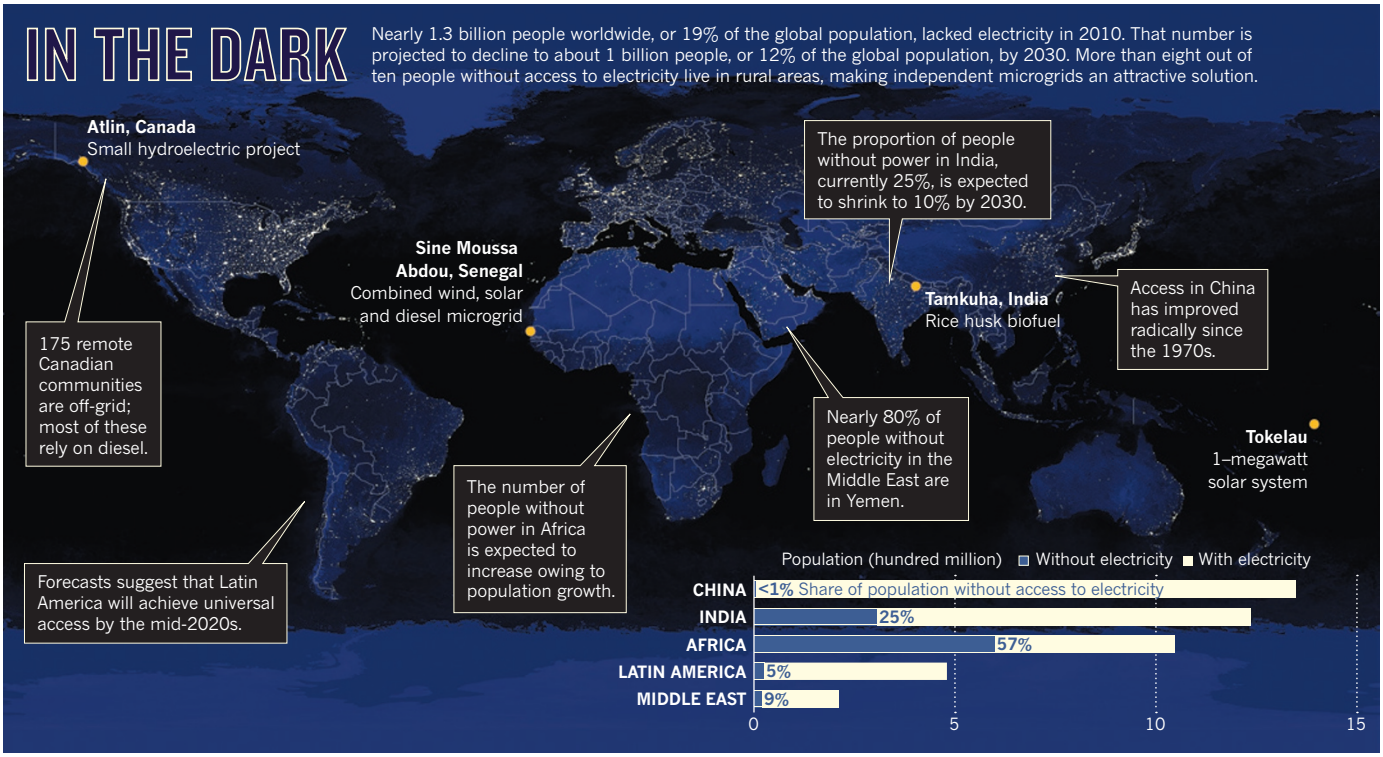

IMAGE: CRAIG MAYHEW AND ROBERT SIMMON, NASA GSFC/DATA SOURCE: IEA, WORLD ENERGY OUTLOOK 2013

Although the cost of the power is more than three times what urban customers might face, the business model is designed to promote sustainability and flexibility. Nico Peterschmidt, managing director of Inensus, foresees a scenario in which local companies own a grid and contract out the supply of power, fostering competition and freeing up companies and communities to shop around.

The company is now expanding the project into five nearby villages and has launched a larger project targeting 16 villages and 82,000 people in Tanzania. Peterschmidt says the Tanzanian government has perhaps the most advanced microgrid policy in the world, including a simple subsidy of $500 per connection for grid infrastructure, which covers the bulk of up-front costs. The biggest challenge, he says, is convincing governments to abandon fixed electricity rates that do not allow for company profit. "If we can overcome that, we can accelerate the private sector to provide energy access," he says. Kammen notes that there is generally enough commercial competition and watchdog activity to prevent price abuses, with most projects providing electricity at or below the price of diesel power.

The trick, notes Pepukaye Bardouille, an energy analyst who tracks microgrids at the International Finance Corporation in Washington DC, is to balance a nation's desire to attract profitable industry with the wish for their poorest people to get electricity. "Are we trying to promote commercially viable businesses? Or are we trying to promote access at any cost?" she asks. "Sometimes those two do not overlap."

Dean Cooper, an energy-finance specialist at the United Nations Environment Programme (UNEP) in Paris, says that UNEP is working on microgrid demonstrations in different countries to determine which policies and models work best. At present, it is too early to say which will win out. "All of the business models can be scaled up on paper," says Bardouille. "In practice, it is harder to deliver."

ATLIN, CANADA

For years, the only source of power in Atlin, an old mining town of some 400 people in the northwest corner of British Columbia, was diesel generators. The steady drone and smelly fumes were a constant reminder that money was going up in smoke, and members of the Taku River Tlingit First Nation, who make up 25% of the town's population, were determined to find an alternative. After experimenting with a wind turbine, which buckled under ice and wind in the winter of 2002–03, the tribal band settled on a small hydroelectric project. With $15 million from grants, community funds and loans, the Atlin hydroelectric project began generating 2.1 megawatts of power on 1 April 2009.

Atlin is enjoying the benefits. Eliminating diesel prevented more than 5,000 tonnes of greenhouse-gas emissions last year. And, because the First Nation owns the hydroelectric station, the money that residents pay for power stays at home. "We are paying our loans, but there's a little bit extra that is benefiting the community," says Stuart Simpson, general manager of the Atlin Tlingit Development Corporation.

There are 175 aboriginal or northern off-grid communities in Canada, most of which rely on diesel. The Taku River Tlingit First Nation was one of the first to switch to home-owned hydropower, and others are looking to follow.

A new wave of small-scale hydroelectric development aiming to supply both off-grid and on-grid energy in British Columbia has spurred controversy about the potential ecological impacts of such projects. The Vancouver-based Wilderness Committee, for one, has voiced concerns about possible disturbances to grizzly bear habitat and salmon-bearing rivers. But the actual effects are hard to tease out. A review released in January by the Pacific Salmon Foundation, a conservation organization in Vancouver, found no conclusive evidence about effects on fish.

Nigel Protter, executive director of the BC Sustainable Energy Association, says modern hydroelectric projects can, if well-conceived and implemented, improve the local ecosystem; the Atlin project, for example, built a fish ladder to help graylings get around the small dam, and Simpson says that fish counts have increased. The problem, Protter says, is that many rural communities in the developed world want more power than their small rivers can provide without the construction of dams to store up water. "Storage often creates additional environmental and social impacts."

Atlin has all the power it needs for now; it is even considering expanding its project to tie into the main electric grid and to export power to the northern Yukon territory. "In 20 years, when we have this bank loan paid off, we'll have a couple million coming into the community each year," Simpson says. "This is really about our grandkids." ■

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