

THE RACE TO SOLAR POWER AFRICA

Bill McKibben, a former New Yorker staff writer, is the founder of the grassroots climate campaign 350.org and the Schumann Distinguished Scholar in environmental studies at Middlebury College.

The cacao-farming community of Daban, in Ghana, is seven degrees north of the equator, and it's always hot. In May, I met with several elders there to talk about the electricity that had come to the town a few months earlier, when an American startup installed a solar microgrid nearby. Daban could now safely store the vaccine for yellow fever; residents could charge their cell phones at home rather than walking to a bigger town to do it. As we talked, one of the old men handed me a small plastic bag of water, the kind street vendors sell across West Africa—you just bite off a corner and drink. The water was ice-cold and refreshing, but it took me an embarrassingly long moment to understand the pleasure with which he offered it: cold water was now available in this hot place. There was enough power to run a couple of refrigerators, and so coldness was, for the first time, a possibility.

I'd come to Daban to learn about the boom in solar power in sub-Saharan Africa. The spread of cell phones in the region has made it possible for residents to pay daily or weekly bills using mobile money, and now the hope is that, just as cell phones bypassed the network of telephone lines, solar panels will enable many rural consumers to bypass the electric grid. From Ghana, I travelled to Ivory Coast, and then to Tanzania, and along the way I encountered a variety of new solar ventures, most of them American-led. Some, such as Ghana's Black Star Energy, which had electrified Daban, install solar microgrids, small-scale versions of the giant grid Americans are familiar with. Others, such as Off-Grid Electric, in Tanzania and Ivory Coast, market home-based solar systems that run on a panel installed on each individual house. These home-based systems can't produce enough current for a fridge, but they can supply each home with a few lights, a mobile-phone charger, and, if the household can afford it, a small, super-efficient flat-screen TV.

In another farming town, in Ivory Coast, I talked to a man named Abou Traoré, who put his television out in a courtyard most nights, so that neighbors could come by to watch. He said that they tuned in for soccer matches—the village tilts Liverpool, but has a large pocket of Manchester United supporters. What else did he watch? Traoré considered. "I like the National Geographic channel," he replied—that is, the broadcast arm of the institution that became famous showing Westerners pictures of remote parts of Africa.

There are about as many people living without electricity today as there were when Thomas Edison lit his first light bulb. More than half are in sub-Saharan Africa. Europe and the Americas are almost fully electrified, and Asia is quickly catching up, but the absolute number of Africans without power remains steady. A World Bank report, released in May, predicted that, given current trends, there could still be half a billion people in sub-Saharan Africa without power by 2040. Even those with electricity can't rely on it: the report noted that in Tanzania power outages were so common in 2013 that they cost businesses fifteen per cent of their annual sales. Ghanaians call their flickering power *dum/sor*, or "off/on." Vivian Tsadzi, a businesswoman who lives not far from the Akosombo Dam, which provides about a third of the nation's power, said that most of the time "it's dum dum dum dum." The dam's head of hydropower generation, Kwesi Amoako, who retired last year, told me that he is proud of the

structure, which created the world's largest man-made lake. But there isn't an easy way to increase the country's hydropower capacity, and drought, caused by climate change, has made the system inconsistent, meaning that Ghana will have to look elsewhere for electricity. "I've always had the feeling that one of the main thrusts should be domestic solar," Amoako said. "And I think we should put the off-grid stuff first, because the consumer wants it so badly." Electrifying Africa is one of the largest development challenges on earth. Until recently, most people assumed that the continent would electrify in the same manner as the rest of the globe. "The belief was, you'd eventually build the U.S. grid here," Xavier Helgesen, the American co-founder and C.E.O. of Off-Grid Electric, told me. "But the U.S. is the richest country on earth, and it wasn't fully electrified until the nineteen-forties, and that was in an era of cheap copper for wires, cheap timber for poles, cheap coal, and cheap capital. None of that is so cheap anymore, at least not over here."

"I do want a threesome, just not with you."

Solar electricity, on the other hand, has become inexpensive, in part because the price of solar panels has fallen at the same time that the efficiency of light bulbs and appliances has dramatically increased. In 2009, a single compact fluorescent bulb and a lead-acid battery cost about forty dollars; now, using L.E.D. bulbs and lithium-ion batteries, you can get four times as much light for the same price. In 2009, a radio, a mobile-phone charger, and a solar system big enough to provide four hours of light and television a day would have cost a Kenyan a thousand dollars; now it's three hundred and fifty dollars.

President Trump has derided renewable energy as "really just an expensive way of making the tree huggers feel good about themselves." But many Western entrepreneurs see solar power in Africa as a chance to reach a large market and make a substantial profit. This is a nascent industry, which, at the moment, represents a small percentage of the electrification in the region, and is mostly in rural areas. There's plenty of uncertainty about its future, and no guarantee that it will spread at the pace of cell phones. Still, in the past eighteen months, these businesses have brought electricity to hundreds of thousands of consumers—many of them in places that the grid failed to reach, despite a hundred-year head start. Funding, much of it from private investors based in Silicon Valley or Europe, is flowing into this sector—more than two hundred million dollars in venture capital last year, up from nineteen million in 2013—and companies are rapidly expanding their operations with the new money. M-Kopa, an American startup that launched in Kenya, in 2011, now has half a million pay-as-you-go solar customers; d.light, a competitor with offices in California, Kenya, China, and India, says that it is adding eight hundred new households a day. Nicole Poindexter, the founder and C.E.O. of Black Star, told me that every million dollars the company raises in venture capital delivers power to seven thousand people. She expects Black Star to be profitable within the next three years.

Like many of the American entrepreneurs I met in Africa, Poindexter has a background in finance. A graduate of Harvard Business School, she worked as a derivatives trader before leading business development at Opower, a software platform for utilities customers that was acquired by Oracle last year. (Unlike many of these entrepreneurs, who tend to skew white and male, Poindexter is African-American.) She decided to start the company in 2015, after she began to learn about energy poverty. She recalled watching TV coverage of the Ebola epidemic in Liberia. "There was a lot of coughing in the background, and I was thinking, 'That's someone with Ebola,'" she said. "But it wasn't. It was from the smoke in the room from the fire." Last

year, in the Ghanaian community of Kofihuirom, one of the first towns that Black Star served, the company erected twenty-two solar panels. Today, the local clinic no longer has to deliver babies by flashlight. The town chief, Nana Kwaku Appiah, said that he was so excited that he initially left his lights on inside all night. “Our relatives from the city used to not come here to visit,” he said. “Now they do.”

When I visited the Tanzanian headquarters of Off-Grid Electric, in the city of Arusha, the atmosphere was reminiscent of Palo Alto or Mountain View, with standing desks and glassed-in conference rooms for impromptu meetings. Erick Donasian, the company’s head of service in Tanzania, grew up in a powerless house three miles from the office and joined the company in 2013; he said that, along with his enthusiasm for the company’s goals, one attraction of working there is that it is far less formal than many Tanzanian businesses, where “you have to tuck your shirt in, which I hate the most.” Off-Grid’s Silicon Valley influence was clearest in the T-shirt Helgesen wore. It read “Make something people want,” and sported the logo for Y Combinator, Silicon Valley’s most famous incubator, where Helgesen’s wife had recently developed a bartering app.

Helgesen, who is thirty-eight years old and lanky, with hair that he regularly brushes out of his eyes, grew up in Silver Bay, Minnesota, a small town on the shore of Lake Superior. At fourteen, he came up with the idea of leasing the municipal mini-golf course for a summer, and tripled revenues by offering season passes and putting on special promotions for visiting hockey teams. As a sophomore at Notre Dame, in 1999, he set up a Web site that posted the college’s freshman register online, so that, as he put it, “you’d actually know who that cute girl you saw in anthro class was.” Helgesen started similar sites at other colleges, but, he told me, “I wasn’t as good a programmer as Zuckerberg. Even if I’d gotten it completely right, it would have been more Friendster than Facebook.” His first major company, Better World Books, founded in 2002, took the model of charity used-book drives and moved it online. It’s now one of the biggest sellers of used books on Amazon, and has helped raise twenty-five million dollars for literacy organizations, including Books for Africa.

“Admit it, we’re lost.”

Helgesen made his first trip to Tanzania in 2006, to visit recipients of Better World’s funding and to go on safari. “I was staying at a fancy lodge near Kilimanjaro, and I remember thinking, How do things really work around here?” Helgesen said. He paid a local man to take him to the nearest village. “I was peppering him with questions: ‘Do young people go to the city?’ ‘How much does coffee sell for?’ ” The experience, he said, “flipped my mind-set from ‘People in Africa are poor and they need our help and our donated books’ to ‘This is what an emerging economy looks like. This is young people, this is entrepreneurialism, this is where growth will be.’ ” During a second trip to Africa, he went scuba diving in Lake Malawi (“to see the cichlid fish, which keep their babies in their mouths”), and was invited to dinner by his scuba instructor. “It was a decent-sized town, maybe twenty thousand people, but absolutely no electricity,” Helgesen said. “It was all narrow alleys—they were bustling, but they were pitch-black.”

In 2010, Helgesen won a Skoll Scholarship to Oxford, for M.B.A. students seeking “entrepreneurial solutions for urgent social and environmental challenges,” and spent the year researching the renewables market. He found two like-minded business partners, and, in 2012, they set up shop in Arusha. At first, they planned to build solar microgrids to power cell-phone

towers and sell the excess electricity to locals, but, Helgesen said, “it became clear that that was a pretty expensive way to go.” So they visited customers in their homes to ask them what they wanted. “Those conversations were the smartest thing we ever did,” Helgesen said. “I remember this one customer, she had a baby, and she would keep the kerosene lamp on low all night, as a night-light. It was costing thirty dollars a month in kerosene. And I was, like, Wow, for thirty dollars a month I could do a lot better.”

Helgesen decided to “start with the customer, and the price point they could pay, and build the business behind that.” Matt Schiller, the thirty-two-year-old vice-president of business operations, said that, in some ways, it is an easy sell. “If we talk to a hundred customers, not one says, ‘I’d rather have kerosene,’ ” he told me. “Not one says, ‘I’d like the warm glow of the kerosene lights.’ In fact, when we were designing the L.E.D.s, we focus-grouped lights. And the engineers assumed they’d want a warmer light, because that’s what they were used to. But, no, they picked the bluest, hardest light you can imagine. That’s modernity. That’s clean.”

There were solar panels in sub-Saharan Africa before companies like Off-Grid arrived, but customers generally had to pay for them up front, a forbidding prospect for many. “Cost is important to the customer at the bottom, but risk is even more important,” Helgesen told me. “A bad decision when you’re that poor can mean your kids don’t eat or go to school, which is why people tend to be conservative. And which is why kerosene was winning. There was no risk. You could buy it a tiny bit at a time.”

Off-Grid, like several of its competitors, finances the panels, so that people can pay the same small monthly amounts they were paying for kerosene. Customers in Tanzania put down about thirteen dollars to buy Off-Grid’s cheapest starter kit: a panel, a battery, a few L.E.D. lights, a phone charger, and a radio. Then they pay about eight dollars a month for three years, after which they own the products outright. The most popular system adds a few more lights and a flat-screen TV, for a higher down payment and about twice the monthly price. Customers pay their bill by phone; if they don’t pay, the system stops working, and after a while it is repossessed. That scenario, it turns out, is uncommon: less than two per cent of the loans in Tanzania have gone bad.

Despite Off-Grid’s Silicon Valley vibe, it faces challenges unfamiliar to software companies. Aidan Leonard, Off-Grid’s Arusha-based general counsel, told me that the company “requires a lot of people walking around selling things and installing things and fixing things. There’s a lot of hardware—someone’s got a physical box in their house, and a panel on the roof, and they have to pay for it on a monthly basis.” Poindexter, of Black Star, put the problem more bluntly. “We’re a utility company,” she told me, and utilities are a difficult business.

In America, utilities are burdened with infrastructure, such as the endless poles and wires that come down in storms. Off-Grid doesn’t have to worry about poles, and the wires only run a few feet, from panel to battery to appliance. Still, the company is working with technology that is brand-new and needs to be made cheaply in order to be affordable. When solar energy first came to Africa, it was expensive and unreliable. Arne Jacobson, a professor of environmental-resources engineering at Humboldt State University, in California, is a couple of decades older than most of the entrepreneurs I met in Africa. He got his doctorate studying the first generation of home solar in Kenya, in the late nineteen-nineties. “In Kenya, I was trying to understand the quality of the panels that had started to flood the market,” he said. Much of the technology had “big troubles. Chinese panels, panels from the U.K., all this low-quality junk

coming in. Later, L.E.D.s that failed in hours or days instead of lasting thousands of hours, as they should. People's first experiences were often really bad."

Jacobson has spent his career in renewable energy; he helped build the world's first street-legal hydrogen-fuel-cell vehicle, in 1998. He now runs Humboldt's Schatz Energy Research Center. ("You want to know why a lot of early solar research happened in Humboldt?" he asked me. "Because there were a lot of back-to-the-land types here, and they had cash because they were growing dope.") After seeing the unpredictability of solar technology, he created, in 2007, what he calls a "de facto consumer-protection bureau for this nascent industry." The program, Lighting Global, which is run under the umbrella of the World Bank Group, tests and certifies panels, bulbs, and appliances to make sure that they work as promised. Jacobson credits this innovation with making investors more willing to put their money into companies such as Off-Grid, which has now raised more than fifty-five million dollars. His main testing lab is in Shenzhen, China, near most of the solar-panel manufacturers. He also has facilities in Nairobi, New Delhi, and Addis Ababa, and some of the work is still done in the basement of his building at Humboldt, where there's an "integrating sphere" for measuring light output from a bulb, and a machine that switches radios on and off to see if they'll eventually break.

Because many of Off-Grid's potential customers have experience with bad products, or know someone who has, the company takes extra steps to build trust with its clients. After an Off-Grid installer shows up on his motorbike, he opens the product carton with great solemnity; in an Ivorian village, I watched along with seventeen neighbors, who nodded as the young man held up each component, one by one. He then climbed onto the roof of the house, nailed on a solar panel about the size of a placemat, and used a crowbar to lift up the corrugated-tin roof to run the wire inside. He screwed the battery box to the cement-block wall and walked the customer through the process of switching lights on and off several times, something the man had never done before. The company also offers a service guarantee: as long as customers are making their payments, they can call a number on the box and a repairman will arrive within three days. These LightRiders, as the company calls them, are trained to trouble-shoot small problems. They travel by motorcycle, and if they can't make repairs easily they replace the system with a new one and haul the old unit back to headquarters.

This sales-and-installation system presents some engineering challenges. When the company expanded into Ivory Coast, last year, it had to redesign its packaging to fit on the smaller motorcycles used there. It also runs into problems coordinating coverage across a vast area where most houses don't have conventional addresses. "We had to build our own internal software to make it possible," Kim Schreiber, who runs Off-Grid's marketing operations in Africa, said. "We optimize, via G.P.S. coordinates, the best routes for our riders to take. The LightRider turns on his phone every morning, and he has a list of his tasks for the day, so he knows what parts to take with him."

Solar companies also contend with the complexity of the mobile-payment systems. In Ghana, where many customers don't use mobile money, Poindexter's Black Star team instead sells scratch cards from kiosks, which give customers a code they need to enter on their meter box to top up their account. Off-Grid delivers these codes over the phone, but the company still needs a call center, manned by fifteen people, to help customers with the mechanics of paying. Nena Sanderson, who runs Off-Grid's Tanzanian operation, showed me the steps entailed in paying a bill through a ubiquitous mobile-money system called M-Pesa. There are ten screens,

and the process ends with the input of a sixteen-digit code. “And I have a smartphone,” she said. “Now, imagine a feature phone, and imagine you may not know how to read, and the screen is a lot smaller, and it’s probably scratched up. Mobile money is a great enabler, but it’s not frictionless.” One of Off-Grid’s competitors, PEGAfrica, has printed the whole sequence on a wristband, which it gives to customers.

Because one of the biggest obstacles to the growth of solar power in the region is the lack of available cash, many of these companies are essentially banks as well as utilities, providing loans to customers who may have no credit history. That can make it hard to figure out what to charge people. “What you see in this space is at least eight to ten decent-sized pay-as-you-go solar companies, all trying to parse through what the actual end price to the customer really is,” Peter Bladin, who spent many years in leadership roles at Microsoft and now invests in several of these firms, told me. Bladin first started studying distributed solar—solar electricity produced near where it is used—in Bangladesh, where the Nobel Prize winner Muhammad Yunus used his Grameen microcredit network to finance and distribute panels and batteries. Lacking that established financial architecture, companies in sub-Saharan Africa are constantly experimenting with different plans: Off-Grid began by offering ten-year leases, but found that customers wanted to own their systems more quickly, and so the payments are now spread out over three years. PEGAfrica customers buy their system in twelve months, but the company gives them hospitalization insurance as a bonus. Black Star is a true utility: the customers in the communities where it builds microgrids will always pay bills, but the charges start at only two dollars a month. (The business model depends on customers steadily increasing the amount of energy they buy, as they move from powering televisions to powering small businesses.)

Companies like Burro—a Ghanaian outfit launched by Whit Alexander, the Seattle entrepreneur who founded Cranium games—sell lamps and chargers and panels outright, saving customers credit fees but limiting the number of people who can afford the products. “I don’t want to sit so close to the stage that the actors can see my eyes glaze over.”

This uncertainty about the most practical financial model reflects the fact that in sub-Saharan Africa there is a great deal of economic diversity, both between countries and within them. One morning, I found myself walking down a line of houses in the Arushan suburb of Morombo. At the first house, a two-room cinder-block structure with a broken piece of mirror on one wall, a woman talked with me as we sat on the floor. The home represented a big step up for her, she said—she and her husband had rented a place for years, until they were able to buy this plot of land and build this house. She had a solar lantern the size of a hockey puck in her courtyard, soaking up rays. (Aid groups have distributed more than a million of these little lamps across the continent.) She assured me that she planned to get a larger solar system soon, but, for many of Africa’s poorest people, buying a lantern is the only possible step toward electrification.

Next door, a twenty-six-year-old student named Nehemiah Klimba shared a more solidly built house with his mother. It had a corrugated-iron roof on a truss that let hot air escape, and we sat on a sofa. Klimba said that, as soon as he finished paying off the windows, he was going to electrify. He and his mother were already spending fifteen dollars a month on kerosene and another four dollars charging their cell phones at a local store, so they knew they’d be able to afford the twenty dollars a month for a solar system with a TV.

One door down was the fanciest house I'd seen in weeks. It belonged to a soldier who worked as a U.N. peacekeeper, and the floors were made of polished stone. There was an Off-Grid solar system on the roof, but it was providing only backup power. The owner had paid a hefty fee to connect to the local electric grid, so he faced none of the limitations of a battery replenished by the sun. In his living room, he had a huge TV and speakers; a stainless-steel Samsung refrigerator gleamed in the kitchen.

"This is how the solar revolution happens—one hot sales meeting at a time," Off-Grid's Kim Schreiber whispered to me as we watched one of the company's salesmen, an Ivorian named Seko Serge Lewis, at work. We were visiting the village of Grand Zattray with Off-Grid's Ivory Coast sales director, Max-Marc Fossouo. A couple of dogs tussled nearby; a motorbike rolled past with six people on board. In the courtyard next to us, a woman was doing the day's laundry in a bucket with a washboard. Her husband listened to the sales pitch from Lewis, who was showing him pictures on his cell phone of other customers in the village.

"That's to build up trust," Fossouo said. He'd been providing a play-by-play throughout the hour-long sales call. "This customer is on a big fence," he said. "He's stuck in the trust place. And I'm pretty sure the decision-maker is over there washing the clothes anyway." Fossouo was born in Cameroon and went to school in Paris. In his twenties, he spent seven summers in the U.S., selling books for Southwestern Publishing, a Nashville-based titan of door-to-door marketing. (Rick Perry is another company alum; so is Kenneth Starr.) "I did L.A. for years," he told me. "Hi, my name is Max. I'm a crazy college student from France, and I'm helping families with their kids' education. I've been talking to your neighbors A, B, and C, and I'd like to talk to you. Do you have a place where I can come in and sit down?" All selling, he said, is the same: "It starts with a person understanding they have a problem. Someone might live in the dark but not understand that it's a problem. So you have to show them. And then you have to create a sense of urgency to spend the money to solve the problem now."

The man turned down Lewis's pitch. He was worried that he wouldn't be able to make the monthly payments in the lean stretch before the next cacao harvest. "That's crap," Fossouo whispered, pointing again to the man's wife. "He loves this woman, he can move the world for her." When we went to the next house, Fossouo took over. This prospect was a farmer and schoolteacher, and they talked in his classroom, which had a few low desks with shards of slate on top. Fossouo had the man catalogue everything that he was spending on energy: money for kerosene, flashlight batteries, even the gas for the scooter that he borrowed when he needed to charge his phone. Then Fossouo showed him what he had to offer: a radio and four lights, each with a dimmer switch. "Where would you put the lamp?" he asked. "In front of the door? Of course! And the big light in the middle of the room, so when you have a party everyone could see. Now, tell me, if you went to the market to buy all of this, how much would it cost?" Fossouo tried angle after angle. "You have to think big here," he said. "When I talked to your chief, he said, 'Don't think small.' If your kid could see the news on TV, he might say, 'I, too, could be President.'"

"This is great," the man said. "I know you're trying to help us. I just don't have the money. Life is hard, things are expensive. Sometimes we're hungry."

Fossouo nodded. "What if I gave you a way to pay for it?" he asked. "So the dollar wouldn't even come from your pocket? If you get a system, people will pay you to charge their phones. Or, if you had a TV, you could charge people to come watch the football games."

“I couldn’t charge a person for coming in to watch a game,” the man said. “We’re all one big family. If someone is wealthy enough to have a TV, everyone is welcome to it.”

“I just want to say that I appreciate the way you’re blamed for everything.”

The hour ended without a sale, but Fossouo wasn’t worried. “It takes two or three approaches on average,” he said. “You always have to leave the person in a good place, where he loves you stopping by. This guy wants to finish building his house right now—his house is heavy on him—but it won’t be long.” As we talked, the first prospect came over, asking for a leaflet and a phone number. His wife, he said, was very interested.

The arrival of electricity is hard for today’s Westerners to imagine. Light means differences in sleeping and eating patterns and an increased sense of safety. I talked with one Tanzanian near Arusha who had traded in a kerosene lamp for five Off-Grid bulbs, including a security light outside his door that went on automatically when it got dark. “Crime is here,” he said, “but also dangerous animals. Especially snakes. So it’s good to have lights.” Everywhere I went, I met parents who said that their children could study at night. “You can feel the effects with their grades now at school,” one Ivorian father said. Several town chiefs told me that they hoped to get classroom computers, and one planned to mechanize the well so that townspeople would no longer need to pump water by hand. Farmers in West Africa were getting daily weather reports from Farmerline, a Ghanaian information service that uses G.P.S. to customize the forecasts. “If a farmer puts fertilizer on the field and then it rains, he loses the fertilizer—it washes away,” Alloysius Attah, a young Ghanaian entrepreneur who co-founded the service, told me. “And the farmers say they can’t tell the rain anymore. My auntie could read the clouds, the birds flying by, but the usual rainfall pattern has shifted.”

“Our killer app is definitely the television,” Off-Grid’s Schreiber said. “If the twenty-four-inch is out of stock, lots of people won’t buy.” Wandering through newly electrified towns, I saw teen-agers watching action movies. Black Star’s Poindexter told me, “There was a kid in town that I liked, Samuel, and when I came back after the power was turned on his arm was in a cast. He’d watched a karate show on TV, and he and his friends were playing it, and he broke his arm. I was horrified—I was, like, society is not prepared for this. And then I remembered that I did the same thing after I watched ‘Popeye’ as a kid. I ran right into the hedge and had to get twenty stitches. That’s kids and TV.”

In Daban, after I asked what the most popular program was, everyone began laughing and nodding. “‘Kumkum!’” people shouted. “Kumkum Bhagya,” an Indian soap opera set in a marriage hall and loosely based on Jane Austen’s “Sense and Sensibility,” airs every night from seven-thirty to eight-thirty, during which time village life comes to a standstill. “All the chiefs have advocated for everyone to watch, because it’s about how relationships are built,” the local chief, Nana Oti Awere, said. Of course, the changes brought about by electrification will affect local communities in unpredictable ways that will play out over many years. One mother I spoke to explained that the TV “keeps the children at home at night, instead of roaming around.” The Ivorian farmer who told me about the effects on his children’s grades went on to say, “In the old time, you had to go outside and talk. Now my neighbor has his TV, I have my TV, and we stay inside.”

A decade ago, most experts would have predicted that foreign aid, rather than venture capital, would play a central role in bringing power to sub-Saharan Africa. Off-Grid Electric has been funded by sources including Tesla and Paul Allen’s venture fund, Vulcan. Allen, one of the

world's richest men, is worth twenty billion dollars, or roughly half of the G.D.P. of Tanzania, a country of almost fifty-four million people. Should he be able to make yet more money off the electrification of African huts? There's more than a whiff of colonialism about the rush of Westerners and Western money into Africa. As Attah, the young Ghanaian who helped found Farmerline, put it, "There are a lot of Ivy Leaguers coming to Africa to say, 'I can solve this problem, snap, snap, snap.' They're doing good work, but little investment goes to community leaders who are doing the same work on the ground."

"I don't know what that is, either—it could be the Olsen twins."

The Westerners I spoke to, though they pledged to hire more local executives, didn't think that the drive to help was incompatible with the desire to make money. As Poindexter put it, "There is a level of responsibility that I feel, and that I think any appropriate investor needs to have, about extraction versus contribution. I am not willing to be an extractive capitalist here, but I think that capitalism has an extremely important role to play in these communities."

Helgesen—who, despite his occasional oblivious tech-dudishness, spends most of his time in very remote places trying to provide power—is unapologetic about his company's funding sources. Billionaires, he says, have the capital to make companies grow fast enough to matter. "Paul Allen didn't invest because he thought it was the easiest way to make more money," Helgesen said. "I got an awful lot of 'no's along the way from people who wanted easier money." In any event, it's not clear that other sources of funding are available, at least from the U.S.: Trump, pulling out of the Paris climate accord earlier this month, said that the country would not meet its pledge to help poor nations develop renewable energy, dismissing the plan as "yet another scheme to redistribute wealth out of the United States through the so-called Green Climate Fund—nice name."

Even when aid agencies are well funded, they haven't always delivered. Over the last decade, a strong critique of aid, ranging from William Easterly's "The White Man's Burden" to Dambisa Moyo's "Dead Aid," has laid much of the blame for Africa's continued underdevelopment on the weaknesses of sweeping programs planned from afar. Still, aid agencies and global-development banks have a useful role to play in the energy transition. It will be years before it makes financial sense for solar companies to expand to the most remote and challenging regions of the continent. As new companies launch, they will need an infusion of what Helgesen calls "ultra-high-risk capital." Private investors will supply it, he says, "but they want forty per cent of your company in return, which makes it hard to raise capital later on, because you've already sold off such a big chunk." Some aid agencies have funded private ventures in the early stages, to help them get off the ground or reach new geographic areas. U.S.A.I.D. gave Off-Grid five million dollars toward its early costs, and, over the past few years, a Dutch development agency has given the company several hundred thousand euros as it has extended into the impoverished lakes region of Tanzania, where it otherwise wouldn't have been profitable to go. Currency risks pose another problem: Poindexter told me that when she builds a Ghanaian microgrid she has invested in an asset with a twenty-year life span in a country where inflation is highly unpredictable. "We just had an election in the U.S. with huge consequences for policy," she said. "But over here every election is potentially like that." And, like anywhere in the world, national governments can make things easier by establishing clear policies. Rwanda's leaders, for instance, specified the regions in which the rapidly developing country planned to extend its grid, thereby delineating where solar would be needed most.

“African leaders used to think solar was being pushed on them,” Clare Sierawski, who works on renewable energy with the U.S. Trade and Development Agency in Accra, said. “But now they all want solar. It’s a confluence of things. Mostly, it’s getting cheaper. And governments were tuned in to it by the Paris accord.” Ananth Chikkatur, who runs a U.S.A.I.D. project in the city, had just returned from taking thirteen high-ranking Ghanaians on a trip to study solar power in California. “Renewable energy should not be considered an alternative technology,” he said. “It’s becoming a conventional technology now.” Rwanda is not the only nation expanding its grid, and many countries are turning to large solar farms to generate power. Burkina Faso, for instance, has plans for solar arrays across its desert regions.

Distributed generation, however, is especially essential in rural areas, and it is growing fast—maybe, according to some observers, too fast. The investor Peter Bladin told me that the push for quick returns on investment could lead some companies to try to “squeeze more out of poor households” and warned about “mission drift, trying to make money off the backs of the poor in a dubious way.” Earlier this year, three principals from the impact-investment firm CeniARTH, which had put money into Off-Grid and similar companies, said that it was backing out of the industry for the time being. In an open letter, they wrote that the hype of venture capitalists and the lack of government regulation “puts consumers at risk and places a great deal of responsibility on vendors to self-police.” The gush of money, they cautioned, “may be too much, too fast for a sector that still has not fully solved core business model issues and may struggle under the high growth expectations and misaligned incentives of many venture capitalists.” Helgesen, unsurprisingly, disagreed with their analysis of investor over-exuberance. “It’s like looking at a Palm Pilot and saying, ‘This is not so great,’ ” he said. “Or even an iPhone 1. The iPhone 1 was a necessary step to the iPhone 7. People who have raised real money have not raised it on the premise that we’ll be selling the same stuff in ten years.” But he wasn’t waiting for the technology to mature. “We have to think about the future, and we have to sell something people want today,” he said.

Most customers I met had little interest in the fact that their power came from the sun, or that it was environmentally friendly. Since these communities weren’t using power previously, their solar panels fight climate change only in the sense that they decrease pressure to build power plants that consume fossil fuel. But some observers hope that the experience in Africa—which today has more off-the-grid solar homes than the U.S.—could help drive transformation elsewhere. Already, a few dozen American cities have pledged to become one-hundred-per-cent renewable. (Pittsburgh did so the day after Trump held up its theoretically beleaguered citizens as a reason for leaving the climate accord.) The U.S. has already sunk a fortune into building its electric grid, and it may seem far-fetched to think that users will disconnect from it entirely. But, as Helgesen told me, “As batteries get better, it’s going to be a lot more realistic for people to stop depending on their utility.” He thinks that, in an ideal world, technological change could lead to cultural change. “The average American has no concept of electrical constraint,” he said. “If we accept some modest restrictions on our power availability, we can go off-grid very quickly.”

For many people in the countries I visited, solar power is creating a new hope: for electric fans. When I was there, Off-Grid Electric was expanding from the relatively cool highlands around Mt. Kilimanjaro to the scorching, humid lowlands of West Africa, and in every village we visited the message was the same: The TV is great, the light bulb is great, but can I please have

a fan? Many homes are poorly ventilated; windows are expensive, and can attract burglars. Fans, however, draw a comparatively large amount of current, threatening to quickly drain the battery that a solar panel has spent the day filling. And, unlike light bulbs or televisions, fans have moving parts that easily break. “Our customers tend to make heavy use of their equipment,” Off-Grid’s Schreiber said. Still, she promised one village after another that fans were coming soon.

Shea Hughes, Off-Grid’s product manager, is one of the employees charged with delivering on that promise. Hughes told me that he hopes to someday make Off-Grid’s product powerful enough to perform industrial tasks: pumping water for irrigation, milling cacao, and so on. “I’m confident solar is capable of doing that,” he said. “You just add more panels and you get to the power requirements you need. And as the price drops, well . . .” He had recently been to a consumer-electronics fair in China. “I was amazed to see the prices,” he said.

For the moment, though, a workable fan would be nice. “We’d always thought a fan would take too much power for the current systems we’re selling,” Hughes said. “But the people in Ivory Coast were so insistent that we went back and looked at it.” Because of the emerging market for super-efficient appliances, in the U.S. and elsewhere, some manufacturers had a product that, as long as you kept it set to medium, drew only eight and a half watts. (The standard incandescent light bulb that hung in American hallways for generations drew sixty.) “We’ve told the manufacturer to eliminate the high-speed option,” Hughes said. “Now medium is high. And in our tests people are satisfied with the air speed. But they say the battery tends to run out at 3 or 4 a.m., and they typically sleep till 6 a.m. So it’s not perfect, but it’s getting there.” ♦

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Bill McKibben, a former New Yorker staff writer, is the founder of the grassroots climate campaign 350.org and the Schumann Distinguished Scholar in environmental studies at Middlebury College.