increased students' performance. (One independent evaluation found that students learning with EVS scored twice as high on reading comprehension tests and mastered writing and mathematics three times faster than students taught by the rote method.) By 1985 de Souza had persuaded Bombay's municipal school board to introduce EVS in 1,700 schools through a pilot program. Within three years, almost a million students were learning with her methods. By the end of the 1980s, the Indian government had incorporated EVS into its national curriculum, making it India's official standard of instruction in grades one through three.[6]

Today, more than twenty years later, de Souza is still the driving force behind Parisar Asha. In the intervening decades, her work has influenced a generation of teachers and curriculum developers in India. Each year she improves her curriculum, extends her work to more cities, and looks for ways to adapt the methods to different environments, such as rural and tribal areas.

3.

The Light in My Head Went On

Fábio Rosa, Brazil: Rural Electrification

In 1982, at the same time that Gloria de Souza was launching her Environmental Studies curriculum in India, Fábio Rosa, twenty-two, a recent graduate in agronomic engineering, was trying to deliver electricity to poor people in Brazil. It all began when Rosa received a phone call from one of his university classmates inviting him to come to Palmares do Sul, a rural municipality in Brazil's southernmost state, Rio Grande do Sul, an area famous for its beautiful grassy plains—the pampas—inhabited by gaúchos, Brazil's cowboys.

Rosa didn't know that his friend's father, Ney Azevedo, had just been elected mayor of Palmares. Azevedo had previously been the technical director at the state's rice institute, and one evening, over dinner, he and Rosa got into a long conversation about the possibilities for improving life for local villagers. After listening to Rosa's ideas, Azevedo offered him the post of secretary of agriculture.

Although Rio Grande do Sul is one of Brazil's wealthiest states, Palmares was a depressed area, reminiscent of the Mississippi Delta. The municipality had recently been cobbled together. When Rosa showed up for work his first day, he found no city hall, no records, no municipal employees, not even a pickup truck. A local priest let him work out of a church. Rosa dropped off his boxes and set out to talk to the villagers.

What he heard surprised him. Politicians in Rio Grande do Sul were always talking about building roads. But when Rosa asked farmers about their priorities, nobody mentioned roads. They spoke about educating their kids and escaping poverty and holding onto their farms. They didn't want to move to the city. But unless they could find a way to boost their farm incomes, they would soon have no choice.

The primary wealth in Palmares was the irrigated rice crop. Ninety percent of the land was lowland, good only for rice production. And Rosa quickly discovered that the villagers had a big problem. Rice needs a lot of water to grow, but wealthy landowners owned most of the dams and irrigation channels, and they set the price of water high. Rosa found that small farmers were paying as much as a quarter of their production costs on water, triple the world average.

"Without water there was no production," Rosa explained. "And without production there was no wealth. The whole political situation was determined by this fact."

Looking for ideas, Rosa read a book written by a Brazilian agronomist who had traveled to Louisiana in the 1940s and documented how rice plantations were irrigated with artesian wells. It made him wonder: "Could something similar work in Palmares?" First they would have to get the water out of the ground—and the only way to do that cheaply was with electricity.

That was a problem. Among the many differences between Brazil and the United States—countries of comparable size—is that Brazil never had a government works projects comparable to the Rural Electrification Administration, the New Deal agency that brought electricity to 98 percent of U.S. farms between 1935 and 1950.

Brazil's electrification standards had been designed under a military regime to serve cities, industry, and large farms. In the 1970s, a short-lived abundance of credit for rural electrification led Brazil's utilities to rely heavily on expensive technology. The cost of providing electricity to a single rural property in the early 1980s had soared to $7,000, five to ten years' income for a poor farmer.[1]

"The electric companies install lines with excess capacity, forcing small and medium landowners to pay huge sums for power they won't use," Rosa explained. As a result, the lines weren't built. Today 25 million Brazilians have no access to electricity: no refrigeration, no lights, no computers.[2] In short, no future. That was seemingly the case in Palmares, where Rosa found that 70 percent of the rural population—about 9,000 people—had no electricity.

Watching the TV news one evening, Rosa happened on an interview with Ennio Amaral, a professor at the Federal Technical School of Pelotas, in a municipality a few hours south, who had developed an inexpensive rural electrification system. Rosa knew that as a candidate for mayor Azevedo had campaigned on the promise to bring electricity to all of Palmares. "I was committed to it," Azevedo told me, "but

I didn't know *how* to do it." So when Rosa mentioned Amaral's interview, the mayor handed him $20 and keys and said: "Take my car. Go there tomorrow."

Rosa was impressed by Amaral's approach. By contrast to conventional power distribution systems, which employ three wires ("three-phase"), Amaral employed a high-tension "monophase" current system suitable for modest energy consumption, in which a single wire carried the current through a transformer to a house and the system was grounded in the soil. Amaral further reduced costs by substituting cheaper materials for expensive ones: wood instead of cement poles, steel rather than copper wire, and steel-and-zinc conductors in lieu of aluminum ones. He used fewer poles and smaller transformers and employed ordinary people from the community as builders.

"The light in my head went on," Rosa said. "With cheap electricity, poor farmers could drop wells and irrigate their land. Then they would be free from the tyranny of water."

Fábio Rosa is an easygoing and affable person, with a disarming smile and a precise mind. He is the sort of person you would be lucky to encounter in an airport lounge while waiting an hour for a flight. That's about how long it would take him to explain the basics of rural electrification, rice farming, managed cattle grazing, the causes of landlessness, and the connection between poverty and the destruction of the environment. Afterward, you'd get on your flight and look out the window and the land below would seem more fragile and more beautiful.

Rosa's mother, Nice, was a school teacher with an irrepressibly cheerful disposition. His father, Geraldo, was a methodical thinker who managed a bank branch in Porto Alegre. Both Nice and Geraldo had grown up on farms, and Rosa's childhood tales revolved around life on the pampas. His mother's forebears had all played in a family farm orchestra, an image that enchanted Rosa. "Can you imagine?" he said to me. "A small orchestra in a farm lost in the vastness of the pampas at the end of the nineteenth century!" His father's parents had raised cattle and cultivated rice, and Rosa loved to hear the story of the 1929 market crash when cattle and rice prices plummeted, but his grandfather refused to lay off a single farmhand.

As a child, Rosa's favorite pastime was playing in his backyard with toy cows and fences, designing mini-irrigation systems and dams. Later, carrying on the musical tradition, Rosa taught himself to play guitar.

Fábio Rosa

For a number of years, he considered becoming a professional musician, but, in the end, his first love—of cows and dams and fences—won out.

Returning from Pelotas, Rosa was eager to see if Amaral's approach could be used to power an irrigation system. First, he prepared a hydrogeological survey to see if there was sufficient underground water throughout the municipality to irrigate rice. "There was water," he recalled. "It was not too deep: an average of twenty-three meters below the surface. There was enough. It was of good quality for irrigation. The door was open."

Amaral had spent a decade developing his system. It was fully operational. But state and federal energy interests had prevented him from extending it beyond a test site. "He kept running into what you might call a 'small-big' problem," Rosa explained. "What he had invented worked beautifully, but it was illegal."

In Brazil at the time, state electric companies determined technical standards. If a system didn't comply with the "norm," the company wouldn't turn the electricity on. The state electric company in Rio Grande do Sul saw no reason to change the norm. Rosa disagreed. "If the government has no money and the technical standard is expensive," he explained, "then you *have* to change the standard."

Rosa needed authorization from the state electric company to experiment with Amaral's system. For help, he turned to Ney Azevedo, who was friendly with a number of senior government officials in Rio Grande do Sul. With Azevedo's influence, Rosa was granted permission to proceed.

Ennio Amaral went to Palmares to advise Rosa. Before he left he said: "I'm sending you my best student—a really loyal guy." A few days later Ricardo de Souza Mello, an electrical technician, showed up in Palmares, and he and Rosa have worked together ever since.

Rosa got hold of an abandoned ambulance. He put in a new motor and lashed the doors with rope. That became Mello's official vehicle. The two men went to work developing a plan to spread Amaral's system to a few hundred households. Mello focused on the technical details while Rosa met with farmers. Would they help build the system? The farmers had been promised electricity many times before; they were skeptical. But they assured Rosa: If wires, poles, and transformers actually materialized, they would put them up.

Next: How to sink the wells?

The traditional woodpecker-style drills used to bore artesian wells ran on three-phase electricity, which was unavailable. But Rosa discovered that water pressure pumps, operating on diesel fuel, loosened the subsoil enough to force polyethylene tubes down to the water level. That problem was solved. However, the water pumps needed to bring the water to surface also ran on three-phase power. Rosa had no solution to that problem, but he was confident that one would present itself.

And it did. "After we dropped a few wells, the water pump solution appeared," he explained. The natural ground pressure brought the water to an average depth of four meters, shallow enough for a monophase electric pump to carry it the rest of the way to surface.

Low-cost irrigation was beginning to look like a distinct possibility.

One of the other major problems facing farmers in Palmares was "red" rice. Red rice is like a weed. Its seeds multiply quickly. If land is continually cultivated, eventually the red rice will destroy the desired rice crops. To inhibit the weed growth, small farmers cultivated only one-quarter of their land each year, leaving the remainder fallow for three years before replanting.

Rosa had a better solution. Farmers could flood the fields before planting the rice and keep them saturated while the rice grew. The soil would be deprived of oxygen, preventing red rice seeds from germinating. The trick would be to *pregerminate* the domestic rice plants in

prepared beds and transplant them to the submerged paddies. Then only the desired rice would grow.

In Palmares, this kind of rice farming, known as water seedling, had been impractical because water was so expensive. But cheap irrigation changed everything. "Using the saturation system," Rosa explained, "we could multiply the land that each farm could use by a factor of four."

He put it together like an equation: inexpensive electricity + shallow artesian wells + monophase pumps = cheap irrigation. And cheap irrigation + water seedling = more efficient land use, increased income, a rural future.

Rosa created a municipal department to train locals in the new rice farming methods and added a credit mechanism so they could take loans to prepare their land, sink wells, and pay for irrigation.

"Finally," he said, "we had a complete system."

After drafting his plan, Rosa traveled to Rio de Janeiro to present it to the Banco Nacional de Desenvolvimento Econômico e Social (BNDES), the $50 billion federal agency responsible for long-term national development funding. "I showed them the cost structure and they jumped," he recalls. "It was like selling sweets to children."

Rosa found a strong supporter in Aluysio Asti, one of BNDES's project analysts. Asti, who later nominated Rosa to Ashoka, was no fan of wishful thinking; he liked good data. Rosa had lots of it. He had charts showing farmers' expenditures, costs of materials, well capacities, expected rice yields and prices, with studies to back everything up. Based on his analysis, the bank's investment would be repaid in four years.

It was obvious to Asti that Rosa was organized and determined. What particularly impressed Asti was Rosa's initiative. "Just to have an agricultural development department in a small municipality in Rio Grande do Sul was itself an innovation," he told me. "Especially an agricultural department that actually worked with small farmers."

Rosa told Asti: "If we don't succeed with this project, the people of Palmares will find their own solution: the worst solution for everybody. They will flee to the cities."

In recent decades, like the Okies in *The Grapes of Wrath*, millions of rural Brazilians, in search of work, had abandoned their land in favor of urban shantytowns, causing massive social upheaval and sending unemployment and crime rates skyrocketing. To the extent that the Brazilian government was responding to the problem, it was

attacking the symptoms—for example, trying to resettle the landless on government-owned land, at best a short-term solution. Rosa, by contrast, was attacking the root cause. And, if he was successful, Asti saw, he would have something valuable to show the country.

Asti recommended financing for the project.

The major obstacles remaining were resistance from the state electric company, Companhia Estadual de Energia Elétrica (CEEE), and political opposition from cement and aluminum cartels. "We didn't need contractors to carry out the work," Rosa recalls. "The whole thing could be done by the community with one technician hired by the mayor's office. It was practically an autonomous system. And the state company knew that if we succeeded in Palmares, it could lead to other things."

To mobilize political support for rural electrification, Rosa met with journalists and visited mayors in neighboring municipalities, urging them to lobby the state assembly. Meanwhile, he purchased wire and contracted with two companies, which agreed to manufacture the miniature five-kilowatt-amp transformers that Amaral's system required. Mello created a schedule for installations. The farmers had agreed to supply trees from their properties for electric poles. Rosa found they could get by with three poles per kilometer, one-quarter the number that the government required. And he found a way to extend the life of the wood from three to thirty years by saturating the poles in creosote, a chemical solution. Everything was set to go when he received a letter from CEEE withdrawing permission.

Ney Azevedo immediately telephoned Jair Soares, the state governor, who called a meeting with Rosa, Azevedo, and the president of CEEE. Rosa has a vivid recollection of the encounter. As he recalls, the president of CEEE, hoping to put an end to the Palmares project, offered to cut a deal with Azevedo, promising to provide electricity to rural areas of Palmares through the conventional grid if Azevedo would abandon Rosa's project.

Rosa smiled when he recalled Azevedo's response: "Ney said to him, 'But could you do that for the whole state?' And he had to say, 'No.' Then Ney said, 'I don't sell my opinion so cheap. You have to think about this problem and try to solve it throughout the state—and throughout Brazil.'"

BNDES then informed the state government that its funding would be cut if CEEE stood in the way of the Palmares project. Not long after the meeting, the state energy minister arrived in Palmares by helicopter,

with a contract authorizing Rosa to proceed. "I remember this meeting as if it happened yesterday," Rosa told me. "I was very emotional signing this paper. I still guard it very closely. But we would have other David and Goliath battles."

As a selling point, Rosa had told the villagers that his plan could provide a household with electricity for about the price of a cow. Two years later, in 1988, he and Mello delivered on the promise: 400 rural families were hooked up to the electric grid at a cost of $400 per family, less than one-seventeenth of the government's figure of $7,000. Seventy-five percent of the farmers bought water pumps; 80 percent bought refrigerators or television sets. Others bought rice processing machines, electric lights, fences, and water heaters.

Initially most farmers were reluctant to change to water seedling, but those who did were rewarded. Incomes jumped from $50 to $80 a month to between $200 and $300 a month. For Rosa, the most compelling finding was that almost a third of the households served—130 out of 400—were people who had returned from the city because of the Palmares project. This was a striking development: It showed that, contrary to assumptions, it was possible to slow the flood of rural-to-urban migration, allowing the cities more time to absorb the millions squatting on their hillsides.

Rosa made sure that journalists and politicians heard about the Palmares project. Soon technicians were visiting from other states. "For a small municipality recently created to have visitors coming from around Brazil was something very exciting," recalled Azevedo. The government of Rio Grande do Sul asked Aluysio Asti, from BNDES, to coordinate a meeting on rural electrification so Rosa and Mello would have the opportunity to explain how the project could be expanded.

But CEEE was not ready to accept a major change to its distribution norm. "At this meeting, all the Ph.D.s and masters from the state company were on one side—and Ricardo [Mello] and I were on the other," Rosa recalled. A debate ensued. Rosa argued that a new legal distribution standard was needed. The CEEE officials countered that his results were inconclusive. "What you've done in Palmares, you won't be able to do anywhere else," they said.

After that meeting, CEEE refused to budge for almost a year. Eventually, however, the Palmares project caught the attention of Rio Grande do Sul's newly elected governor, Pedro Simon, who had vowed to expand rural electrification in the state. BNDES was offering loans

to spread Rosa's system. Finally, in 1989, CEEE gave in. Rosa's technical standard was officially approved as the *025 Norm*. "At last," Rosa recalled, "we could say we weren't breaking the law."

In 1999 I visited Palmares do Sul with Rosa. In the intervening decade, Rosa had moved to Porto Alegre and broadened the focus of his work to the rest of Brazil. As we drove by rice plantations and fields with buffalo cows grazing, Rosa was uncharacteristically quiet. The land was flat, the horizon visible all around.

Because of term limit laws, Azevedo could not run for mayor again after his six-year term expired in 1988. The townspeople of Palmares (who had electricity) elected a conservative candidate who proceeded to shut down Rosa's departments, dismiss his technicians, and divert the loans he had negotiated. Recalling the events, Rosa commented: "We don't have the mechanisms yet for democratic government. Each emperor comes in and destroys everything that preceded him.

"It feels very sad coming back here," he added.

We drove in silence for a while, then Rosa tapped my arm and pulled over to the side of the road. "Look," he said, pointing to a little gray box hanging on a pole. "Monophase."

I got out to take a closer look. A single wire strung over thin poles led a quarter mile to a farmhouse.

"Just one wire," he said. "You see?

"Ennio Amaral made his first five-kilowatt-amp transformer in a milk can."

Back in the car, Rosa was happy again. As we continued, he interrupted our conversation periodically with "Look, monophase," and "Look, over there, monophase."

We visited Paulo Sessim, one of the first villagers served by the Palmares project. Sessim came out of his house when he heard the car pull up and smiled broadly when he recognized Rosa. He pulled Rosa toward him with a warm handshake. "It's been a long time," he said with unmistakable affection. He invited us in and served us cold drinks. I was grateful for his refrigerator. I could hear the TV in the next room.

I told Sessim I was writing about Rosa's work.

"Before the electricity," he offered, "we used to have dances and there would be candles and kerosene lamps in every corner of the building. When you would touch the face of the girl you were dancing with, black grease would rub off."

Sessim wasn't talking about the 1930s, but the 1980s. The townspeople and well-to-do farmers had had electricity for years. "When you entered a poor family's house," Rosa recalled, "you could hear the sound of the wind moving in the wires. Below, people would be using gas lamps."

"When Fábio first spoke to us about electricity," commented Sessim, "we said, 'It will never happen here.'"

Now he couldn't imagine how he had lived without it.

A short distance from Sessim's home, Rosa showed me the stone memorial that locals had erected in memory of Ennio Amaral, who had died of cancer at the age of forty-five, a few months before construction had begun on the Palmares project. A plaque read:

> *In the fight for an ideal, we face those who are deceptive, envious and incompetent. The man who is firm pays no mind to such people and wastes no time counting them. For he who marches toward the light need not worry about what occurs in the darkness.*
>
> *To Prof. Ennio Amaral, who through his genius, idealism and perseverance, made it possible for poor people in the fields to gain access to electric energy benefits—our eternal recognition and gratitude.*

"Ennio was a very pure man," Rosa said thoughtfully as we returned to his car. "One of the most impressive human beings I've ever met."

In 1988, after all his work, Rosa found himself out of a job. He wanted to continue expanding the Palmares project, but he needed to make money. He'd also just gotten married. He didn't even know how he would describe himself in a résumé. He was an agronomist, but his work went beyond agriculture. He was an engineer, but technical issues occupied only a fraction of his time. He'd been working in government, but he wasn't a civil servant. Much of his time was spent persuading people to try new things.

Then Aluysio Asti, from BNDES, nominated him to Ashoka.

When Rosa met Drayton, he found a new way of looking at himself. "Bill made me see that I was a social entrepreneur," Rosa told me. "He showed me that my role was to take things beyond theory and find practical solutions for all the problems that emerged along the way."

Ashoka's stipend—$9,600 a year—gave Rosa enough of a financial cushion to continue his work. He traveled around Rio Grande do Sul promoting rural electrification. He leased land to experiment with rice planting techniques. He knew that BNDES had offered the state $2.5 million in loans for rural electrification, on the condition that he oversee the project. He waited until CEEE finally came around.

After the 025 Norm was approved, Rosa organized a meeting of mayors from forty-two municipalities. In each municipality Rosa had surveyed terrain, developed plans for electrical distribution, and identified local champions to organize the community. Between 1990 and 1993 he and Mello implemented Pro Luz (Project Light), carrying electricity to 25,000 low-income rural dwellers. Working with corn, soybean, and milk farmers, they demonstrated the widespread applicability of the Palmares project. With inflation, the installation cost per household had jumped to $600.[3]

One of Asti's colleagues at BNDES put Rosa in touch with Fernando Selles Ribeiro, a professor at the University of São Paulo, which housed the country's best electrical engineering department. After studying Rosa's experiences, Ribeiro established a resource center for low-cost electrification, with the 025 Norm ensconced as its central standard.[4] "That put an end to the ongoing conflict that our standard wouldn't work or would work only in one place," Rosa recalled.

In 1991 BNDES instituted a special credit line to promote low-cost rural electrification based on the 025 Norm. Other states picked up the model. For a short time the prospects for Brazilians without electricity looked bright. But the following year, with the economy spiraling out of control, the Brazilian government slashed social spending and BNDES terminated its credit line.

To Rosa, the idea that the government would withdraw support for a cheap, proven system that alleviated poverty, spurred economic growth, and forestalled rural exodus was incomprehensible. But this was the second time that government had brought years of his work to a halt.

"I felt like Sisyphus," he said.

And he resolved to rid himself of the burden of working through the government.

In 1992 he established a for-profit company—Sistemas de Tecnologia Adequada Agroeletro (Agroelectric Adequate Technology Systems), or STA Agroeletro—and began spreading photovoltaic solar energy (which converts light to electricity) across Brazil. "It's much quicker

than spending ten years of my life arguing with the government," Rosa explained.

Solar energy—clean, renewable, decentralized, easy to install—has always had one major drawback: high cost. Rosa saw that to make it cost effective, he would have to package it with something else—the way he'd packaged Amaral's monophase system with irrigation in Palmares.

Having grown up in a family of gaúchos, Rosa knew that one of the major problems in rural Brazil was inadequate fencing for animal grazing. Because of the high cost of conventional fencing, cattle farmers used fences sporadically. The result was overgrazing, which translated into lower farm yields and degradation of pastureland. However, Rosa saw that if *electric* fences were used—if solar energy were sold as a package with inexpensive polywire and fiberglass posts—it would bring down the price of the fencing by 85 percent. Farmers would receive electricity, increase their farm production, and improve land management all at once. Brazil has a vast cattle stock; the potential market was enormous.

Using this business model, within five years, STA Agroeletro installed 700 solar electric and fencing systems in sixteen Brazilian states. Rosa traveled from the pampas in the south to the Amazon rain forest in the north, to the *cerrados* (savannah) in central Brazil, to the dry *sertão* (arid lands) in the interior of Bahia, to the semiarid northeast. He was away from home two to three weeks each month. His wife, Liege, frequently asked him to cut down on his traveling. Each time Rosa came home early from the office on a weekday, his son João Pedro inquired: "Are you leaving again?"

Away from home, Rosa spent his days in the sun installing solar panels, pumps, and lights, measuring paddocks, and running wire. At night he slept in farmhouses. By the mid-1990s STA had a six-month backlog of work, and Rosa had gained national recognition as a leader in the delivery of low-cost solar energy.

While Rosa built up STA's business, he continued to promote the 025 Norm, offering his services as a consultant to state governments. Even without BNDES's special credit line, state governments continued to pursue rural electrification. In 1996 Rio Grande do Sul launched Pro Luz II, a $34 million plan, based on the 025 Norm, to carry electricity to 160,000 more people. For political reasons, the state company declined Rosa's help. Later that year the government of São Paulo

State launched a $240 million rural electrification project based on Rosa's system to provide electricity to 800,000 people.

In 1997, when I first interviewed Rosa, he had just been recruited as a consultant on the São Paulo project and was optimistic. Two years later, however, he reported that Pro Luz II and the São Paulo project had both fallen short of their goals. In Rio Grande do Sul, the state company had extended the system to about 40,000 rural dwellers. In São Paulo state, the project was reaching a quarter of its intended recipients. In both places, Rosa said the problem was lack of motivation and follow-through. "The technicians were trying to make the project work from their offices," Rosa said. "You have to *go* there."

By 1999, however, the political landscape in Brazil had shifted. Under pressure from the International Monetary Fund, Brazil's state governments divested their utilities. In 1997 Rosa had told me that he would have to work quickly because rural electrification would be abandoned by the power companies once they were privatized (it is more profitable to serve cities), and privatization had come more swiftly than he expected. As a result, rural electrification by the power companies had slowed to a trickle. "For years I have shown the government how to respond," Rosa said. "I had become well respected in Brazil. But since privatization, the people I knew are gone. Everything is different."

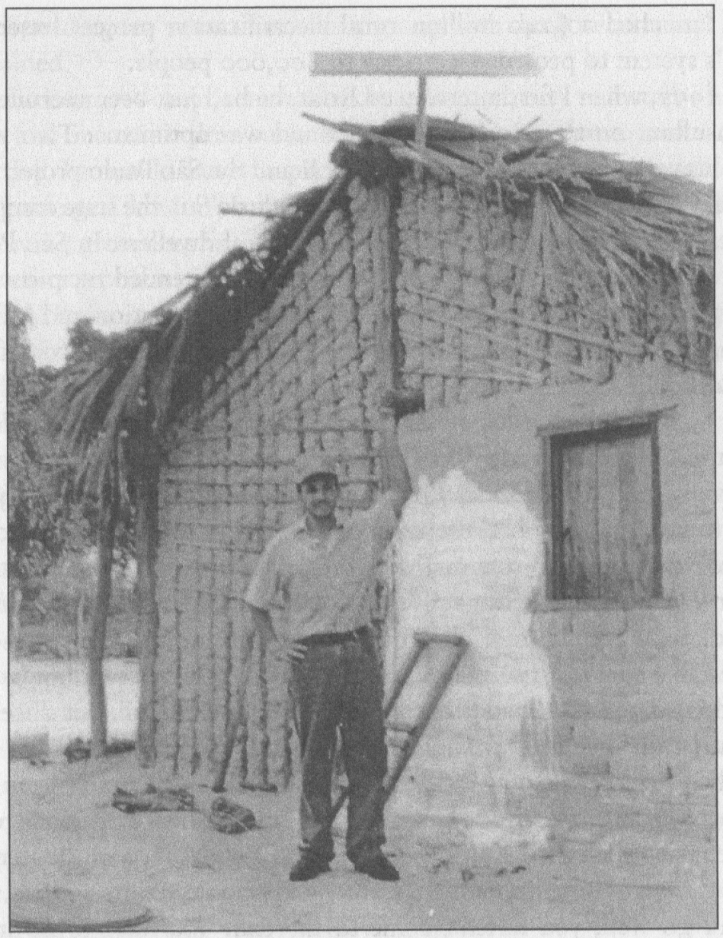
When Rosa spoke of this—yet another—setback, he didn't seem discouraged or bitter. "The context and the environment have changed," he went on. "But the necessity of my work is the same. I am an entrepreneur, and as an entrepreneur, I am always possessed by an idea. If it doesn't go well, you haven't come to the end. You have to do more work. If you haven't succeeded, the work goes on."

But what about seventeen years of his life?

"Yes, I am very angry," Rosa conceded after considerable prodding. "Every time I think about it, I get angry, I feel like shouting out at the top of my lungs. But I try to transform the feeling into a positive force: into solutions."

I didn't feel sympathy for Rosa. What I felt was a thrill at the way he experienced life: Despite all the problems, he still saw himself as the central mover of events. And the effect it had on me, as I'm sure it had on many people he'd met along the way, was to make me want to help him.

By the late 1990s Rosa had installed solar electric systems across Brazil. He had traveled to almost every corner of the country and



Bringing solar energy to rural Brazil

talked with thousands of people about their problems, and the stories he heard were strikingly similar. Everywhere, he encountered farmers whose farm yields and incomes were declining.

Nationally, millions of poor people could no longer subsist on their land. A major new political movement—the Movimento Sem Terra (landless movement)—had spread across Brazil. In the mid-1990s, in response to pressures brought by this movement, the Brazilian government had launched an ambitious land reform program that, by 2002, had distributed 18 million hectares of land to a half million families.[5]

Unfortunately, the government hadn't taken the steps to provide electricity to these people or help them establish viable farms. In Rio

Grande do Sul, for example, the government simply resettled many of the *sem terra* (landless people) in the pampas, where they proceeded to plow the grasslands to plant rice, wheat, corn, and soybeans. Such farming practices destroy the soil composition that protects natural pastures from wind and water erosion. The result has been environmental degradation and a perpetuation of poverty.[6]

Across Brazil, most of the families resettled by the government are struggling to support themselves. A quarter abandon their land within two years; the remainder barely hang on. In some regions, almost half have quit.[7] The problems are fundamentally the same ones that Rosa encountered in Palmares.

This downward economic-environmental spiral is not unique to Brazil or to the pampas. In fact, the pampas, as grasslands, have a global significance. Grasslands are the earth's second largest ecosystem, occupying vast areas of Europe, Asia, Africa, Australia, and the Americas. Like rain forests, grasslands are endangered, but they are rarely managed, and in many parts of the world they are seriously degraded. In addition to their inherent value as pasturelands and wildlife habitats, grasslands are major water catchment areas. Allan Savory, an authority on holistic resource management, has called water the "Achilles' Heel" of modern industrial and postindustrial civilizations. He writes: "[I]ts quantity and quality are determined by the state of the land on which it falls."[8]

Looking for ways to address some of these problems, Rosa again sought guidance in an old book: *Grass Productivity,* a classic 1957 text written by André Voisin, a French farmer and biochemist who was legendary for spending hours on his farm in Normandy watching his cows graze.

Voisin had made the breakthrough discovery that the key factor in grazing was time.[9] If animals grazed in any one area too long, or if they returned to an area too soon after grazing, they overgrazed.

Voisin came up with a system called rational or managed grazing, in which a pasture is subdivided into numerous paddocks (fenced-in areas) and animals are rotated from one to another in a regular fashion. He established precise guidelines to govern this process.

Managed grazing had many benefits, Voisin demonstrated. Farmers could reduce operational costs, cut their dependence on inorganic fertilizers and grain supplements and reduce soil erosion, while boosting milk and meat yields. Animals tended to forage evenly and spread their own manure over the land. Biodiversity increased and cows'

health improved. Rather than being subjected to confinement feeding, where conditions cause cow stress and illness, cows could wander around outside and rest in the shade of trees. Farmers required less machinery, saving on fuel and making it safer to work alongside their children.

Voisin's techniques were implemented in France and New Zealand. Managed grazing was later adapted to rangelands in Africa. In recent decades it has spread in Canada and the United States, particularly in Wisconsin, where it is known as management-intensive rotational grazing (MIRG) and, having proven to be more cost-effective than feedlot production, is one of the fastest growing dairy farming practices.[10] However, when it was introduced in Brazil in the 1970s, the results were disappointing and the idea was abandoned.

Rosa suspected that people hadn't taken the time to work out the bugs. He thought: If he could demonstrate that Voisin's system worked in Brazil, he would be able to influence grassland management and government resettlement policy. "It is *unbelievable*," he told me, "that in millions of hectares of natural grasslands—protected from snowfalls and extreme drought—no one has taken the care to design an organic pasture grazing system."

Why hadn't Voisin grazing worked in Brazil?

The key to the system is rotation. "You can only do it if you can create many small paddocks at low cost," Rosa said. "And you can only create many small paddocks at low cost if you use electric fencing, and, in Brazil, you must have the appropriate technology to deal with the land, climate, plants, and lightning."

Once again it was necessary to delve into the details. When Voisin's methods were first attempted in Brazil, the electric fencing systems were imported from Europe. But in Brazil's subtropical climate, plants grow taller than in Europe—tall enough to touch an electric fence and drain the current. A cow will "respect" an electric fence with 2,500 volts; sheep will respect an electric fence with 3,500 volts. Both Rosa's machines and the European ones put through 6,000 volts, Rosa explained. But when plants touched the wire with European machines, the current dropped to 2,000 or even 1,000 volts. So Rosa and Mello designed machines in which the current dropped only to 5,500 volts.

Then there were regionally specific modifications. In central Brazil, for example, the soil has low conductivity, which means that higher

voltages are required. "How did we figure this problem out?" Rosa asked. "From the Palmares project!"

Other modifications were required because Brazil has one of the world's highest incidences of lightning. And then there were all sorts of pasture plants and cattle species to learn about. Details, details, details. All of it was different from Europe, Argentina, Uruguay, New Zealand, and North America.

Rosa put together another equation: solar energy + polywire + fiberglass posts = inexpensive electric fencing. And inexpensive electric fencing + Voisin managed grazing = higher yields, sustainable land use, a rural future.

Within a few years Rosa had installed dozens of successful solar/electric fencing/Voisin managed grazing systems in ten states, enabling farmers in Bahia to raise goats, restoring cattle pastures in the state of Rio de Janeiro, helping buffalo farmers produce organic milk and buffalo mozzarella cheese in the state of Paraná. In most cases farmers saw their yields double or triple. In instances where the land had been particularly degraded, the new system produced 500 percent gains.

"We have now demonstrated results in every type of Brazilian environment, and other agronomists are beginning to do the same," Rosa told me in 2001. There was still resistance to the idea, he added, but that was to be expected. "It's difficult to say that something doesn't work for thirty years and then say, 'Oh, I was wrong.' "

But this time Rosa didn't have to worry about the government. The system was spreading through market demand. "Farmers want to do it," he said. "It produces organic milk and meat. And now the world, especially Europe, is willing to pay for it."

During the 1990s, land devoted to organic farming worldwide increased tenfold. The organic food market has global revenues in excess of $22 billion.[11] Brazil's cattle farmers want in, and Rosa plans to help them.

In 2001 Rosa stepped down from STA to build up a nonprofit organization that he had established a few years before, the Instituto Para O Desenvolvimento De Energias Alternativas E Da Auto Sustentabilidade (Institute for the Development of Natural Energy and Self-Sustainability), or IDEAAS.

STA had served as a vehicle to test market and refine a set of practical models. Now, through IDEAAS, Rosa sought to apply those models in poor areas where the for-profit model did not fit.

Initially he planned to concentrate on Brazil's three southernmost states, Rio Grande do Sul, Santa Catarina, and Paraná, which he knew best and where grassland degradation was intensifying. He further narrowed his focus to the southern half of Rio Grande do Sul, where 250,000 people lacked electricity, then targeted 13,000 poor families.

Next he conducted a market study. One key finding was that more than half of the families in his target area spent at least $13 each month on diesel fuel, kerosene, and batteries. "We saw that the amounts that people spent monthly on nonrenewable energy could be transferred to pay a monthly fee for a renewable energy supply, equipment, and service," Rosa explained. In other words, most of the families could afford solar energy at commercial rates provided they were given the option to rent it or pay it off slowly—over five to seven years on average. Villagers who spent less than $13 a month could also gain access to solar energy, Rosa added, but they would need longer-term financing and additional services. "For these people it isn't enough to bring electricity," he explained. "It's also necessary to improve their incomes and change their production models by introducing appropriate technology."

Rosa recruited a team of technicians, businessmen, lawyers, and journalists to help him think through the strategy. To reach the full market would require a mix of for-profit and nonprofit distribution channels, with some clients being served by STA at market rates and others being served at subsidized rates by IDEAAS.

They came up with two projects. The first, which Rosa named the Quiron Project, was a nonprofit venture to boost incomes of approximately 7,000 poor families while safeguarding the environment through a combination of solar energy, organic animal production, managed grazing, and other methods of resource conservation. (Gaúchos are attached to the image of the centaur in Greek mythology, and Quiron—Portuguese for Chiron—was the only centaur distinguished for wisdom rather than brute force.)

The second project, which Rosa dubbed The Sun Shines for All, was a for-profit venture to deliver solar energy, initially, to 6,100 rural families who did not have electricity but could afford to pay for solar panels through a rental system. Rosa estimated that the project could break even between months 42 and 48 and produce a 20 to 30 percent return for investors in addition to providing social and environmental benefits (e.g., switching from kerosene to solar lighting would translate to better health for families as well as reduced carbon emissions).

Rosa was particularly excited by the findings of his market study because it indicated the potential to reach a large number of people through a business format. "If an investment in solar energy will pay itself off in five to seven years, that means that it will be possible to attract investment capital," he explained. "This is very important, because it is not possible to imagine bringing electricity to poor people around the world with only philanthropic dollars."

As I listened to Rosa's plans, I thought about the archaeology of social change: how in each generation people build on the foundation laid by previous generations. As a result of the micro-credit revolution, advanced over the past twenty years by the Grameen Bank and others, poor people in developing countries are today recognized as acceptable credit risks. By 2007, the Grameen Bank had extended home mortgages to more than 645,000 villagers who pay off their houses at rates less than $1.50 a week. Grameen Phone had also leased cell phones to close to 300,000 "village phone ladies" who make a living selling calls to other villagers. The notion that institutions can establish reliable, long-term credit relationships with poor people across the world is no longer radical. It has been proven. And if it works with houses and cell phones, it can work with solar panels, or any other productive assets.

This is an important idea. "Installment buying literally transforms economies," notes Peter Drucker. "Wherever introduced, it changes the economy from supply-driven to demand-driven, regardless almost of the productive level of the economy."[12]

Consider that 2 billion people—30 percent of the world's population—are currently without electricity and about half of them could afford solar power at commercial prices today if they had the opportunity to rent it or pay it off in installments.[13] Bringing electricity to remote rural areas around the globe would not only transform economies, it would transform education and healthcare. It would transform agriculture. Access to electricity is often a precondition for farmers to switch from nonsustainable, low-yielding agricultural practices to sustainable, higher-yielding ones. Global rural electrification also would relieve the population stress on the world's megacities, reducing the urban discontent that is so easily exploited by advocates of violence.

In 2001 Rosa was one of the first forty social entrepreneurs honored by the Geneva-based Schwab Foundation for Social Entrepreneurship,

which supports "outstanding social entrepreneurs" worldwide.[14] Later that year Rosa also won a $50,000 Tech Museum of Innovation Award from the San Jose Tech Museum for applying technology to benefit humanity. Five winners had been chosen from 400 nominees from fifty countries.[15]

I sent Rosa an e-mail, asking how it felt to win.

"It was fantastic!" he wrote back. "When I was walking to receive the prize, lights in my eyes, in my mind in high velocity went the past: the grids, the transformers, the solar panels, Ennio, Ney, Bill Drayton.

"Afterward, when people were silent, it was time for me to say something. I was very nervous. I said: 'I spent my younger days in distant areas bringing electricity to rural people in Brazil. I love technology. I believe it is the principal force to bring change to humanity. Every project I have seen at this gathering is marvelous. When we use our intelligence and knowledge to serve people, humanity has hope. We are the hope, we are the future.' "

In 2003, Rosa was still traveling ten to twenty days a month, but he planned to cut back. He wanted to spend more time with his children. At forty-two, he was also feeling his physical limitations. "I can no longer work two days nonstop without sleep," he explained.

In 2002 he informed me that the Solar Development Group, based in Washington, D.C., had agreed to invest in The Sun Shines for All. He also had received support for the Quiron Project from the Avina Foundation and Canopus Foundation and was planning to seek financing from the World Bank's Community Development Carbon Fund, launched in September 2002. (The fund channels private investment to development projects with an emphasis on renewable energy. Investors receive carbon "credits," which can be traded or used to comply with environmental laws. The idea builds on a foundation that, as we will see, was initially laid by Bill Drayton when he was an assistant administrator at the EPA.)

Rosa was completing technical studies and designing the delivery and service models for both projects. He planned to have the market research completed and seventy test sites installed by August 2003. Twenty-one years after he had begun his work in Palmares, he wrote in an e-mail: "Now I see again that it will be possible to reach all groups with sustainable models and designs—I am starting again!"

4. The Fixed Determination of an Indomitable Will

Florence Nightingale, England: Nursing

When Drayton calls someone a leading social entrepreneur, he is describing a specific and rare personality type. He doesn't mean a businesswoman who gives jobs to homeless people or devotes a percentage of profits to the environmental movement. He doesn't mean someone running a nonprofit organization who has developed a business to generate revenue. He means someone like Florence Nightingale.

Most people know a little about the "lady of the lamp" who tended to British soldiers during the Crimean War. But what did Florence Nightingale really do? Why are nursing students still assigned Nightingale's 1860 book *Notes on Nursing: What It Is and What It Is Not*?[1]

In *Eminent Victorians*, biographer Lytton Strachey observes that, as children in the nursery, while Florence Nightingale's sister displayed "a healthy pleasure in tearing her dolls to pieces," young Florence already displayed "an almost morbid one in sewing them up again." As a girl, Nightingale was driven "to minister to the poor in their cottages, to watch by sick-beds, to put her dog's wounded paw into elaborate splints as if it was a human being." She imagined her family's country home turned into a hospital "with herself as matron moving about among the beds."[2]

In 1845, at the age of twenty-five, Nightingale expressed a desire to work as a nurse in Salisbury Hospital. But when her father, William, a wealthy landowner, was informed of the low moral standards then associated with nursing, he forbade his daughter to take the position. For a woman of wealth and social standing in Victorian England,