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Trading solar panels for grid power: An ethnography of rural energy service in Peru

Dustin Welch García*

University of Washington, Jackson School of International Studies, USA

1. Introduction

In 2010, the nonprofit organization *Luz Solar Andina* started implementing a solar energy program in villages in the northern Andes of Peru. Communities in that area had been waiting on the state to extend the electric grid for years with little result. Electricity meant domestic lighting superior to candles and kerosene and that children could study at night. Despite initial skepticism towards the project, over the years villagers have generally been satisfied with the solar program. However, the project has also generated expressions of local fears and possibilities, ones that have reached far beyond the intentions of the NGO itself. This article explores social aspects of rural solar energy and the forthcoming grid extension. On the one hand, local people saw the solar energy service and the symbolic aspects of modernity it offered them, as a new sign of citizenship.¹ On the other, to be connected to the national electric grid is to be included in the nation, but for these residents, this inclusion has brought increased energy-related uncertainties.

This article examines how rural residents engage with solar energy provision and negotiate transitions to grid electrification in their small Andean community of Peru. I focus on a highland village called Lahuaymarca served by the nonprofit *Luz Solar Andina* (hereafter LSA) through its *Casa Solar* energy program in rural Cajamarca. This ethnographic project fills a gap in critical development studies, infrastructure studies, and the energy humanities literature by examining how people interact with the partial or incomplete presence of modern infrastructure (Gupta 2015). These bodies of literature have largely focused on the financial and policy mechanisms needed to support energy access, the analysis and selection of technologies for reaching unelectrified populations, as well as the sociocultural aspects of program design, implementation, and operation at the community level. While these areas of study have explored the processes involved in providing energy and

sustaining energy service, they have not however, brought awareness to how rural and marginalized populations, who have only fragmented or intermittent access to modern energy service, engage with these infrastructures. In addition, this project expands on calls made by scholars such as Akhil Gupta (2015) and Dominic Boyer (2014) for social scientists to focus their analytical gaze on energy's role in the management and control of human populations. Relatedly, building on the work of Timothy Mitchell (2011), this work explores the linkages between sources of energy and social and political frameworks, following the properties of renewable energy infrastructures to observe how they modify and strengthen structures of power and inequalities in institutions and their operations.

This article argues that residents do not greet the arrival of the national electrical grid with blind optimism, but instead express deep misgivings about the eventual surrender of their solar home systems for fear that the grid electricity will prove less reliable, less safe, and more costly than solar energy. One resident's view expressed the worries of many in his town, saying: "where there's been electrification there have always been problems ... suddenly, 'boom!' it starts to fail and you go ... sometimes a month without light. By then you've become accustomed, it becomes something harmful because ... with the (solar) panels ... there's always light." This ethnographic work took place in a community on the verge of transition between the *Casa Solar* off-grid solar energy program and traditional energy service through the extension of the national electric grid. I argue that residents' engagement with solar energy and the upcoming energy changeover reveals how they are caught in a development paradox. Both solar energy and grid electricity represent infrastructure technology intended to help overcome social and economic disparities, yet both re-inscribe rural residents' status as secondary citizens with little claim to infrastructure rights.

* 1720 E Denny Way, Apt. 304, Seattle, WA, 98122, USA.

E-mail addresses: drw13@uw.edu, dweetrekson@gmail.com.

¹ Over the last two decades, mining-led growth has driven the political economy of development in Peru. During the 1990s, various mining companies founded in Canada, China, and Australia, entered the country. By 2011, 59% of Peru's total exports were derived from mining activities and 21% of the national territory formed part of a mining concession. As mining booms created great enclaves of wealth, they contrasted with the high levels of impoverishment in the areas these extractive activities took place, most notably the indigenous Andes. Peru's modern mining industries have come to be perceived as laden with labor abuses, land dispossession, and environmental mishaps (Orihuela, 2012; Arce, 2014b).

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1.1. Luz Solar Andina program model

LSA's off-grid solar energy program, *Casa Solar*, provides electricity via solar home systems (hereafter SHS) to nearly 4,000 households in rural areas surrounding the city of Cajamarca that the national electric grid has been unable to reach. The roof-mounted SHS that LSA installs consist of (1) 85 W solar panel, (1) 100Ah battery, (1) 10 A charge controller, (3) 5 W LED lights; the installation also includes (1) electrical socket. Potential daily uses of the SHS include: (3) 5 W LED lights for 8 h, (1) radio for 6.5 h, or (1) black and white TV for 3.5 h; as well as cell phone charging. (It should be noted that at the time this research was conducted, neither the SHS technology utilized in this project model, nor the Peruvian regulatory system, allowed for SHS grid integration or any sort of residential net metering.) Residents make a monthly payment to LSA representing 20% of the state-mandated solar tariff, while the remaining 80% is covered by a national cross-subsidy called FOSE (Electrical Social Compensation Fund). This is a cross-subsidy where energy customers (generally located in poor rural areas) consuming less than 100 kWh of energy per month receive a discount that is financed by those consumers (generally located in urban areas) using more than this amount of energy per month. This amounts to 10 Soles (PEN) (\$3 USD) per month paid by residents and 40 Soles (\$12.25 USD) covered by the FOSE subsidy. LSA is responsible for all aspects of service, including the installation, operation and maintenance of the SHS, as well as all billing transactions (Egido Aguilera, 2014). Residents are required to pay their energy service bill monthly via their town's electrification committee or by paying in-person at the LSA office in Cajamarca. If a resident fails to make their payment for two consecutive months then LSA technicians cut power to the SHS until the resident settles their debt. After six consecutive months of delinquent payment LSA technicians permanently remove the SHS from the resident's home.

LSA's unique institutional history and corporate connections warrant discussion, as these ties have provided financial assistance and administrative support, which have enabled the organization to thrive. LSA gained recognition by the Peruvian Agency for International Cooperation (APCI) as a Peruvian NGO in 2009, but was in fact founded with the express intent of conducting corporate social responsibility (CSR) projects on behalf of its parent company, the Spanish infrastructure and energy giant, InfraLuz Solar. As such, LSA has served as InfraLuz Solar's vehicle to accomplish its CSR mission of fostering access to basic infrastructure, such as energy and water, in communities in developing countries where these services are unlikely to reach. Another element that has aided LSA's institutional stability is InfraLuz Solar's initial financial support of the LSA during its first few years of operation, without which the latter's success would not have been possible.² At the time this research was conducted, LSA still received ongoing administrative support and technical advising from InfraLuz Solar, but LSA's financial operations had been self-sustaining since 2014,³ through customer payments and receipt of the FOSE subsidy.

The ongoing sustainability of the program is challenging for various reasons. Among the many challenges, rural residents must agree to pay for SHS, which offer considerably less energy output than the national electric grid. Lahuaymarca is located at just a 30-min hike to the nearest town with electricity, and there are dozens of other towns connected to the electric grid along the two and a half hour drive to Cajamarca. Needless to say, Lahuaymarquinos have been exposed to the grid and understand, despite reports of nearby brownouts and black outs, that it should operate 24 hours a day. Through familiarity with the power grid residents know it has more electrical capacity than their SHS, which can generally only support lighting and small appliances (like a black and white TV) for roughly 5 hours a day and prohibit use of typical AC-powered domestic appliances. To address this, LSA holds various

community meetings to teach residents about solar energy, the financial aspects of energy service, and manage community expectations of SHS performance. SHS models utilized by LSA do not feature DC to AC inverters. Without inverters the SHS are cheaper, it lowers demand on the battery, and improves useful life of the system. Unfortunately, most domestic devices like blenders and sewing machines use AC power (as does the Peruvian electric grid), and the SHS used by LSA are only intended to support lighting, cell phone charging, and small DC-compatible devices like black and white TVs. That is to say, these SHS lack the capacity for residents to use income-generating tools, but instead, are intended for bare necessity energy uses.⁴ While use of SHS models that include DC to AC inverters would potentially allow for more productive activities through the use of AC-powered tools and appliances, it would also increase the likelihood of system abuse and ultimately, put the technical sustainability of the program at much higher risk. As a result, LSA opted for provision of DC-only SHS. Additionally, at the time this research was conducted, more robust, distributed generation technologies, such as hybrid microgrids, were not accounted for in Peruvian energy regulation and did not qualify for subsidies.

1.2. Methods

The data presented in this article were drawn principally from participant observation and interviews in two sites: the community of Lahuaymarca and the organization LSA itself, riding along with its technicians as they carried out program maintenance and operation and other administrative tasks. Unless otherwise noted, the names of all interviewees, towns, organizations, and programs have been changed to pseudonyms. I have made these changes to protect the identities of my research participants. All community members, NGO officials, and subject matter experts gave verbal, informed consent to be a part of this study and understood that their responses would be fully anonymized. What is more, in an effort to be transparent in their public-facing roles, these NGO representatives and public officials gave express permission to use their real names. Nonetheless, in keeping with standard ethnographic practice, all names have been anonymized.

Over the course of four months I lived in this small highland community of approximately 35 families. The village is separated from the city of Cajamarca by a bumpy, two and a half hour drive in 4 × 4 truck. Perched on an imposing hillside nearly 12,000 feet above sea level, Lahuaymarca⁵ overlooks an immense valley floor, dotted with dairy cows and crisscrossed with irrigation canals, stonewalls, and hundreds of narrow footpaths. The latter are well worn, and a testament to villagers' continued reliance on walking across the rugged landscape. During this time I arranged to live in a local resident's unoccupied adobe house and slowly became a familiar face in the community. My methods consisted of participant observation and interviews. By participant observation, I mean I engaged in everyday chores and shared routines that punctuated daily life, such as helping townspeople plow their fields by pick axe and by oxen team, eating heaping plates of potatoes, rice, and *quesillo* in small but warm, smoke-filled kitchens, and sharing cups of *cañazo* with the local men at dusk. I enjoyed pleasures such as playing

⁴ Access to reliable modern energy sources is widely accepted as a necessary condition to spur social and economic development in rural settings of developing countries, yet there are many debates on household solar energy's role in supporting these advances. For more on these debates see: Bambawale et al., (2010); Mahama (2012); Jacobson (2007); Azimoh et al., (2014); Martin and Susanto (2014); Kirubi et al., (2009); Rahman and Ahmad (2013).

⁵ Lahuaymarca is considered a *caserio* or hamlet, which have between 151 and 1000 inhabitants, houses that are partially dispersed or located along a main road/path, a multi-use communal house, and an operative school.

² Carla Saenz, interviewed by the author, August 2015.

³ Tomás Huilca, interviewed by author, July 2017.

lung-bursting games of soccer with school kids, and the connections to families that such events provided; in the process, I met almost all the town's residents. I also attended local meetings, including a *rondas campesinas*⁶ meeting that sought to resolve a physical altercation between two local families. Besides this participant observation, my methods included 36 in-person interviews (with 40 people in total). The diversity of my interviewees allowed for a generous sample of residents, one from nearly every household in the village.

I selected Lahuaymarca as my project site because it was recommended by LSA itself as a good place to study its energy service. LSA's manager, Carla Saenz, told me this was an ideal community to conduct my research because 1) of the town's location far enough from active mining sites to be free of related social conflicts; 2) its transactional history with LSA, which was "representative of all of LSA's communities": compliant customers, communication mishaps, cutting power to customers who do not pay and reconnecting power to residents once they do, and removal of SHS for residents who fail to pay for six months or more; 3) in other words it was "Similar ... to a broader population in all respects that might affect the hypothesis of interest" (Gerring, 2012, 435) and lastly; 4) given the tense social atmosphere that mining has created throughout much of rural Cajamarca, the individual residents living there would be socially amenable to intrusion by an unknown *gringo*. That is to say, open and welcoming enough to consent to my sustained presence there and willing to cooperate with my academic inquiries.

While there were clearly practical and social benefits to carrying out research in the community that LSA itself had recommended, in order to ensure residents' understood that I was not sent by LSA as a project evaluator and could speak freely about their energy service, I made a practice of emphatically identifying myself as a student researcher with no affiliation with LSA (nor any branch of the Peruvian government, and most especially, with no connection to mining companies). Nonetheless, residents with whom I spoke initially assumed that I was associated with LSA in some way because of my interest in LSA's solar energy service and related issues.

More importantly, and in spite of LSA's description, the ethnographic work that I conducted in this community was still shaped in many ways by social conflicts generated by mining activities in the region. While this community had not been directly affected by mining or social mobilizations related to it, this region of rural Cajamarca is located within the general sphere of influence of the mines. As a result, town residents have heard a great deal through broadcasts over their battery-operated portable radios (found ubiquitously in the rural Andean communities), stories told by friends and relatives, and trips to nearby population centers (*centros poblados*),⁷ about the environmental and social conflicts that regional extraction has generated. Residents reported hearing not of improvements in livelihoods in communities near extraction sites, but of abuses and environmental deterioration. In Lahuaymarca, all the

residents with whom I spoke adamantly opposed the area's mining activities. These residents showed great fear of mining incursion into their communities and its consequences. Modern extractive technologies draw heavily on local water supplies and could possibly leave villagers without sufficient water to support their agricultural and pastoral livelihoods. Additionally, residents showed unease that mining activity could lead to degradation or dispossession of their land (Orihuela, 2012; Arce 2014a,b).

Given the potential threat that mining posed to these communities' lands and livelihood, most residents demonstrated a palpable apprehension and guarded skepticism towards strangers in the area.⁸ The historical and contemporary processes that have led to highland suspicion of strangers were evident throughout my time in Lahuaymarca. Due to my appearance as an unknown white person, this extended to me. Many interviewees suspected that my benign appearance belied some sinister intention of promoting mining company interests; that I was not the student I claimed to be, but a harbinger of environmental abuse and financial disruption that residents heard about through radio and word-of-mouth. Despite my efforts to alleviate locals' fear of me, after four months in the community, some residents remained suspicious of my motives for being there.

As mentioned above, I prefaced my conversations with residents by explaining my academic background, research interests, and the anonymity of their responses in order to assuage their worries that I was working for a mining company. While I never felt restricted in the kinds of questions that I asked, on occasion, residents' responses betrayed their residual fears of mining company infiltration of their community under cover of LSA's solar energy program—they voiced worry about being dispossessed of their land; described how outsiders had reportedly run soil tests that killed off local wildlife; one woman forbade me from photographing her picturesque home at dusk for fear the documentation would later be used by mining companies to identify her home and strip her of her land; another elderly man that I interviewed, more worried about losing energy service, asked that I leave a detailed note in his possession (even though he admitted to being illiterate) as proof of our interaction so he would not run afoul of LSA. These fears of mining encroachment, environmental degradation, and disruption to energy service challenged the way I recorded data, as only two residents allowed me to audio record our interviews.⁹ Because of this I relied heavily on taking hand written notes, which at times hampered the natural flow of interviews, though it greatly increased residents' sense of ease and openness during our conversations. Interview notes were then open coded in a quote-by-quote strategy, allowing for themes to be grouped into main categories and sub-categories.

⁶ *Rondas campesinas*, literally "peasant rounds," are community nightwatches created to safeguard villages against theft of property, crops, and livestock. The *rondas* first sprung up in 1976 in Cajamarca, stepping in for ineffective local government which was seen as corrupt and unwilling to address the heightened insecurity and material poverty that pervaded the region's highlands. The atmosphere for the *rondas*' emergence was created in part by General Velasco's failed 1968 agrarian reform, which exacerbated already poor conditions in rural communities of the highlands. In addition, from the late 1970s into the early part of the 1990s, Peru (and much of Latin America) suffered its worst economic downturn and crisis, known as "the Lost Decade." In this context of state absence and economic adversity, *rondas* proliferated in the 1970s and into the 1980s, eventually playing a role protecting many of their communities against infiltration by the Maoist insurgent groups, *Sendero Luminoso* and Túpac Amaru Revolutionary Movement (MRTA) (Stern, 1999).

⁷ A *centro poblado rural* is a place of dwelling that is not the capital of the district and contains more than 100 homes, located in dispersed or grid settlement patterns.

⁸ A powerful example of the threat posed by mining intrusion is represented by the case of Máxima Acuña. She is a campesina landowner, who was accused by the multinational mining company, Yanacocha, in 2011 of employing violence to illegally occupy land it wanted in order to expand its mining activities. She had purchased the rural property called Tragadero Grande, located in the province of Celendín, Cajamarca in 1994. The mining company claimed that it had acquired the land from the community, but Acuña and her family asserted they had never given their permission of the sale. For years leading up to the lawsuit, Acuña and her relatives suffered intimidation, attacks, attempted evictions, as well as attacks on their land, pets and livestock. Through her successful stand against Yanacocha's harassment she emerged as a prominent environmental leader, eventually winning the Goldman Prize for environmental defenders in 2016. In 2017, Perú's Supreme Court found her not guilty of illegal occupation of the land (Frontline Defenders 2017).

⁹ This type of reaction among highland community members is not uncommon as anthropologists have long been seen as potential CIA agents. Also, given Perú's contentious mining history, this antipathy and suspicion towards outsiders is understandable.

2. Rural energy and citizenship

During my research in Peru, I often heard government officials, NGO, and private sector workers make a joke that betrayed the common pessimism towards development in the Andes. Rural people, it was often said, “switch on the lightbulb to look for the candle.” The underlying message is that highland peoples are too ignorant and stuck in their ways to properly utilize a technology that is in their best interest. They are obdurate and unmodern, culpable for project failures and their own lack of advancement. But this belief was not just one among economic development experts; it was shared by much of the nation. The “Indian problem,” as it was once called before Peru’s agrarian reform of the 1970s, was that Peru might not advance because *campesinos* were not interested in pursuing profit and thus were a stumbling block for Peruvian capitalism (Degregori, 1978; De la Cadena, 2000; García, 2005).

Blaming development failure on race, geography, and ignorance conceals the social complexities and contradictions that must be addressed to in fact implement successful rural electrification projects in the Andes. In Lahuaymarca, LSA’s *Casa Solar* program has been attentive to community-focused efforts cited in development literature as necessary for program success. LSA has involved local authorities in implementing the program, held various meetings to build residents’ understanding of the project, tapped community members to carry out maintenance and repair of SHS, all of which has helped create a sense of community ownership of the program and contributed to its sustainability.¹⁰ However, my ethnographic research shows that residents’ feelings of ownership of the program have not been created through the abovementioned community development practices alone, but have also been shaped by playing on residents’ poverty, marginalization, and deep fear of losing the material and citizenship benefits that SHS represent. Leveraging the physical and symbolic properties of energy is especially salient in this case because “electrification has provided the twentieth century with perhaps its most vivid symbol of modernization and development” which would “link all of the country’s citizens in a universal, national grid of modernity” (Ferguson, 1999, 242). Rural residents can be seen embodying contradictory feelings of both empowerment, earned through their active contribution to program success, and also constant distress about the possibility of being dispossessed of their SHS. *Campesinos’* ownership of SHS helps them counter the narratives of “contemporary highland peasants as outside the flow of modern history” (Starn, 1991, 64), seen by urban residents and coastal elites as living “without water (i.e., faucets), light (i.e., that kind of light which can be turned on and off), without medical attention, without roads that link them to the rest of the world” (Vargas Llosa et al., 1983, 36).

In much of rural Peru, citizenship is not a universal category to which all people enjoy equal access. Borrowing from concepts of citizenship laid out by Nikhil Anand (2017), I argue that for these rural residents, their “energy citizenship” is not earned through a linear political process that culminates in a single event (i.e. grid extension), but rather something that happens sporadically over varying timeframes, and most notably, that can be undone. The provision of solar energy infrastructure by an NGO highlights how citizenship rights are fluid and only attained through actions and exchanges carried out back and forth between the NGO (in absence of the state) and its customers (Anand, 2017). That is to say, benefits of energy citizenship can be revoked and undone if a resident simply fails to pay their monthly energy bill. At this juncture it should be pointed out that unlike household connection via the national electric grid, LSA retains ownership of SHS equipment and household items. As a result, if a customer falls behind on payment, solar energy service is not merely disconnected, but all of the associated energy

equipment—solar panel and roof mounting, battery, charge controller, as well as all of the interior wiring, light bulbs, switches, and plug in—are physically removed. In contrast, when a grid-connected household becomes delinquent in payment their service simply ceases. Energy distribution companies do not show up and strip the delinquent payees’ households of both the exterior and interior electrical equipment and wiring, as is the case with the *Casa Solar* program. So in this sense, rural residents’ full access to citizenship becomes contingent upon their ability to pay for it.

2.1. Rural engagement with energy

Lahuaymarca was among the first communities where LSA implemented its *Casa Solar* program starting in 2010. The organization’s community development efforts, including coordinating with local authorities to register potential energy customers, holding numerous meetings to raise general awareness of its program, and teaching residents the details of the *Casa Solar* project, helped lay effective groundwork for program sustainability. While residents’ testimonies affirmed that these meetings helped them to understand the program, what truly compelled villagers’ compliance was the ongoing threat of LSA cutting power to their SHS or their removal, if they fell behind in payment. One resident named Sara, told me that she could not let two months slip by without paying her energy bill. Otherwise, she said, LSA would come and cut the power to her SHS, and in addition to paying her debt, she would have to pay a fee of 12 Soles (roughly \$3.50 USD) to have her power reconnected. She added that she would even go without eating if she had to in order to make her energy payments. Sara’s stark commentary spoke to her family’s financial precariousness and their commitment to maintaining energy service despite personal sacrifice. She went on to make a simple statement, representative of townspeople’s lack of alternatives and fear of taking backward steps after growing used to the SHS, saying that *Casa Solar* “is the only option, otherwise we have to go back to candles ... There’s just no other solution, candles don’t last long at all. With candles you have to be searching for matches late at night.” Comments such as these were typical and largely captured the importance that residents placed on retaining their SHS at all cost.

This material poverty and the deficiency of infrastructure that rural residents experience is reflected in their sentiments about their current satisfaction with solar energy service and life before the arrival of *Casa Solar*. One resident named Amalia, said that she was content with her SHS, and went on to recount the drudgery of having to do her domestic work and raise her kids by candlelight and by the light of firewood. Pointing off to the zigzagging foot trails that descend into a nearby valley, she said that prior to *Casa Solar*, they could only illuminate the room beyond candlelight by “burning the heel of a shoe” that she found abandoned along the trails. This bleak description of resorting to the light given off by smoldering rubber illustrates the advancement that SHS represent for residents and why they feel fortunate to have overcome that energy-deprived lifestyle.

The *Casa Solar* program is one of the only infrastructure services residents are provided, and if they were deprived of it residents would have no recourse to other modern energy sources via private or public institutions. What is more, the benefits of this solar energy program have created a bottom threshold of acceptable levels of energy access for these residents and represents an infrastructure service on which they can rely amid an otherwise precarious rural existence. Another resident, Victoria, described how she felt “now accustomed (to the SHS). We’ve forgotten antiquated customs of the past.” Not only does her statement capture the degree to which the solar energy infrastructure has become normalized to her, but it begins to reveal how access to energy, or its absence, plays into Lahuaymarquinos’ conceptions of modernity and development. Over and over I heard commentaries from Lahuaymarquinos expressing their deep fear of having their solar panels taken away and being forced to return to a life of candles and kerosene; a lifestyle that has simply become unimaginable to them.

¹⁰ For recent literature discussing the role of social and cultural engagement in renewable energy program sustainability, see: Fernández-Baldor et al., 2014; Hancock (2015); Ikejumba et al., (2017); Urmee and Anisuzzaman (2016).

It was clear that the constant threat of cutting power and removal of energy equipment scared the residents, caused them to worry about losing the benefits of solar energy to which they have grown accustomed, and ultimately, compelled them to continue to pay for energy service. Jorge, who lived in the house adjacent to mine, captured the sentiment of many town residents, saying that “at the beginning we didn’t think that LSA would be so rigid at enforcing the rules,” and since residents only had experience with candles and not SHS, they had a tough time adjusting to making payments. Residents’ experiences of LSA’s reliability was demonstrated back in the beginning of the *Casa Solar* program, and extended beyond just the physical threat of a LSA technician showing up to cut power. A town resident name Marcos echoed the general consensus of most all Lahuaymarquinos, when he told me how LSA has come through on more than just enforcing the consequences of late payment, because the organization had delivered on its first and most incredulous promise to the village—bringing solar energy. A promise which many residents were highly skeptical of in the early stages of collaboration. What is more, he described that LSA had also built trust and credibility with townspeople by delivering on the promise to lower residents’ monthly energy bill from 15 to 10 Soles, once LSA had qualified for a state subsidy through a 2011 change in state energy policy.

2.2. Coproduction and citizenship

While the disciplining actions carried out by LSA have led residents to live with an ever-present worry of losing their SHS, curiously, it has also led to residents to simultaneously view themselves as “coproducers” of energy service and constitutive components of the program’s continuing success. Ostrom (1996) describes coproduction as “the process through which inputs from individuals that are not ‘in’ the same organization are transformed into goods and services.” Conventionally, the group that generates the service of health, education, and infrastructure has been the government, providing for “clients” who receive these services in a passive way. Clients are acted upon, while coproduction means that citizens play a role in producing the public goods and services that they desire (Ostrom, 1996, 1079). Relatedly, Bebbington (2000) claims that above all, people encounter development when attempting to make something they can call their own. In these instances, “modernizing development,” like the implementation of solar energy programs, does not face resistance but is absorbed, remade into something that may serve the purposes of people’s own design. According to Bebbington, almost everything that comes about in development comes through coproduction, as institutional and popular practices intersect and comingle with market, historical, and modernizing notions and practices (Bebbington, 2000, 513–514). Advancing these ideas of coproduction in a more conceptual direction, my ethnographic work exposed how Lahuaymarquinos have internalized this energy program and have become empowered by their role in its ongoing functioning, to the extent that they claimed their financial compliance was vital for program success.

As such, residents did not conceive of themselves as passive recipients of energy service, but rather as vital operational components of *Casa Solar*, on par with the technical performance of the energy equipment and the maintenance and operation activities carried out by LSA technicians. When asked their opinion on why the *Casa Solar* has continued to work all these years, many residents were clear about their responsibility in making the program function, saying things like: “It’s because we make our payments punctually. What would happen if we didn’t pay? LSA would take back their panels. It just wouldn’t work if we don’t pay.” Other residents echoed the same feeling of pride in being responsible for the function of the energy service, rhetorically situating their payment compliance as an equal contributor to program operation, as the technical performance of the SHS and the prompt service LSA provides in addressing technical or financial problems.

The preceding paragraphs have outlined the contradictory nature of

Lahuaymarquinos’ experiences with *Casa Solar*, as they have expressed both a persistent fear of losing solar energy access and also undeniable feelings of pride and empowerment in coproducing it. For these residents, the SHS represent a more modern, advanced infrastructure than candles and kerosene, yet it is understood as an inferior technology to the grid. SHS are seen as providing energy and light better-than-before, but they still do not represent something as technically capable as the national electric grid. Despite only a 30-min walk separating Lahuaymarca from the nearest population center (*centro poblado*) connected to the electric grid, SHS are still one of the only infrastructure goods to which these rural residents have access. And unlike grid power, where drop lines and meters are generally not dismantled and removed from a resident’s house in the case of nonpayment, LSA has the right to dispossess a customer of their SHS once they fall behind on their bills. Thus, these villagers desperately cling to a technology they feel is useful and dependable, but recognize it is less robust than the power that can (potentially) be supplied by Peru’s national electrical grid on a 24/7 basis.¹¹ This situation highlights how these poor rural residents who depend upon the *Casa Solar* program have been presented with energy as an economic good, which dictates that their purchasing power, and not rights granted to them through citizenship, are what determine their access to energy (Bjorkman, 2015).

Scholars have demonstrated how social and cultural differences have served as the basis for withholding, as well as the granting of citizenship demands, as disenfranchised groups are often perceived and treated as inferior citizens by their respective governments (Anand, 2017). Nowhere is this more evident than in Lahuaymarca, where the town’s elementary school teacher, Ronaldo, resided in the school during the week, which was not part of *Casa Solar* and had no electricity. Like many teachers in Peru’s small hamlets (*caseríos*), his placement there was not coordinated under the state’s Ministry of Education, but rather arranged and paid for directly by the local municipality. Since the local municipality was said to operate on a minimal budget, Ronaldo was paid even less and given even fewer resources to work with than Ministry-authorized teachers. His situation as a rural teacher living in a schoolhouse with no electricity, while surrounded by homes with solar energy, illustrates the difficulties and contradictions of state presence, infrastructure, and citizenship in Lahuaymarca. He told me that in his view, LSA, as an NGO, did things properly, “how they should be done.” Unlike the absentee state, LSA had brought “solar panels where the other electricity (the grid) doesn’t reach. Where other institutions don’t go.” He added that LSA has also been able to provide energy service much sooner than other state institutions. Ronaldo’s energy-deprived living situation and his opinion of LSA filling an infrastructure void left by the state helps us understand both how residents of Lahuaymarca perceive the state, and the way in which residents are viewed and regarded as (un)worthy subjects by the state (Scott, 1998; Corbridge, et al. 2005).

3. Trading solar panels for grid power

I arrived in Lahuaymarca amid a period of overlapping transition between solar energy service and the arrival of the national electrical grid. Household rooftops were outfitted with SHS, while cement utility poles stood newly erected and distribution lines were suspended high above the main road. Thin service wires drooped down from the tall cement utility poles to much smaller wooden posts and then reached the houses and connected to new energy meter boxes, embedded with fresh mortar into the sides of the homes’ earthen walls. Despite the appearance that solar energy and grid electricity were both operative, only the

¹¹ Estimates from 2015 indicate that large scale hydroelectric dams (48.4%) and natural gas (46.4%) serve as the overwhelming source of energy generation for Peru’s national electric grid (SEIN, Sistema Eléctrico Interconectado Nacional). Small-scale hydro-electric, biomass/biogas, solar, and wind make up the remaining 5.2%.

SHS were functioning at that time. On one of my last days in Lahuaymarca I sat on the porch belonging to my neighbor and town matriarch, doña Zeneida, taking notes on recent interviews and waiting for the rain to stop. A local resident named Rodrigo showed up to chat and offered me a sip of a plastic soda bottle filled with homemade cane liquor called *cañazo*. As we drank, I peppered him with questions about the upcoming grid extension and his thoughts about this nearing transition from solar to grid. He told me he wanted to keep his SHS instead of letting LSA remove it once the grid arrived (as the company confirmed to me it would do). Like many other residents he was concerned about the prospect of being forced to forfeit his SHS, which was widely seen as much more reliable than the grid electricity in these rural parts. Lahuaymarquinos plainly felt that the grid could offer more electrical capacity than SHS, but also knew the grid was susceptible to power outages caused by foul weather, and that the energy distributor, Caxa Eléctrica, was slow to remedy rural power outages. Like much of Lahuaymarca, Rodrigo's clear desire to keep his SHS spoke to the degree to which residents had grown accustomed to the benefits solar energy systems provided and their apprehension towards electricity from the grid. Residents found themselves in a contradiction—they preferred the SHS, which they saw as more reliable and nearly unfailing, compared to an unpredictable grid and the poor service offered by the state, which they soon would have to accept. The solar-to-grid transition soon to take place in Lahuaymarca outwardly appeared to represent linear progress from partial access to energy and lighting via SHS, to a more technically robust infrastructure, via the national electric grid. Instead, I suggest that grid electricity in rural areas of Lahuaymarca represents an infrastructure of mimicry that is “not quite” as good as the grid power provided in nearby urban areas, and a “representation of difference that itself is a process of disavowal” (Bhabha, 1994, 86). The lesser quality of rural infrastructure reinforces the differences between urban and rural dwellers; it reminds us of *campesinos*' “partial” and “incomplete” presence in the eyes of the state and reifies their position as inferior citizens of Peru (86).

3.1. Reliability and cost of solar power vs. grid power

Residents asserted that with access to grid power they would acquire electro-domestic tools like TVs and blenders, and use electricity to support activities like carpentry and sewing. Grid power and SHS were commonly understood as belonging to two distinct categories: saying things like “the grid has more benefits; for carpentry, or whatever use. The (solar) panels are just for lighting” (*Cableado tiene más beneficios; para carpintería, para cualquier uso. Los paneles son para luz, no más*). But residents' frequent and most revealing comment comparing the SHS with the grid succinctly captured their predicament, “the grid is stronger, but the (solar) panels don't fail you” (*La luz tiene más potencia, pero los paneles no te fallan*).

In the same way that residents expressed their firm reliance on the consistent technical performance of the SHS, they also placed a great value on the fixed monthly cost of SHS service. Residents demonstrated palpable uncertainty and worry about the financial disruption that this transition to grid power represented. Amid their humble existence, residents would soon be responsible for paying for and installing interior electrical equipment in their own houses, including wires, plug-ins, switches, and light bulbs. This is because Peruvian law only requires the public distribution company to install electricity equipment up to the meter, located on the exterior of the house, while the interior equipment

is the responsibility of the homeowner. In contrast, the SHS are installed by trained technicians and include all necessary interior equipment, even the light bulbs. Along with grid extension imposing a new expense and responsibility on residents in order for them to have grid electricity, residents were also worried about how much this new energy service would cost them. Although, like many rural areas, their energy meters will likely operate on a prepay system,¹² residents showed widespread concern about this unknown cost. Thus, while the “grid has more benefits” in residents' view, it correspondingly meant the more electricity they used, the more they must spend. Residents live a precarious existence and derive a sense of financial security from knowing that they can use their SHS as much as the system will allow for a set price that never fluctuates. Despite the advancements that the grid offers, it opens residents up to an increased sense of economic vulnerability around energy that had largely been resolved by the SHS.

3.2. Poor grid service and reluctance to forfeit solar home systems

Residents poignantly discussed the technical and financial worries generated by the thought of moving from the *Casa Solar*'s SHS to state-provided grid power. Yet much of what residents said also expressed the unpredictability about what grid electricity would mean for them. This ambivalence between the two technologies, a sort of straddling of two imperfect realities, was best captured by a resident named Marcos, who was in fact a recipient of one of 10 demonstration panels that were installed in individual homes in various communities during the pilot phase of *Casa Solar* in 2009. Showing how much the SHS had become an integral part of his life in Lahuaymarca, he told me defiantly: “Let the grid come but I'm not giving up my (solar) panel.” Given the frequent power outages and the negligent reputation that Caxa Eléctrica had in the area, there was little wonder why he and others were unwilling to give up their SHS in exchange for a supposedly superior grid, that reports heard over the radio had long contradicted.

Despite their relative isolation, Lahuaymarquinos were well informed about goings-on in surrounding towns through attendance at nearby markets and festivals, word of mouth, and for the most part, through the radio. The radio served a principal role in informing residents about local affairs and especially, shaping their opinions and understanding of the grid electricity service in the area. Largely through radio reports residents had come to understand that the grid was unstable and suffered frequent outages, that Caxa Eléctrica was slow to respond to service disruptions in rural areas, and that the grid brought with it safety concerns for their children and livestock. One morning a resident named Victor showed up at my house, hoping to share his thoughts about the community's energy service. We spoke about the town's transition to the grid and he described how he had heard that many communities in the surrounding areas experience power outages and that these people make calls to Caxa Eléctrica for days to have their electricity reestablished but get no response. From what he had heard, Caxa Eléctrica's service was much poorer in the rural areas than in and Cajamarca and bigger towns. He added that contacting Caxa Eléctrica itself can be a challenging task, since communication from the countryside to the city is difficult, and further exacerbates the effects of a power outage. His comments were representative of many that residents had made to me over my time there—that service in their isolated villages was subpar and their demands for service went unheeded by state energy distributor, Caxa Eléctrica.

For residents that spend much of their time outdoors, dedicated to

¹² In poor rural areas where access is difficult and customers' energy consumption is low, companies often use a pre-pay system. Instead of reading a user's energy meter every month and distributing a bill to each household, the users purchase a pre-paid card from a local, authorized agent. The cards have a code on them that the user then manually enters into their energy meter or via cell phone network, depending on the technology used by the company.

agricultural activities and raising livestock, they were keenly aware and commented that the grid was frequently affected by natural causes like fallen trees, heavy rains, and thunder and lightning storms. Much like Victor's description above, other residents were fearful about nature's ability to disable a finicky grid and disapproval about the time it reportedly took for service to be returned to normal. Residents' accounts of the duration of power outage varied from two to three days, to 15 days, to a month. But their comments on the erratic grid were always coupled with contrasting statements describing the stability of the SHS. Beyond issues of dependability, residents also perceived the grid as a very real safety threat compared to the innocuously safe SHS. Again, they recounted stories about neighboring villages and family members whose houses experienced fires or had burned down entirely due to faulty electrical issues related to the grid. Both male and female residents also expressed concern that their children and livestock may be harmed by running into or playing on the electrical poles.

Touching on a specific concern that leads to a much broader theme of this article, Victor voiced his worry that there may be "manipulation of the wires," (*manipulación de los cableados*) resulting in the theft of electricity once the grid arrives. While theft of electricity in developing countries is not uncommon, it brings into question whether the electric grid can not only support extension into rural areas such as Lahuaymarca, but also provide comparable electrical capacity as supplied to urban customers. Comments from the manager of LSA, Carla Saenz, cast doubt on the grid's capacity to satisfactorily supply energy to former *Casa Solar* customers. She spoke of the considerable voltage drop that occurs when installing thousands of kilometers of wires to reach remote rural households. And since grid electrification projects always end up excluding some households due to geographical challenges, energy theft is inevitable and further increases voltage drop. This has resulted in residents located near the outer edges of the grid complaining that their household electricity has barely enough voltage to power a lightbulb, that reportedly illuminate so poorly they are no brighter than a candle. Saenz described how at another *Casa Solar* community near Lahuaymarca, where grid electricity service had begun just 10 days prior, residents were already lamenting their dissatisfaction with the performance of grid energy. Saenz reported that these residents, much like those of Lahuaymarca, did not want to give up their SHS and told LSA officials "I'll keep paying (for SHS)" despite having grid electricity. Reflecting a certain frustration with the contradictions and constraints of this rural reality, Saenz said "you can't have a panel if you already have the grid."

Saenz then explained that she personally had no qualm with allowing residents to utilize both the SHS and grid power, but that LSA was legally obligated to remove SHS once the grid arrived, as Peru's energy regulations prohibit a household from receiving the FOSE subsidy for both their SHS and grid connection. As a result, LSA would begin removing SHS from Lahuaymarca once the grid became operative there. However, she emphasized, the removal of SHS would take place over an undetermined amount of time. This uncertain timeline was due to the logistical constraints of removing SHS from Lahuaymarca and the other nearby communities that received power as part of the same grid expansion, as well as the challenge of warehousing and performing a technical review of all of these SHS before installing them in new communities.

This brief narrative from LSA helps substantiate what Lahuaymarquinos have long been aware of—that the grid infrastructure implemented in Cajamarca's countryside is inferior to that provided in more urban areas. This provision of a public good that is the same but demonstrably unequal, works to reinforce rural residents' view that the state is incapable of effectively providing public goods in remote areas, and that as rural *campesinos* they are viewed by the state as inferior citizens whose socioeconomic development needs do not merit the state's most robust infrastructure services. The above narratives show that the changeover from SHS to grid infrastructure is not a linear progression. Rather it is characterized by uncertainties and contradictions,

as the arrival of modern infrastructure will bring back many of the safety, financial, and energy insecurities that residents thought they had moved beyond and left firmly in the past.

4. Conclusion

The ethnographic work presented here contributes to scholarly understanding of how rural people perceive, negotiate, and contest transitions from solar energy to grid electrification. On one hand, the *Casa Solar* program has been successful in compelling residents to pay for their ongoing energy service. LSA officials attribute this success to the organization's community development efforts, such as workshops and trainings, that have clearly explained the parameters of the program to residents and helped foster their sense of ownership of the program. However, my ethnographic research has revealed that it was residents' fear of LSA cutting the power to, or removal of their SHS equipment if they fell behind in payment, that compelled them to continually pay for program service. Interestingly, this financial compliance has simultaneously created feelings of empowerment within residents, who have come to perceive themselves as "coproducers" of energy service in collaboration with this socially-driven NGO. Still, from a technical standpoint, the SHS represent a sub-optimal technology, which only provides limited electricity and light for a few hours a day.

On the other hand, while grid power cannot be physically removed like a SHS, the arrival of the electric grid relegates residents to being passive recipients of energy service from a state energy distributor. By many accounts this energy distributor has shown to be reluctant to provide energy in isolated rural areas, and when it does, the technical capacity and customer service in these areas is known to be poor. For these rural dwellers, the impending access to this hallmark of modernity—grid electricity—in fact camouflages social inequalities, as grid capacity in the countryside is not comparable to or as reliable as the electrical capacity and energy service provided in urban areas.

This reduced quality of infrastructure further strengthens the contrasts between urban and rural residents, serving as a material and symbolic reminder that rural Peruvians occupy inferior positions in society and are only perceived as "partial" citizens in the eyes of the state (Bhabha, 1994, 86). This is important, because as scholars have pointed out (Anand, 2017; Nye, 1992; Larkin, 2013; Howe et al., 2016), infrastructures have long been considered to represent the aspirations and trajectories of modernity—cultural and physical assemblages that help to differentiate advanced societies from those still in the process of developing (Anand, 2017). What these paradoxes of energy provision tell us, is that Peru's aspirations and trajectories of modernity, understood as social and economic inclusion and full and equal claim to citizenship rights, are still a long way from being realized.

These sites of infrastructural transitions are deeply informative about the social conditions during the time in which they occur (Howe et al., 2016), as the testimonies in this paper answer the question that infrastructure continually poses about who benefits from its presence and who is marginalized by its absence (Anand, 2017). In Lahuaymarca, state-led grid extension efforts have a poor reputation, earned through years of power outages reported on the radio and through word-of-mouth. The extension of faulty infrastructure into rural areas not only reflects the inferior position and stereotypes held by the communities the grid is meant to serve, but is also one of the "constitutive elements of historically structured spatial inequalities" (Weinstein, 2015, 2). This article challenges the often accepted notion that infrastructure is "by definition invisible, part of the background for other kinds of work" (Lampland and Star, 2009, 17), as Lahuaymarquinos' conceptions of future grid infrastructure clearly contradicted this. Instead, they see infrastructure as something highly faulty and thus, visible. Not a tool to carry out other kinds of work, but rather a source of disruption of their daily lives; something that may appear as invisible from the outside, but is in fact the focal point of their daily concerns and a cause of deep worry (Carse, 2012).

The state-led efforts to extend energy provision in Lahuaymarca threaten the town's solar energy arrangements, which have generated local empowerment and become socially and culturally embedded (Bjorkman, 2015), ever reliable and representative of an established level of citizenship. If energy infrastructure is a symbol of the “good life,” an amenity that facilitates advancement and equality, then the state-led grid extension may represent a troubling paradox for Lahuaymarquinos. Residents' narratives suggest that their anxieties and fears are not simply transitional, but a more enduring condition of their existence, a place of negotiation between their past and an unfulfilled future (Gupta, 2015; Bebbington, 2009). And if building new infrastructure serves as a kind of promise made today about the future (Appel et al., 2019), then the energy future for this community and many others like it, is surely precarious. As one resident described, they must give up a certain past for an unknown future, one that is necessarily reliant on an unreliable state, “It's no longer unordinary, we are already accustomed to the reality of the government ... it always happens ... they come, they offer you [a project], and it can be up and running and in the middle it stops.”

Declaration of competing interest

None.

CRedit authorship contribution statement

Dustin Welch García: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Project administration, Funding acquisition.

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Appendix A. Supplementary data

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