What is it like to get electricity for the first time? With humanity at the peak of almost two-centuries of rapidly increasing dependence on fossil fuels to power civilization, this seems like an odd question. How easy it is for us in the industrialized nations to forget the large swaths of people, mostly poor, mostly rural, who remain energy poor (Sanchez, 2010). The one-time gift of cheap fossil energy has fueled the wonders of our modern world: getting humans to the moon, transforming night into day and enabling historically unprecedented mobility. Characterized by a kaleidoscopic, intersecting maze of spaces and ‘scapes’ (Appadurai, 1990), the fractured complexity of the globalizing world grips the imaginations and challenges the traditional cultures of the two-thirds of humanity in the ‘developing’ world. High-energy globalism, with its unequal terms of trade, is continually relegating the peasant and remnant tribal world to relative material and symbolic backwardness, even as it fosters whole cultures of desire for movement and ‘progress’.

Electricity symbolizes this globalizing culture, and is particularly associated with urban ways of living and cultural forms. Centrally marked by its...
lack of electricity, rurality as a result is widely associated with poverty and isolation. Rural electrification upsets and blurs this urban/rural dichotomy (already a simplistic and problematic trope (cf. Nugent, 1996) because it: (1) facilitates rural economic options, counteracting poverty and thus quelling the lure of urban migration; and (2) allows for various forms of communication, urban consumption styles and connectivity, counteracting isolation. Such new economic options and enhanced connectivity strengthen ties to globalization forces, raising a tangle of new and unexamined issues and tradeoffs regarding cultural autonomy and change.

While grid and locally generated electricity in rural areas might seem to have similar social and cultural effects, under the assumption that electricity is always just electricity, technology is never neutral. Here we draw on ethnographic and survey research from 2008–2011 with members of four off-grid communities in Cajamarca, Peru, to examine how electrification with small-scale renewable technologies intersected local social fields and cultural understandings. In general, while rural electrification with small-scale renewable energy technologies has provided meaningful benefits for villagers’ daily living patterns (e.g., lighting, communication and entertainment), it has not yet altered longstanding livelihood strategies nor basic social, cultural, political or economic relationships in the region. While villagers value decentralized, renewable energy because of these benefits and its strong connection with local natural resources, local production of electricity and off-the-grid autonomy, they continue to aspire for the material and symbolic benefits of 24/7 grid-quality electricity.

Within that general frame, however, specific alternative energy technologies (solar, wind and micro-hydro) offer villagers different opportunities and constraints, due to differences in the quantities and qualities of electrical energy these technologies produce and their particular intersections with economic, social, political and cultural circuits. It is these local complexities, connections and tradeoffs which we examine in this paper.

**Contexts**

Peru has enormous energy resources: world-class solar incidence (especially in the desert southwest), wind (moderate by world standards, but good on the north and south-central coasts and at high elevations), substantial hydro potential (especially on the east slope and threatened by climate change, though there are no glaciers in the study region), oil (though Peru has likely already peaked) and natural gas (deposits of which are still in the early stages of being brought to the world market). The associated energo-politics are complex and dynamic, and there has been a dramatic quickening in the last decade or so in assessing and developing these resources and in extending the national grid (Ministerio de Energía y Minas, 2010). Popular concern with various of these neoliberal privatization and energy resource development schemes is widely apparent, however, from popular uprising in Arequipa in 2001 over the proposed sale to a foreign company of the regional electric system, to the deadly confrontation in June, 2010, in Bagua, near northern Cajamarca Region, over the government’s proposed leasing of oil and gas deposits in the eastern rainforest lowlands.

Despite this overall energy wealth, however, Peru has one of the lowest electrification rates in Latin America. An estimated 23% of the total population (nearly 6.5 million people) and more than 67% of the rural population in Peru did not have access to electricity (Ministerio de Energía y Minas, 2007). Cajamarca is one of the poorest regions in Peru; 64.5% of the population lives below the poverty line (with incomes lower than the national poverty line) and Cajamarca has the lowest electrification rate in the country at 40.2% (Ferrer et al., 2010), all pointing to the region’s predominantly rural character.

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1 'Rural' and 'rustic' share the same etymology.
While grid electricity is rapidly expanding in Peru and throughout the world, there are significant barriers to electrification at local levels (Sanchez, 2010). In Peru, the extreme geography of Andean peaks and vast jungles and sparse rural population in the Andean highlands pose huge challenges to extending the conventional energy grid. Dispersion of households and low electrical demand (poverty) make extending electricity grids highly unprofitable for private companies (vid. Nye 1990, p. 287ff.).

By the 1980s, with micro-hydro, and the 2000s with solar and wind, renewable energy technologies came to be seen as a way to tap Peru’s enormous energy resources and bring the benefits of electricity to off-grid villages. Rural electrification with such technologies came to constitute a core program of work in rural development in Cajamarca by Soluciones Prácticas-ITDG (SP), the South American office of UK-based Practical Action, assisted in the last several years by US-based Green Empowerment (GE) and several other European NGOs, mostly Spanish. Since 1991, SP in Cajamarca has focused primarily on agro-pastoral rural community development projects, basic services (rural electrification and water) and disaster prevention, all based on the Schumacher-inspired appropriate technology movement (Schumacher, 1973). SP is highly regarded in the Cajamarca region, where more than 3000 families in 21 villages have benefited directly from access to energy, including 28 micro-hydro systems (total 1.5 MW) powering 200 small businesses as well as 209 PV panels (Soluciones Prácticas, 2006). Like SP, GE focuses on community development through rural electrification with renewables as well as on water and watershed conservation, so the collaborative potential between the two is strong.

**THE STUDY SITES IN REGIONAL CONTEXT**

Despite the tropical location, at this high altitude cold and wind dominate the landscape year-round. Annual temperatures vary from 10–15°C; December to May is the slightly warmer invierno, the rainy season, while June to November is verano, the dry season, which is not only colder but accompanied by strong winds. Wind, sun and water resources sufficient to harvest for producing electricity therefore occur in different amounts, places and times.

All four study sites lie an hour or two north of Cajamarca city in rugged, grassy jalca or páramo terrain at generally high altitudes, ranging from a low of 3,150 meters at Porcón to 3,260 at Yanacancha, 3,825 at El Alumbre and 3,900 meters at Alto Perú. Villagers throughout the Cajamarca hinterland depend overwhelmingly on small agricultural plots for subsistence – the suite of familiar high-altitude cultivars like potatoes and other Andean tubers (oca, olluco), barley and broad beans, as well as some minor crops like mashua and chocho, or chugur (lupine), and most families also raise some combination of sheep, pigs, guinea pigs, chickens and rabbits for household consumption. Horses (but few donkeys) are often raised, primarily for transport and hauling bulky or heavy loads, such as milk jugs. Most villagers herd dairy cattle for daily sale of milk to trucks fanning out from Cajamarca city dairy plants, and seasonal sale of cattle for modest cash flow, a pattern dating back to the late hacienda period in the late 1940s when Nestlé built an evaporated milk plant there.

Prevailing social patterns in rural Cajamarca are marked by nearly 400 years of peasant domination by the hacienda system, and especially by twentieth century transitions of these relations linked to growing rural population, seasonal labor emigration to coastal sugar plantations and

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2 Rural electrification since the Velasco era has been in the hands of the state, with a complex, evolving and still largely unexamined relationship among national, regional and local governments, mining companies and rural dwellers.

3 Nestlé has always relied primarily on larger producers in the main urban basin; we do not know when collecting of milk from these highland communities began.
to Amazonia, sale of marginal hacienda lands and the agrarian reform (cf. Deere, 1990) and, more recently, large-scale gold mining (Bury 2004). While many haciendas in Cajamarca and elsewhere in highland Peru were already faltering economically by mid-century, the remainder which had not already been divided up by owners were expropriated during the late 1960s agrarian reform into a variety of state-directed groupings, only to be parcellled out to hacienda workers with the reform’s general failure in the 1980s (Mayer, 2009). The Porcón cooperative, one of our study villages, is a notable, if not unique exception to the disintegration of reform-era cooperatives (Love ms.).

In this paper we examine how electrification proceeded in the communities of El Alumbre, Alto Perú, Yanacancha and Porcón through NGO-driven community development projects over the past two decades. We deal primarily with the first two, which were both more recent and primarily wind projects, given their high altitude, and draw comparative material from the others. During this discussion, however, we must not forget that like rural dwellers throughout the moist northern Peruvian highlands, members of these four communities are not economically, socially or energetically isolated. Households depend on purchased batteries, flashlights, candles and kerosene lanterns, and a few households used gasoline generators, for example to run lighting in the chapel at Alto Perú. Their apparent isolation is remarkably deceptive, for most make regular trips to Cajamarca city to collect milk payments, have family living or studying there, and they have been enmeshed in, indeed dependent on regional marketing systems which rely on truck and bus transportation.4 A veritable maze of graveled roads and rutted tracks criss-cross even the most remote jalca grasslands and deep valleys.

El Alumbre, the first rural community in Peru (and apparently the first in the world at high elevation) to be wind-electrified, is a small center in southern Hualgayoc province with a school and medical post serving some 33 dispersed households. The school also has a small PV panel, installed as part of SP’s Yachán project (described below under Yanacancha). Beginning in January, 2008, wind turbines were installed in two phases: 100 W turbines on each of 21 houses and a 500 W turbine on the school, and a year later 12 more family systems and a 500 W turbine on the health center. The turbines were designed by SP and fabricated in Lima. Our discussion of El Alumbre is based on notes generated from our participant observation and informal interviewing during 15 total days (spanning 2007–2010), as well as on two household surveys (pre- and post-installation) conducted by the author (AG), SP staff, and Ingeniería Sin Fronteras - Spain.

Alto Perú, another community in Peru to be wind electrified, is a dispersed network of 85 households in the highest reaches of San Pablo province. A small cluster, situated along the main road north between Cajamarca and the Hualgayoc provincial capital of Bambamarca, was electrified in June, 2009, this time with a micro-grid to power 13 houses by means of two 500 W turbines. There is a small PV panel on the elementary school in the lower part of the community, a gift from a neighboring gold mine when the community gave permission to construct a line of high voltage towers across the middle belt of the community lands. In 2010, solar panels were installed for a clinic and for all of the rest of the homes not connected to the wind-powered grid, and a pico-hydro system is being planned as we write, making Alto Perú an emerging demonstration site of wind, solar and hydropower together. Our discussion of Alto Perú is based on notes generated from our participant observation, house-to-house surveys and informal interviewing during 30 total days (spanning 2009–2011), as well as on four focus group sessions with ronda (local vigilance committees) and APAFA (parent–teacher associa-
tion) members as well as two household surveys (pre- and post-installation) conducted by AG and SP staff. The study is enriched by a detailed house-to-house post-installation survey conducted by SP staff. In addition, AG lived and worked in the region of Cajamarca on various energy and water projects for 21 months (2008–2009). We examine in more detail elsewhere various social and cultural consequences in this hamlet from developing, installing and operating these energy technologies, including some primarily city-dwelling villagers’ strategic uses of rurality (Love & Garwood, in press).

Yanacancha is the central village in a constellation of roughly 15 settlements which participated in 2002–2007 in the Yachán Project, a comprehensive, EU-funded rural development project in the north of Cajamarca Province (Elliot, 2008). As part of the Yachán project, PV panels were installed on schools in nine villages in the same watershed. We visited but did not directly study a micro-hydro system in Yanacancha, also built as part of this project, which powers homes, public services and small businesses. Our discussion of PV is based on notes and an internal report generated by two US students from their participant observation and informal interviewing during 12 total days of a six week research period in 2009 (Severson & Inouye, 2010). Of 13–15 villages that got panels in 2006, only nine were able to be relocated (internal NGO records were incomplete); interviews with ronda and APAFA members were completed in most of these villages, with intensive informal interviews with teachers in four. Technical surveys were completed in the seven villages that still had their panels three years after installation (two were missing).

Porcón (or Granja Porcón), the last village we studied, took a very different development path out of the hacienda era (Love ms.). The hacienda was effectively taken over by the Ministry of Agriculture as a sheep breeding and agricultural experiment station in the 1950s, in conjunction with SCIPA (Servicio Cooperativo Inter-Americano de Producción de Alimentos), a US-, Canadian- and Belgian-advised Peruvian agricultural modernization program. With the Agrarian Reform of 1968 intent on cooperativizing many haciendas, in 1975 Porcón and adjacent haciendas and service cooperatives of smallholders became the SAIS (Sociedad Agraria de Interés Social) Atahualpa, a state-run cooperative. As agrarian reform unraveled nationwide in the 1980s, workers on the SAIS, most of them now evangelical Christians, achieved recognition as the Cooperativa Agraria Atahualpa Jerusalén de Trabajadores – one of a handful of cooperatives from that era to survive and prosper (Porcón, 2008). For present purposes, it is important to note that Porcón was site of one of SP’s earlier micro-hydro installations – a 35 kW station installed in 1992. As with Yanacancha, given our focus on the two wind projects, our discussion here of Porcón is limited, based on notes generated from a short visit in 2009 and three days of participant observation and informal interviewing by TL in 2010.

**WIND, SUN AND WATER**

In this section we explore both differences and similarities among the three energy resources tapped in these rural development projects. While all three are renewable and fueled people’s expectations and desires for electrification, each has specific characteristics which have intersected local development plans and aspirations in complex ways.

**Wind**

Cajamarca has important wind resources, but they are found primarily at the highest altitudes where agro-pastoral productivity is lowest. These are typically poorer, often more recently settled areas, though mine-related road traffic has been increasing rapidly in recent years, leading several of these families to set up small shops with food, crackers and various drinks. Wind potential declines at lower elevations, where most people in the region live.
Wind strength is very seasonal, with velocities during the windiest months almost three times stronger (9 m/s) than during the rest of the year (3.5 m/s) (Ferrer et al., 2010). Turbines are designed to operate at the prevailing lower wind speeds, so seasonally stronger winds are not fully harvested and rated output (e.g., 500 W) is only sometimes achieved. High gusts blew several vanes off at Alto Perú shortly after installation in July 2009. These and similar problems at Alumbre were promptly addressed by NGO personnel and technical design development aims to make the systems more durable in the highest gusts.

Wind is more local and episodic in nature than solar, but like solar is diffuse and picks up as the day proceeds, peaking in the early afternoon. While seasonal variation creates management problems and limits overall capacity, daily and day-to-day variation is handled by storage in deep-cycle batteries. Indeed, this is the heart of the technological solution to variable wind speeds, although batteries can only store a few days’ worth of energy; depending on the frequency of recharging, they eventually need to be replaced. Training of local managers to oversee the proper functioning of inverters and batteries is a central feature of these NGO community development projects. While the capital costs of installation were borne by the NGOs (with international foundation support) and the local government, the cost of the battery replacement is designed to be covered by the community’s reserve fund – build up with monthly tariff for the electricity.

Wind turbines are modular and available in several sizes, adapting to isolated farmsteads (as in Alumbre) or to clusters of households sharing power from turbines (as in Alto Perú). In various ways, social and cultural circuitry is as important as technology to project success. The microgrid management model in Alto Perú, for example, is working because most of the 13 families involved in the initial project phase are related, everyone knows the operator trained to manage the project and most belong to the same small evangelical church there.

**Sun**

Average annual solar intensity in the Cajamarca region is excellent by global standards and relatively good for Peru – over 2200 kWh/m². Solar intensity varies considerably with the weather, though unlike wind, because at the tropical location of these villages daylength and baseline insolation are relatively similar year-round. Unlike wind or water, there is little need to monitor sunlight potential in the community before installation, other than to adjust exposure and angle appropriate to latitude during installation. This is easily determined with available maps of PSH (Peak Sun Hours), unlike wind’s need for anemometers or hydro’s need for streamflow measurements. Solar panels, like wind turbines, can be placed right at point-of-use. Because sunlight is even more diffuse in nature than wind, panels (even more than turbines) are less physically dependent on specific sites. Whereas wind strength can be much greater for homes even just slightly uphill than others, or on taller support structures, solar radiation is essentially uniform across a village and generally stable from year-to-year. Solar, then, is even easier than wind for tiny energy applications like those in project villages, for example the schools electrified in the villages surrounding Yanacancha as part of integrated development project.

Like most renewable energy technology, solar photovoltaic systems are characterized by high up-front capital costs. As with wind, batteries have a several year life cycle, depending on the frequency of recharging, and eventually need to

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5 The projects studied were funded by a diversity of institutions including Soluciones Prácticas, Toyota Environmental Activities Grant Program via Green Empowerment, Ayuntamiento de Valencia via Ingenieria Sin Fronteras, WISIONS, Christadelphian Meal a Day Fund of the Americas and the local government.
be replaced. Also similar to solar systems, the controllers and inverters will eventually need to be replaced.

PV modules are even more scalable than either wind or (especially) micro-hydro. Coupled with high initial costs and solar panels’ direct point-of-use applications, for better or worse there was less need for the whole community to coordinate or decide on long-term projects. All this put more weight on institutional processes shaping the utilization of this technology, which in the nine Yachán project villages meant that SP staff, working with teachers (who are not village residents) and with the company from Piura which had been contracted to actually install the panels, were central in decisions about the utilization of the panels. In several villages, while parents and ronda members were supportive of teachers’ efforts to educate their children, and nobody was against the PV installations per se, there was palpable friction with teachers over who should utilize the electricity – teachers in classroom learning or community members for lighting for community meetings and charging cell phones (Severson, & Inouye, 2010). Panels in two villages – Baños Chanta and Quinua Baja, had gone missing under unclear circumstances. All this points again to the importance of social and cultural circuitry in the implementation of these new energy technologies, where local disputes can severely affect project outcomes; pueblo chico, infierno grande (small town, big hell), we were told. One result is that since only the schools were electrified (not homes), villagers continue to aspire to the greater strength and 24/7 reliability of hydro- (or grid) power, for reasons we explore below.

Finally, unlike either wind or micro-hydro, solar panels can be purchased (in Cajamarca city) by a single family, if they have the economic resources. Since 2010 there is even a company renting 50W solar panels to communities in the region, and as we write several families in another part of San Pablo province have already rented some. This portends shifts in energy provision from a public infrastructure good to a private consumer good, the implications of which are just beginning to come into view.

**Water**

As noted, Peru has tremendous hydroelectric potential, especially on the many Amazonian headwater rivers on the east-facing Andean flanks. About half of the nation’s electricity is generated by hydroelectric stations, such as one familiar to many tourists at the base of Machupicchu in southern Peru. While there is great potential for small-scale hydro development, perennial streams of sufficient capacity are unevenly distributed.

Micro-hydro is a well-developed technology which generates more electricity, more consistently than either solar or wind. The cost per kWh is dramatically less than solar or wind, making micro-hydropower an attractive option for rural development. It is produced at a small centralized plant, run by a micro-enterprise, and service is delivered to customers, like an energy utility. Having baseload power 24/7 means more opportunities for economic development. Power from Yanacancha’s station runs street lights (for ‘safety’, oddly enough), a dentist’s office, restaurants, manjar factory, carpentry, clinic (vaccine refrigeration and sterilizer), schools, and two computers with internet in a general store, in addition to domestic uses of electricity such as for lights, TVs, radios and cell phones.

In Porcón, electricity from the micro-hydro station was sufficient to launch a number of cooperative enterprises, including a sawmill (processing trees from their massive reforestation project), milk cooling machinery, lighting in the village center, and computers and other equipment in the coop office. Looms remain hand-driven, though, part of the increasingly tourist-driven ‘traditional’ (and feminized) work of the village (Love ms.). The cooperative-owned power station provided initial electrification – a crucial bridge for community development for over a decade before grid power arrived in 2005.
Located on perennial streams, micro-hydro provides greater reliability, 24/7 availability and more power (35 kW in Porcón vs. 4.3 kW for the combined turbines in El Alumbre, and 2 kW in Alto Peru), which in turn intensifies the sense that it is more equivalent to urban grid power. Dedicating at least some of the electricity to public lighting, both in Yanacancha as well as Porcón, points to this longing for the trappings of city life, even as rural enterprises in Yanacancha and especially Porcón increase local employment opportunities. As such, it seems that the common pattern of seasonal emigration by males to coastal and Amazonian lowlands for agricultural labor, or to Cajamarca city for other opportunities would be forestalled, but we have only anecdotal data on this point.

Unlike wind or solar, however, micro-hydro equipment cannot be easily removed and relocated should the national grid eventually arrive. Connecting the micro-hydro to the national grid is an option, but faces some technical and legal obstacles. Though up-front costs are not as severe, relative to the amount of power produced, canal and turbine station infrastructure is big and permanent. The micro-hydro system in Porcón still operates even though the national grid arrived six years ago.

Whereas hydro systems may have seasonal variations depending on rainfall and operators must keep an eye on water flow, wind and solar operators and users have to be more aware of the status of the natural resource and adapt their energy consumption over several days at a time according to how hard the wind is blowing (or the sun shining) and thus how fast their batteries are being charged or discharged.

And though water flow is typically predictable from season-to-season and year-to-year (generating systems are not constructed on non-perennial streams), its intersection with local social circuitry and cultural understandings is again critical to project success. It was remarkable to sit in on the heated debate at a community meeting in June, 2010, over who owned a local spring in the lower part of Alto Perú. Phases of village electrification subsequent to the wind project up at the road were proposed to tap into water for a pico-hydro station, but this brought its own set of issues. Who actually owned the spring? What did ‘ownership’ mean, actually, when the landowner there didn’t use much of the water and lived in Cajamarca much of the year anyway? Who owned the water once it flowed off the ‘owner’s’ property? Who gets to decide who receives the energy generated by the turbine; the owner of the land where the turbine is sited, or the community at large? In this case, another stream (with a willing landholder) was chosen for the pico-hydro project, illustrating the non-technical factors that go into site selection.

While we cannot explore local understandings and tensions over water in great detail here, a few observations about water are in order. Cultural valorization of water as well as politicized struggles over its control figure prominently in the Andes (e.g. Gelles, 2000). As if such tensions over water weren’t enough, Alto Perú stewards regionally-significant water supplies. The whole area is called ‘Lagunas’ on maps, and constitutes the headwaters of one of the primary tributaries of the Jequetepeque River. Water is heavily utilized by the growing number of large open pit gold mines in the region; the lagoon area is owned by the Yanacocha mine, and yet the Province of San Pablo has declared it intocable (untouchable) due to its importance for water resources in the whole province. Though this particular dispute is in a temporary judicial/political lull, it promises to flare up again as mining continues to grow, encouraged in Peru’s current neoliberal regulatory regime (cf. Bury, 2004). Tensions around this are palpable, revealed in the eager telling in Alto Perú of a story of a Yanacocha mine agent caught on community

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6 More work is needed on water rights in relation to micro- and pico-hydro water development projects (cf. Boelens 2008). We thank one of the anonymous reviewers for this lead.
property without permission by the ronda, who was made to walk naked at night off community lands. Regional conflict has already developed over the Yanacocha mine’s focus on the waters of Cerro Quilish, believed to be a major source for the city of Cajamarca’s water supply (Arana, 2007). There are rumors of back-door land use arrangements between the mine and the Porcón cooperative down-valley from the mine, and reforestation efforts with several species of non-native pines at Porcón have stoked local concerns about loss of water through excessive evaporation.

Such disputes point to a fundamental difference between water and wind or sun. Unlike solar or wind, water resources are always localized and have many other uses already recognized socially, culturally and economically; as a result, the sharing of water resources to generate electricity is much more contentious and has to be negotiated first, making the harnessing of hydro (unlike solar or wind) energy necessarily a more community-level project. The community scale of micro-hydro projects necessitates a coordinated effort, backed by the government or NGOs, unlike the sale or installation of an individual solar panel.

MANAGING AND USING THE NEW SYSTEMS

Central to each project is a modelo de gestión – a management model for operating and maintaining the systems. Since community development is the overall project goal, parallel to the process of installation an SP sociologist and an engineer worked with the community to form a management model and train people on all of the skills necessary to keep the systems working. An oversight committee was elected and technicians were selected, with the requirement of living permanently in the community and having an elementary school education. These technicians accompanied the SP engineer on all technical tasks, so that they each had basic skills; one of them was chosen by the committee and SP staff, based on how well they had learned the administrative and technical skills and their general reputation for community participation, and was named the ‘operator-administrator’ of the energy micro-enterprise. He was in charge of collecting a monthly tariff (10 soles, about US$3) from each user. The funds go into a reserve fund, kept at a bank in Cajamarca, accessible only with three signatures (from the operator, a community authority and an energy user). The fund is used to provide a stipend to the operator, make small repairs and replace batteries in the long run. In Alto Perú, the local municipality has also agreed to feed the reserve fund, and the Operator-Administrator is also in charge of managing the solar panels and wind turbines installed. In Alumbre, the following stakeholders were part of the management model: the municipality of Bambamarca, the committee for community electrification, the rural business entity, the fiscal control entity, and the users. (Soluciones Prácticas, 2010a) In sum, there is a system of checks and balances designed to promote the fair and transparent management of the electrical services (cf. Love & Garwood in press).

In El Alumbre, there is widespread satisfaction with the wind system and its several benefits. Members of rondas charge their flashlights and cell phones and have light for evening meetings and preparing documents; a local store now has light at night; the medical post can keep vaccines and medicines in a refrigerator; an enterprising young man runs a local radio station, broadcasting local news and messages to neighboring villages; children have light for studying at home at night and the school has computers and audio-visual equipment which parents and teachers believe has greatly improved learning. Though 86% of the users have had to skip a monthly payment, the vast majority say the flat rate quota of 10

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7 We are most familiar with the models developed in relation to wind installations in El Alumbre and Alto Perú, since this is where we focused the fieldwork on which we report here.
soles/month is appropriate and the micro-enterprise operator is doing a good job. There are ongoing problems, however: knowledge of how the management system works is murky for most, attendance at user meetings is spotty, and many householders are not adequately maintaining their batteries and the vanes were replaced by SP staff with an improved design after seeing that the initial design did not withstand the strong gusts of wind. Since the project installation several years ago, the national grid seems to be slowly creeping closer. While villagers would like the reliability and 24/7 availability of grid power, there is general uncertainty about eventually connecting with the national grid, including its higher costs (depending on amount used) and whether government-controlled grid power would be a good thing overall. (Soluciones Prácticas, 2010a)

Patterns are similar in Alto Perú, though fewer families were involved in the wind part of the project (13 vs. 33), and since few had school-aged children, the educational benefits were minimal from the wind generators. The teacher of the school however reports noticeably higher performance of the students since the solar panels were installed and is optimistic about the newer pico-hydro project for powering a computer. Depending on both supply and demand, villagers could count on 1–4 hours of electricity per day with the wind power. People remarked on improved air quality and lower outlays from having replaced candles and kerosene lanterns with CFL lighting. Apart from lighting for a small store, renting out lit rooms to road workers generated temporary income and there is talk of setting up a road-side restaurant although that plan has not been realized yet. Villagers recognized that the amount of electricity was insufficient to power other business activities that require greater energy. Apart from lighting, the primary uses for the electricity were to run TV/DVD systems for news and entertainment (radios running on batteries were already in use), and to charge cell phones. As in Alumbre, for similar reasons the chief community organization that benefitted of the new electricity was the ronda. People were generally pleased with the cost of the electricity and the way the system was being managed, and understood the management model and who was involved. Unlike Alumbre, most families were keeping up with their monthly payments. These latter differences are products of the different social relations in Alto Perú, which consisted of fewer, more closely related households. Like villagers in Alumbre, however, Alto Peruanos would like to see grid power extended to their area, and seemed less anxious about possible downsides to this. (Soluciones Prácticas, 2010b)

**DISCUSSION AND CONCLUSIONS**

The problems examined above are microcosmic examples of a growing worldwide challenge with developing renewable energy resources to generate electricity: how to best develop and integrate this rather unpredictable electricity generation into existing use patterns, social fields and cultural understandings. For many rural communities, small decentralized energy systems are more economical than grid extension but they still usually require subsidies for installation and a management model for paying for maintenance.

At the time of installation, the national grid was inaccessible for the communities in this study, hence the selection of decentralized small-scale energy production by NGOs working with community members. Grid construction and ongoing maintenance and operation costs are high (cf. Revolo, 2009), so connecting to the grid is an option only for places with that have profitable resources, have the ability to make a large economic investment, are already close to low voltage grid infrastructure, or where political forces may more directly affect strictly market considerations. Since installation, the national

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8 Many people from neighboring villages with no electricity are coming to Alto Perú to charge their cell phones (one sol per charge).
grid has arrived in Porcón and may be slowly approaching Yanacancha and Alumbre. The high voltage lines soar directly above the village of Alto Perú, a visual reminder of their proximity to yet exclusion from the power that the grid represents.

Brokering external funds, public and private, with community needs, NGOs help overcome startup costs, bring technical know-how and develop local capacity to manage these systems. For example, SP working with the local government of the San Pablo Province, in which Alto Perú and several other community-based renewable energy projects are implemented, has developed a Plan for Rural Electrification using renewable energy to power the communities not included in the medium-term plans for grid extension. The local government is co-funding the renewable energy projects – a demonstration that these decentralized systems are increasingly seen by the state actors as a viable option for remote communities. To leverage Peru’s initiatives of decentralization to local governments, SP worked with the local government to develop the capacity of the local government to access state funding for renewable energy projects.9

The systems examined here are designed to meet just the needs of the local community.10 At a local level, as we have argued, integrating these renewable technologies poses complex challenges, given variability in the quality and quantity of wind, sun and water energy resources, both in space and time, and meshing these with local social patterns and cultural understandings. Of these three small-scale renewable energy sources, only micro-hydro provides reliable electricity of sufficient quantity and wattage to run motors and sizable electrical equipment. Wind and solar power important community assets like schools and medical posts, but simply do not provide enough electricity to change basic production patterns involved in raising food or managing dairy cattle. Villagers are well aware that even such simple devices as irons, let alone agricultural equipment such as milking machines, cannot be powered with the limited electricity from the wind and solar projects at the scales installed. Few commercial improvements directly from electrification are evident in Alumbre, Alto Perú and the Yachán project villages (except for Yanacancha itself, which also has micro-hydro). Though some people would like to open up businesses, insufficient electricity (as well as costs, market access and lack of know-how) hold them back.

Given the generally low and often interrupted amounts of electricity generated by wind and solar technologies, most members of the project communities still expressed enthusiasm for the basic electricity – a step up from candles and kerosene. This sentiment was captured, for example, through a conversation with a father who was planning on sending his son to go live in Lima. He was conflicted by the idea, because while he wanted to give his son more opportunities, he didn’t want him to pick up the bad morals of city life – an age-old story. He told us how, if they had water and electricity, he could then stay in the community, maybe open up a carpentry workshop. ‘What more could we want?!’ Since the time of the conversation in 2009, he provided volunteer labor to construct a micro-hydro plant in his community and at this time the son is attending the local high school.

With material benefits so limited, it has been the symbolic value of electrification which also fuels villagers’ enthusiasm for these projects. Even a little electrification meant that aspirations for ‘urban’ amenities, such as health and education, could begin to be met. Electricity symbolizes ‘progress’, especially when used in schools and clinics. While obviously catering to NGO project goals, villagers still frequently commented on how lighting extends activity, particularly chil-
dren’s studying, into the night, further valorizing education for the social mobility it promises.

Even more significant was our finding that electricity was valued primarily for the sense people had that they could now be connected, or ‘in the loop’, even while living out in the country. The major economic effect of these wind and solar projects so far has been the increased consumption of domestic and educational electronic devices. Many households already had or quickly acquired cell phones (which seemed to be used mostly by men and which worked, ironically, thanks to the tower system erected by the gold mines), televisions, radios and DVD players (there is a vibrant market in cheap, pirated DVDs in Cajamarca). While we have not studied the type of TV programming consumed or its long-term effects, people noted how they were better able to track the 2011 presidential election.

Despite all the technical and other differences among wind, sun and water resources discussed above, villagers’ general enthusiasm for renewable energy systems is based on the meanings they attach to them – both the convenience of stepping up of urban consumption styles and enhanced communication just discussed, as well as the ways in which these technologies ground energy production locally.

Local natural resources
Wind, sun and water are not just ‘natural resources’, they’re resources natural to an area and characteristic of a place. These qualities connect with villagers’ social identities, and have an immediacy very different from the impersonality of tapping distant resources to produce and deliver grid electricity. Speaking of the health benefits, a villager in El Alumbre remarked:

Ese humo lo absorbíamos y eso nos hacía mal a los pulmones y ahora es más saludable, sobre todo porque usamos del viento, una energía natural y

sana (we absorbed this smoke and it damaged our lungs, but now it’s healthier, above all because we’re using the wind, a natural and healthy energy).

Paradoxically, while the wind turbines, solar panels and hydro generating systems are made elsewhere, villagers value that they do their work with local resources in this place.

Local productivity
In addition, villagers’ investment of sweat equity to harness local resources through human labor to produce renewable energy is symbolically like agro-pastoral production more generally, as it generates value from known, personally experienced, place-based labor and resources. This is very different than the relationship urban dwellers have with their grid-delivered electricity. Urbanity is associated with the consumption of goods made it far-off places, whether goods mass-produced in factories or media images consumed by watching television. The electricity powering this consumption generally comes from hidden sources. Energy that can be produced and consumed in the same community seems to preserve a sense of self-reliance, central to their pride of place and understanding of ‘rurality’. One villager in El Alumbre started his own radio station:

Para pasar música no es o sea no salimos diario, sólo salimos dos días a la semana y a veces pasamos comunicados o avisos que es al servicio de
la comunidad (to play music mostly, maybe twice a week, and sometimes we broadcast communications or notices to serve the community).

Villagers evinced a growing sense of intimacy in the production of electricity; for example Alto Peruanos choosing to call the wind turbines mari- posas (butterflies) rather than turbinas, and painting one of their main buildings blue and red, the colors of the turbines and vanes.

11 Though we did not examine this, linguistic references to bosques eólicos (wind forests), parallel to English ‘wind farms’, point to this meaning.
**Autonomy**

Communities armed with their own power source are finding new forms of autonomous representation in regional economic and political matters, closely correlated with those communities with micro-hydro systems, which as we have seen open up so many more development possibilities. As one can see on their website (Porcón 2008), the community is extremely proud of the business initiatives they’ve launched and the recognition they’ve gained as a model agrarian cooperative producing dairy, wood, weavings, and other products. Though not part of our study, the community of Conchán, north of Bambamarca in Chota Province, has micro-hydro power from an earlier SP project. First they had an 80 KW system, then they added an additional 100 KW system. The national grid came close four years ago (in relation to gold mine development), but they decided to just keep their micro-hydro system, since the cost was about the same and they could have ‘autonomy’ (*fide* Walter Mantilla, SP sociologist).

In conclusion, rural electrification with small-scale renewable technologies is replete with paradoxes, blurring the urban/rural dichotomy which frames so much development work. With just a little electricity rural villagers can begin to consume like urban-dwellers and counteract their felt exclusion and isolation, even as rural vitality is enhanced by decentralized energy production based on local production using local natural resources.

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**References**


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