CASE

Power from manure and agro-waste for rural electrification (Santa Rosillo, Peru)

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Supporting case for Business Model 5	
Location:	Santa Rosillo, San Martin, Peru
Waste input type:	Livestock waste and other agro-waste
Value offer:	Biogas, manure and slurry, electricity efficient waste and water management, climate change mitigation and adaptation, Economic development through renewable Energy Increase of local food production, and added income streams
Organization type:	Public and non-government organization
Status of organization:	Owned by Municipality of Huimbayoc, Operational since 2010; plant managed by the community including its O&M
Scale of businesses:	Small electricity generation plant of 16 kW supplying power to 42 families
Major partners:	Comercial Industrial Delta SA (CIDELSA), SNV, Regional Government of San Martin, Cordaid, Fact, Practical Action

Executive summary

Santa Rosillo, a rural community in the deep jungle of the Peruvian Amazon in northern Peru, is more than 16 to 21 hours away from the nearest city, Tarapoto, and is only accessible by boat and on foot. Santa Rosillo consists of 42 households (220 people) who have an average monthly income ranging between USD 23 and USD 47. Due to the extreme remoteness of the village, prior to this project, most of the community did not have access to electricity and relied on candles, batteries and lighters for domestic lighting. Approximately 12% of the population had access to electricity through private diesel generators.

In 2010, SNV Netherlands Development Organisation (SNV), a non-profit international development organization, in partnership with the regional government initiated a rural electrification project to install two bio-digesters in the village linked to a power generator and mini-grid to provide electricity to the community. The community's primary economic activity is livestock and agriculture (cocoa), and all organic waste is fed into the two bio-digesters. The biogas generated is fed into the electricity generator and electricity is distributed to each house. The installed electrical capacity is 16 kW which provides electricity to 42 houses, the local doctor's office, the local college and public lighting for approximately

5.3 hours per day. Approximately 60% of the slurry by-product produced by the bio-digesters is then used as fertilizer to improve the soil quality of the communal grazing area, while the remaining 40% is sold to local farmers. Comercial Industrial Delta SA (CIDELSA), a Peruvian engineering company, supplied the two lagoon bio-digesters for the project.

KEY PERFORMANCE INDICATORS (AS OF 2013)						
Land use:	3,000 m^2 (including community grazing area for animals)					
Water	50,000 L/year					
Capital investment:	USD 130,519					
Labor:	1 x system operator / administrator (full-time)					
O&M cost:	USD 0.57 per kWh (total levelized cost of electricity over a life of 20 years)					
Output:	16 kW for 5.3 hours/day, supplying 85 kWh/day of electricity, Biol (solid fertilizer) and Biosol (liquid fertilizer)					
Potential social and/ or environmental impact:	42 households now have access to electricity; it has reduced the environmental pollution from manure and improved livelihood of remote community					
Financial viability indicators:	Payback period:	N.A.	Post-tax IRR:	N.A.	Gross margin:	N.A.

Context and background

The Santa Rosillo community is located in the district of Huimbayoc, 190 km from the city of Tarapoto in northern Peru. The community's main activities are agriculture, livestock and forestry, all of which generate organic waste, which was not being utilized prior to this project. Because of its remote location, the community is not connected to the national energy grid and had very limited access to gas or electricity, leaving its 42 families reliant on diesel generators or candles for power and lighting. In 2010, SNV in alliance with Practical Action and local partners commissioned the installation of two bio-digesters by CIDELSA, a company with over 10 years of experience building and installing bio-digesters. The project in Santa Rosillo was the pilot installation for SNV's rural electrification program, "BIOSINERGÍA: Access to energy with biofuels in the Peruvian Amazon." The National Public Investment System, a government investment initiative, funded the grid connecting the power generators to the village whilst the foundations CORDAID and FACT funded the installation and equipment costs for the power generators.

Market environment

Prior to the installation of the bio-digesters, only 12% of the population had access to electricity, generated through private generators and solar panels. Average usage was 2.5 hrs/day and the monthly cost ranged from USD 9.6 to over USD 465 per household/family. The families with higher costs were those that had small businesses such as a restaurant or furniture shop. The remaining 88% used battery-powered lights and candles for lighting. This project provides electricity to 100% of the community of Santa Rosillo. One of the principal advantages of this project is the anticipated low cost of electricity compared to other available forms of rural electrification. Each family is undergoing a grace period until January 2013, at which point a flat rate of USD 6 (average cost prior to project) will be charged until an exact wattage consumption has been determined. The final cost will be determined by demand, operational and maintenance costs, in addition to the population's ability to pay (approximately USD 6/month).

In Santa Rosillo, the cattle alone produce approximately 300 kg of manure daily that is now used as fuel rather than contaminating the local waterways. If this project proves successful it is intended that it will be rolled out to other rural communities throughout Peru.

Business model

The project has two key value propositions: providing electricity service to houses and businesses and providing fertilizer to farmers in Santa Rosillo (Figure 51). The municipality, donor agency and local organization played a key role in mobilizing the community and financial resource to establish electricity service provision. Since the project results in carbon offset, there is potential for generating revenue from sales of carbon.

FIGURE 51. SANTA ROSILLO RURAL ELECTRIFICATION BUSINESS MODEL CANVAS

KEY PARTNERS

- Municipality of Huimbayoc
- SNV
- CIDELSA
- Regional Government of San Martin
- Cordaid, Fact and Practical Action

KEY ACTIVITIES

- Agreement with relevant partners
- Community mobilization
- O&M of the biogas unit
- Sale of electricity and fertilizer
- Organic waste collection

KEY RESOURCES

- Land
- Capital
- Labor
- Organic waste

VALUE PROPOSITIONS

- Providing low-cost electricity service to houses and businesses in Santa Rosillo from livestock and agriculture waste
- Produce high quality solid/ liquid fertilizer

CUSTOMER RELATIONSHIPS

- Interaction with community through a local a subsidiary that manages the operation of the unit

CHANNELS

- Through appropriate agreement and self-interaction
- Direct sale of bio-fertilizer

CUSTOMER SEGMENTS

- Households and businesses
- Farmers

COST STRUCTURE

- Investment cost (Land, building, machines)
- Operational cost (raw material, labor, maintenance cost)

REVENUE STREAMS

- Sale of electricity to households/business
- Sales of fertilizer/slurry

SOCIAL & ENVIRONMENTAL COSTS

- Potential leakage of CH_4 from bio-digesters

SOCIAL & ENVIRONMENTAL BENEFITS

- Jobs creation
- Environmental benefit through reduced CO_2 emissions by generating electricity from renewable source
- Better local environmental condition by improving quality of water and reducing soil pollution and foul doors
- Reduced GHG emission (CH_4) and climate change mitigation

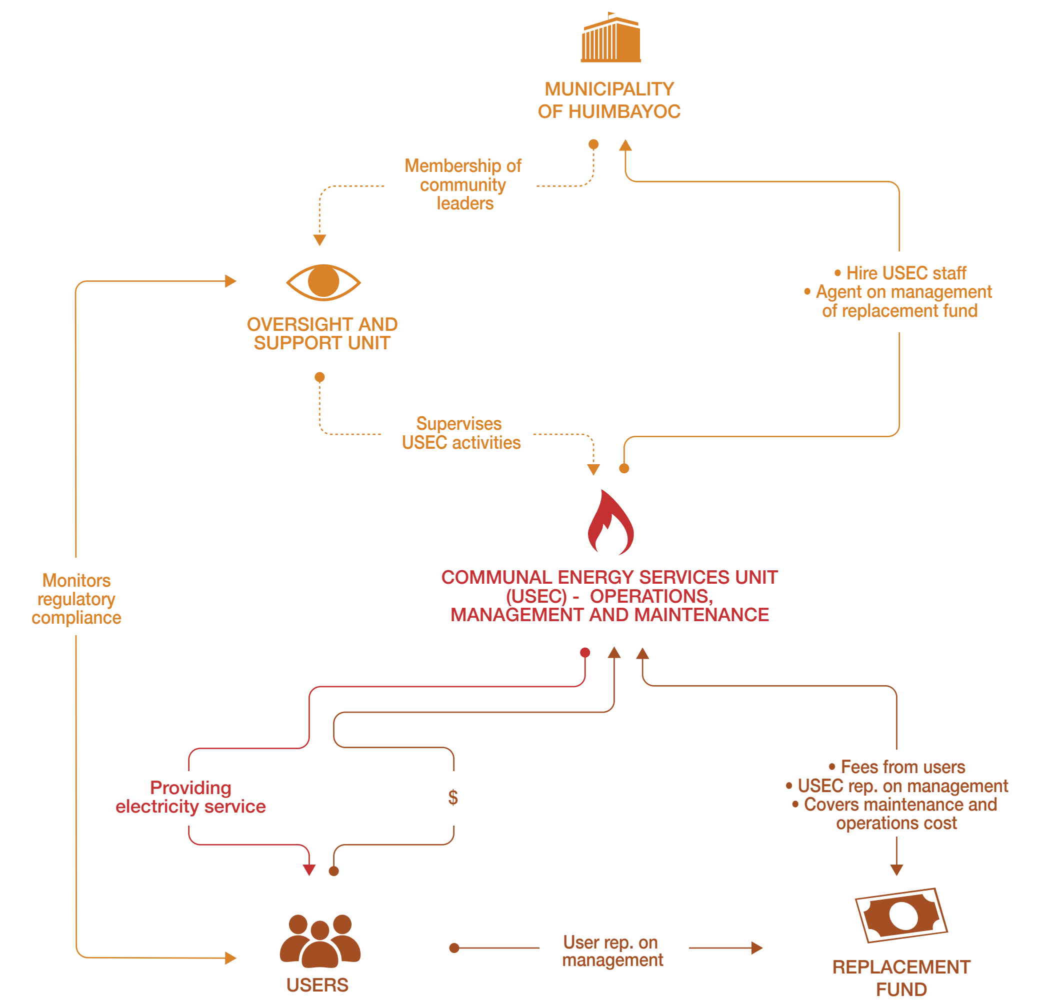
Value chain and position

Santa Rosillo's two bio-digesters are fuelled by the waste produced by the community's cattle (approximately 60), which are kept in a partial barn. Cattle spend 12 hrs/day in a communal pen, and two members of the community are responsible for collecting excrement once daily. Each cow produces approximately 5 kg of manure per day, yielding a total of 300 kg, which is loaded into the bio-digesters on a bi-weekly basis.

The project is designed as a cooperative structure to provide energy service at a cost lower than the possible alternatives. Figure 52 displays the overall management structure. The following describes the role of key actors in the process:

- Communal Energy Services Unit (USEC): The USEC team, made up of two people from the community, is responsible for operating and maintaining the system on a daily basis in direct and constant contact with both users and community authorities.

FIGURE 52. SANTA ROSILLO RURAL ELECTRIFICATION VALUE CHAIN



Note: RF = replacement fund; USEC = Communal Energy Services Unit.

- Municipality of Huimbayoc: The municipality owns the power generation and distribution system and hires USEC to maintain and operate it. The municipality voluntarily undertakes equipment inspection and maintenance checks alongside USEC and subsidizes the maintenance costs that cannot be covered by revenues from the system.
- Oversight and Support Unit: Comprised primarily of community leaders; this unit is responsible for monitoring USEC and user compliance.
- Users: The community members of Santa Rosillo, who will pay a monthly fee for electricity used, once established. Each user will have electricity meter installed in their homes and sign an electricity supply contract.

Income generated from service fees will be used to create a revolving fund designed to cover operational, management and maintenance costs. The revolving fund will be managed by three people from the USEC, a user representative and a municipal agent.

Institutional environment

Electricity access in rural Peru is challenging because of the mountainous terrain and scattered settlements. Low energy consumption and limited purchasing power per household add to the challenge. Investors are therefore not attracted to these projects unless the state provides the right financial incentives and other necessary requirements. Renewable energy is a largely unexploited market in Peru and small-scale renewable energy (biogas, biofuels, small-hydro and solar energy) provides less than 1% of national energy supply.

In 2008, the Peruvian government passed a legislative decree to promote inclusion of renewable energy, which includes biogas. This has helped renewable energy production growth exponentially. The government of Peru projects renewable energy to provide 7% of the national energy supply by 2017. The Ministry of Energy and Mines and its General Directorate of Rural Electrification (MINEM-DGER) have 437 rural electrification projects clustered into 35 groups. The total investment is estimated at USD 418 million and will benefit 1.2 million people (Mitigation Momentum, 2015). Additionally, DGER is implementing 16 other special projects which will benefit 150,000 people; approximately USD 140 million will be invested.

The government of Peru has identified rural development, environmental protection and energy security as national priorities. They have developed a legal and regulatory framework that promotes competition and investment in the sector and, more recently, have successfully developed mechanisms to promote the use of our vast renewable energy resources. The 2013–2022 National Rural Electrification Plan produced by MINEM, in concordance with an Energy Universal Access Plan, establishes a policy for the sector with the aim is to raise the rural electrification rate from 87% to 95% by 2016. The national electrification rate has increased from 55% in 1993 to 87.2% in 2012. The National Rural Electrification Plan 2013–2022 provides strategic direction to provide access to electricity to 6.2 million people in the next 10 years. Peru is undertaking efforts to increase access to energy via auctions for solar photovoltaic systems, grid extension, mini-grids with hydro, solar and wind. The Law for the Promotion of Investment in Renewable Energy Generation[3] grants competitive advantages to projects for renewables.

The following policies have been established to address these issues:

- Use of renewable energy in electricity generation (2008), amended 2011: The government is promoting the use of renewable energy resources by providing tax concessions to qualifying projects, e.g. biomass, wind, solar, geothermal, tidal and hydropower.

- Non-conventional renewable energy resources in rural areas (2005): This law provides additional tax concessions to qualifying projects that promote the use of non-conventional renewable energy in rural communities.
- Investment in electricity generation using water and other renewable resources (2008): In order to incentivize the investment in a renewable energy infrastructure, all renewable energy projects benefit from accelerated depreciation for tax purposes.

Technology and processes

The two bio-digesters, each with a 75 m^3 capacity, produce biogas for electricity (16 kW), and bio-fertilizer. Figures 53 and 54 depict bio-digesters and the power generation system, which in turn is connected to a micro power grid, extending electricity to each family.

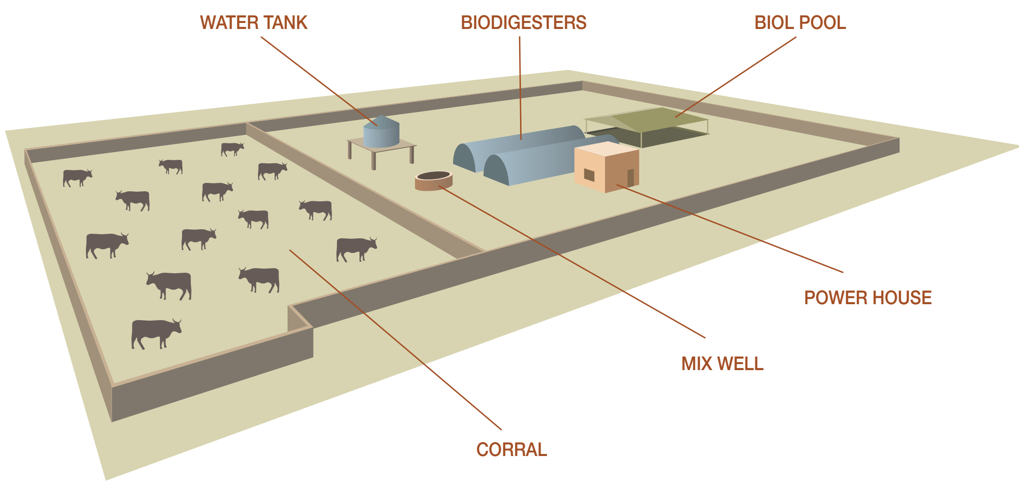
The amount of biogas generated will depend on the quality of cow manure collected, as a rough estimate 1 kg of cow manure will generate about 40 L of biogas.

Despite popular belief, the amount of waste going in the digester is almost equal to the amount coming out. However, the quality of the waste is altered for the better (less odor, better fertilizer, organic load reduced, less polluting). Waste coming out of the digester can be separated (solid/liquid): the solid part can be composted (Biol) and the liquid part can be used as liquid fertilizer (Biosol) or can be treated further and disposed.

Funding and financial outlook

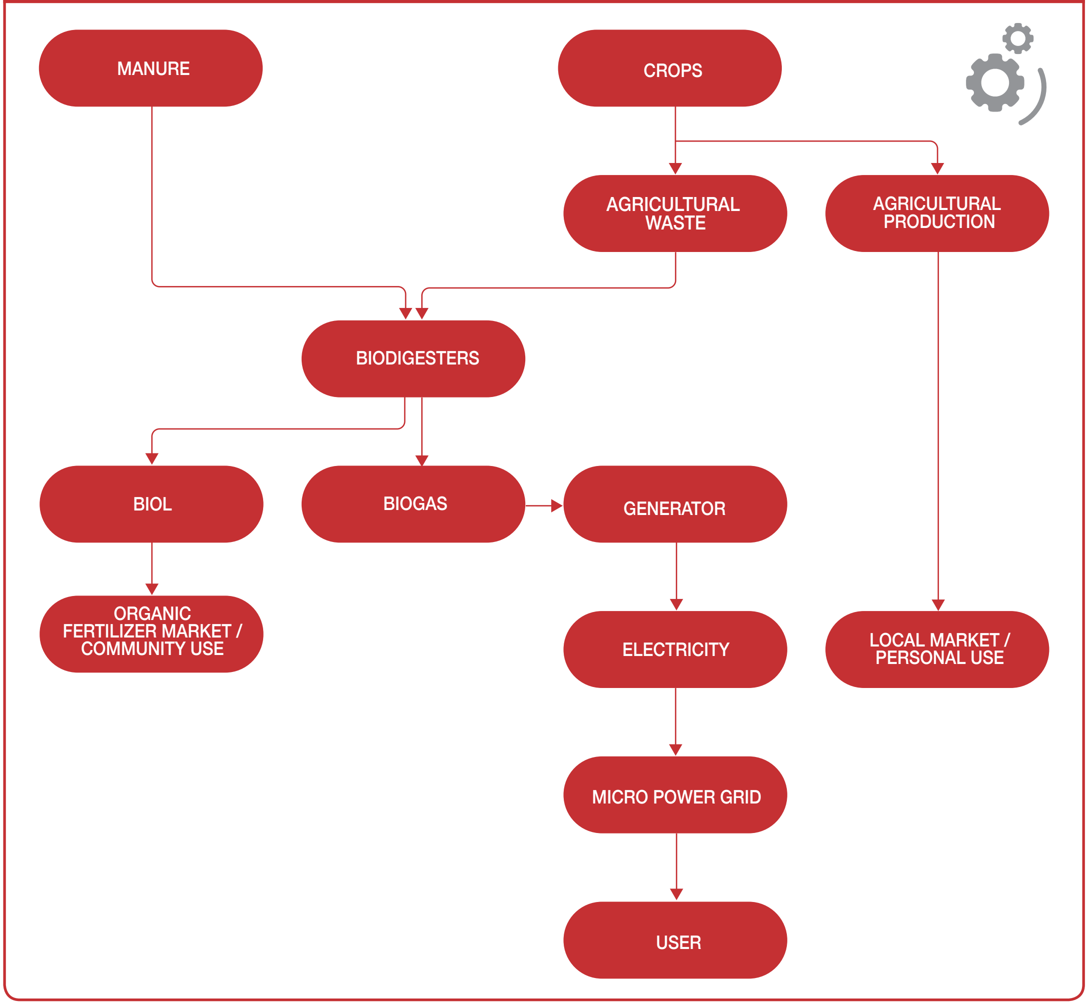
The total project cost of USD 130,519 was funded as grant through a public-private partnership between the Regional Government of San Martin (GRSM) (30%), FACT and CORDAID (68%), in addition to each beneficiary family contributing USD 59 (2%) (Table 17).

FIGURE 53. SANTA ROSILLO RURAL ELECTRIFICATION GRAPHIC



Source: Veen, 2014; modified.

FIGURE 54. SANTA ROSILLO RURAL ELECTRIFICATION TECHNOLOGY AND PROCESS



Source: Veen, 2014; modified.

TABLE 17. INVESTMENT SOURCE AND AMOUNT

ITEM	AMOUNT (USD)
Regional Government of San Martin	39,285
FACT & CORDAID	88,305
Beneficiary (USD 59/household)	2,930

Each family was given a grace period until January 2013, at which point a flat rate of USD 6 (average cost prior to project) will be charged until exact wattage consumption has been determined. The final cost will be determined by demand, operational and maintenance costs, in addition to the population's ability to pay (approximately USD 6/month). In this case, the electricity generator is created to meet a need in the community, which pays for the service. In turn, these revenues allow the proper operation and maintenance of the company, so the service becomes sustainable over time. The sale of slurry will provide an additional income stream.

The following assumptions were built into the financial projections (Table 18):

- Total generating capacity of 619,040 kWh over a 20-year life, slowly ramping up to full capacity over the first 10 years. The generating capacity of the bio-digesters is 16 kW whereas the demand of the community is 13 kW.
- Demand for electricity will grow at a continual pace of 2.5% annually, primarily driven by population growth. Demand is expected to be approximately 17 kW by 2022, slightly higher than the capacity of the two bio-digesters (16 kW).
- Service fees are based on estimated operational and maintenance costs for equipment repairs, replacement parts and servicing. Total estimated costs are USD 3,516 in Year 1, reaching USD 5,621 by Year 20. This assumes a growth rate of 2.5% in line with demand.
- The bio-digesters can produce roughly 1,041 L of slurry per day which, with a potential sales value of USD 0.05/L, will generate a monthly income of approximately USD 1,500. It is estimated that only 40% of the generated slurry will be sold, helping to cover O&M costs that are not covered by the monthly fee income.

TABLE 18. SANTA ROSILLO FINANCIALS

PROJECT FINANCIAL SUMMARY				
USD	**YR0**	**YR1**	**YR2**	**YR3**
Investment				
GRSM	(39,284.56)			
FACT & CORDAID	(88,304.84)			
Community investment (~USD 59 per family)	(2,929.69)			
(+) Income		**11,198.21**	**11,286.10**	**11,376.18**
Annual usage income (50 families)		3,515.63	3,603.52	3,693.60
Growth rate			2.5%	2.5%
Sale of Slurry (41% total production)		7,682.58	7,682.58	7,682.58
(–) Costs		**(11,263.17)**	**(11,263.17)**	**(11,263.17)**
Operational / Maintenance		(11,263.17)	(11,263.17)	(11,263.17)
Cashflow	**(130,519.09)**	**(64.96)**	**22.93**	**113.01**

Source: Authors.

Socio-economic, health and environmental impact

The project benefits the Santa Rosillo community, its approximately 50 families. More than 220 people now have access to electricity, allowing them to improve their living conditions. Children now have more hours of light to do homework, enhancing the learning process. There are improved teaching conditions in schools, enabling the use of computers. The slurry (effluent from bio-digesters) can be used to enhance crop yields, further improving family incomes. There will also be a reduced likelihood of domestic accidents from the use of candles and better illumination in the house, as well as improved conditions in the community health centre, including the ability to now refrigerate drugs and vaccines.

By extracting methane out of waste and using it to produce heat and/or electricity, we ensure that the waste will not degrade in an open environment, therefore reducing direct methane atmospheric emissions. By managing and reusing the livestock excrement, the project has substantially reduced pollution of the local rivers and lakes. Moreover, the energy provided by the biogas is likely to displace fossil fuel which is the main contributor to GHG emissions. By installing a digester the farmer can profit from the biogas by reducing doors and enhancing the fertilizing value of the manure. The project requires less area than aerobic compost, reduces the volume and weight of landfills, produces a sanitized compost and nutrient rich liquid fertilizers, maximizes the benefits of recycling and in the process improves the air quality through improved odor and reducing groundwater contamination.

Scalability and replicability considerations

The key drivers for the success of this business are:

- Strong financial support from municipality, donors and local agencies.
- Strong community participation.
- Simple low-cost model.
- Ease of available animal and agro-waste.

The community of Santa Rosillo is the representative of a large number of rural Amazonian villages within Peru and in other countries with similar conditions that are not connected to the electric grid or other natural resources (e.g. sun or strong water current for solar or hydro power) required for alternative micro-power solutions, but that have high volumes of unused organic waste (e.g. from agriculture or livestock). According to the Peruvian national Census (2007), there are 2.2 million households in rural areas, 36% of which do not have access to the national grid equating to approximately 800,000 households. Many such communities are heavily reliant on cattle and other livestock that produce significant waste, which traditionally causes on-going water pollution and land degradation.

Summary assessment – SWOT analysis

The key strength of the project is its low-cost alternative electricity solution for a remote region and a proven technology that can readily use abundant available waste source (Figure 55). The weakness of the project is its inconsistency in provision of reliable electricity and in addition if the community size grows and when the demand for electricity increases, the electricity generated will not be sufficient to meet new higher demand.

The key threat to the project is from the remoteness of the site. In the event of system failure, due to lack of local technical know-how and available skill, time taken to repair the unit will be longer. This can result in the community losing faith in the overall project. However, based on the success of Santa Rosillo's electrification project, it has very high potential for replication and it can help the Peruvian government define policies to ease the replication of the business with minimum obstacles.

Contributors

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References and further readings

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FIGURE 55. SANTA ROSILLO RURAL ELECTRIFICATION SWOT ANALYSIS

	HELPFUL TO ACHIEVING THE OBJECTIVES	**HARMFUL** TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ▪ Simple and cost-effective example of public-private partnership that can be applied in numerous geographies and communities ▪ Provides a relatively low-cost alternative for electricity to communities that cannot gain access to the grid because of their remote location ▪ Uses an abundant waste source to generate off-grid power ▪ Utilizes very simple technology, easy to operate without significant prior technical knowledge ▪ Limited/low operational and maintenance requirements ▪ The production of fertilizer and gas is not heavily dependent on the type of excrement/waste used	**WEAKNESSES** ▪ Low cost to users is highly dependent on sale of slurry, which is anticipated to provide a subsidy ▪ Power from bio-digesters is inconsistent. The continuous supply of service requires complex infrastructure, unavailable waste volumes and costs that would exceed income ▪ Total energy capacity of 16 kWh may not be adequate if the community grows at a higher-than-anticipated rate ▪ High upfront cost may be a barrier to entry for some smaller communities/governments ▪ Payback period highly dependent on ability to sell fertilizer
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ▪ Highly replicable model in Peru, and in other countries and communities with similar dynamics (estimated 800,000 applicable households in Peru alone) ▪ Peruvian national policy promotes and provides substantial tax incentives to communities and governments seeking to partner on similar rural electrification strategies. ▪ Potential involvement of microfinance organizations to aid funding of the bio-digester roll-out ▪ Government of Peru promotes renewable energy ▪ High value bio-fertilizer for additional revenue ▪ High quality renewable fuel, biogas has several proven end-use applications ▪ Positive environmental impact ▪ Climate change mitigation and adaptation	**THREATS** ▪ Remote location of project combined with lack of local technical knowhow could lead to under maintenance of and hence failure of the system. ▪ Potential competition from large bio-fertilizer companies ▪ Possible risk from leakage of gas thus having negative perception of health risk to employees may force O&M costs higher

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Case descriptions are based on primary and secondary data provided by case operators, insiders, or other stakeholders, and reflects our best knowledge at the time of the assessments 2015/16. As business operations are dynamic data can be subject to change.