

Success Factors of Renewable Energy Projects in the Colombian Off-grid Zones from a Community Perspective:

A Qualitative Evaluation of Three Pilot Projects

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Introduction

The use of renewable energy (RE) sources represents a feasible option for rural electrification in a country like Colombia with vast territories not connected to the national grid but a relatively good availability of RE resources. This potential has been already recognised on a national and international level and first pilot projects exist. Nevertheless, the available descriptive and evaluating information of those projects is substandard.

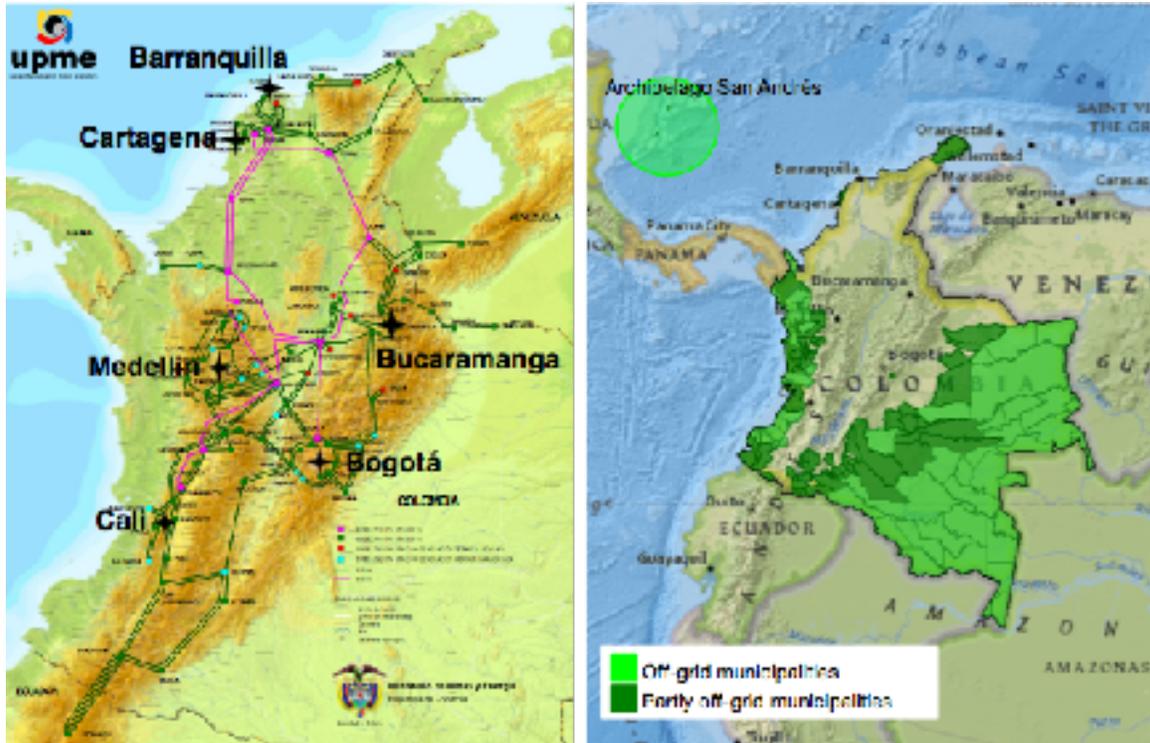
Therefore, this master thesis focuses on three RE pilot projects in Colombia, which differ in technology, location and cultural context in order to develop success factors that might guide future project developers. A particular focus on the community (end user) perspective allows detecting success factors that correspond to the interdisciplinary socio-technical character of such RE delivery systems.

Colombia's urbanisation rate is high and there is a socio-economic division between the cities and the rural areas that cover most of the country's land. This urban-rural gap has consequences for the electricity provision to the Colombians living in remote and difficult to access places. More than half of the Colombian territory is not connected to the national grid. Around 1.27 million (2015) people live in small and often dispersed localities in these vast off-grid regions. Their power supply ranges from zero to 24 hours per day and it is mostly produced with diesel generators. In 2015 it was estimated that approx. 432'000 Colombian citizens had no access to an electricity service at all.

First RE projects using solar-, hydro- or biomass-energy already exist – some of them for many years. The targeted communities are mostly poor, difficult to access and culturally diverse e.g. indigenous or Afro Colombians. Although up to now all projects are non-profitable, even the Colombian government has released a new legislation (Ley 1715) in 2014 for the promotion of public and private RE investments (on- and off-grid).

Figure Map of the Colombian Interconnected
System in 2013 (SIMEC, 2016)

Map of the Colombian Off-grid Zones in 2016
(CNM, 2016)



The three pilot projects

Biogas project, North of Cauca

The two main elements of the project are a semi-industrial bio-digester of 300 m³ on the farm Gualanday in the municipality Santander de Quilichao and 20 small digesters installed at eleven families and nine agricultural schools in six different municipalities in the north of the Colombian department Cauca. All of the digesters work with the manure of pigs. The individual digesters work with the waste products of six or more pigs and produce biogas and fertiliser for one household.

The semi-industrial digester is able to generate 220 m³ of biogas per day and an expected amount of fertiliser sufficient to yield 88 hectares of land assuming the piggery counts with a maximal number of 1200 pigs. Nevertheless, the fertiliser is distributed equally to the 60 families living on the farm of 200 hectares. The bio-digester provides the five households living close to the piggery with biogas, the heater lamps for the piglets and the community building that serves as a regular meeting place for communitarian events (normally around 150 participants).

The Bio-Digester on Gualanday and the Bio-Digester in Toribio



The project is located in the north of the political department Cauca, between the western and central cordillera of Colombia, in the indigenous community of the *Nasa*, which make up more than 95% of the population of the association of the Indigenous Tribes of the North of Cauca (*Asociación de Cabildos Indígenas del Norte del Cauca* [ACIN]). The 90'000 people of the *Nasa* community have a proper communitarian system of organisation. The region of the *Nasa* has been strongly marked by the presence of armed groups during the Colombian civil war, leaving behind a big number of displaced people and victims and, above all, mistrust towards all the involved state and non-state actors. Due to this scepticism and fundamental cultural differences, the community's objective is to continuously strengthen its cultural, territorial, administrative, legal, economic and energy autonomy. A strong community sense supports this autonomy desire of the *Nasa*. In their eyes, everything that benefits the community also benefits themselves.

Mini Hydro Project, Sierra Nevada

The key element of the project is the repowering of an almost 25 years old mini hydroelectric power plant in a mountain village. This repowering includes the replacement of the local grid, the installation of the new equipment and the fixing of the existing energy infrastructure. The old turbine originally had a capacity of 150 kW but due to continuous overloading the capacity was around 130 kW at the moment of the replacement. The principal element of the new equipment is a second turbine with a capacity of 150 kW. The goal of the project is to have the two turbines working simultaneously and reaching a capacity of 300 kW.

The Powerhouse and the New Turbine in Palmor



The *corregimiento* of Palmor is an administrative part of the municipality of Ciénaga in the Colombian department Magdalena and located in the mountains of the Sierra Nevada de Santa Marta (Sierra Nevada) on an altitude of 960 meters above sea level. Palmor consists of an urban centre and 16 *veredas*, isolated settlements (groups of one or more households). The population of Palmor is estimated to be around 4000 people with approximately 1900 living in the urban centre. Palmor was founded in 1970 by a group of farmers who had been displaced during the civil war of *La Violencia* (1948-1958). The population is very diverse with multiple Colombian origins and cultures. The region's economic revenues come from agriculture, mainly from the coffee production and other food crops such as tomatoes, honey, manioc and fruit.

Solar-Diesel Project, La Guajira

This project in the Colombian desert combines PV technology with a diesel plant and has started in April, 2012, directly after the failure of a previous technology experiment. The PV plant counts a total capacity of 320 kWp with approximately 100 kWp from solar trackers from the previous project and 220 kWp from a recently installed solar farm. The design of the plant is the following: During the day the PV installation provides the energy for consumption and for the recharge of the batteries. In the evening hours when the batteries reach 70% of their capacity, a diesel generator automatically starts to charge the batteries and to secure power consumption. According to the simulations, the diesel plants should approximately work ten hours per day.

The Two Axis Solar Trackers and the New Solar Farm in Nazareth



The two locations Nazareth and Puerto Estrella belong to the municipality of Uribia on the peninsula and the political department of La Guajira. From Uribia, the closest city, it takes about five to seven hours to Nazareth or Puerto Estrella in an off-road vehicle. There is no road in this desert region. Due to this remoteness all the transport of merchandise is complicated and expensive.

Nazareth is located close to the mountains of *La Makaira* and shows a more cloudy weather, which is why the locals call it an oasis. Puerto Estrella on the other hand is almost always sunny and lies on the coasts. Approx. 2500 people live in these two villages. Most people of both villages belong to the Wayuu indigenous. The population of the Wayuu in Colombia was estimated to be around 270'000 in the year 2005, 98% of them living in La Guajira. The Wayuu's native language is the principal language in Nazareth and Puerto Estrella, even though, most of the people speak Spanish too.

Conclusion

Besides socio-economic development and the prevention of carbon emissions, the use of clean energies for rural electrification can even act as an incubator for the national RE development. However, it always implies that “modern” technology is first applied to poor people whose future living conditions depend strongly on the electricity provision. The failure of the poly-generation park in Nazareth, the current solar-diesel project's predecessor, demonstrates that the project should primarily focus on the electricity service and not on performing a technology experiment. The stakes are high because a failed project hinders local development and risks a bad first impression of RETs what makes the impact on climate change mitigation and national RE development unlikely.

This thesis tried to elaborate success factors of RE projects in the Colombian off-grid zones that matter from a community perspective. This customer orientation is more and more common for non-profit activities in order to know the real needs of the beneficiaries. The success of this RE projects certainly depends on many factors and

the community perspective can only assess part of it. Nevertheless, this thesis shows that an interdisciplinary research approach that perceives distributed RE systems as a socio-technical constructs is appropriate. It is supposed that due to the ethnical diversity in rural Colombian it is particularly helpful to consider the social part of the system.

The findings of this thesis show that from a community perspective RE projects in the Colombian off-grid zones should a) let the community assess the technology autonomously, b) use selected recipients and effective communication channels for technology instruction and information, c) define a local management concept at an initial project stage, d) equally involve all community members and respect local cooperation forms, e) make feasible promises regarding the project results and f) establish a tariff system in an adequate decision-making context and set prices that consider the quality of electricity and the financial ability of each user.

The example of the biogas project shows that REs are not just an option for electricity generation in rural Colombia. Considering that agriculture is a key sector in Colombia, such simply designed family bio-digester that use a small amount of biomass for the production of cooking fuel and fertiliser could be useful solutions for regions that are difficult to access and still depend on firewood for cooking and/or have unused biomass waste.

In addition, the hydro project proves that such RE pilot projects can survive during a long time, especially if there is an option to repower and adjust the electricity provision to an updated amount of users.