

Project Proposal for the REPIC Platform

1. Project Profile

Applicant

| | | | |
|------------|---|-------------|------------------|
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Project

| | |
|------------------|--|
| Project Title | Proof of concept: Smart Solar Off-Grid (V1.8) |
| Country / Region | Belize, Central America |

Technology


- Biomass Energy Efficiency Geothermal Energy
 Small Hydropower Photovoltaic Solar Thermal Wind

Project's Time Frame (from - to): Q3 2015 to Q4 2016

Total Project Cost (CHF): 300'541

Expected REPIC contribution (CHF): 150'000

Murg, 29. Juli 2015



2. Summary / Abstract

- The partner country's needs**

The Government of Belize is interested in a pilot project to proof the concept of a solar off-grid system supplying remote communities with electricity.

The Belizean Ministry of Energy, Science & Technology and Public Utilities (MESTPU) has identified rural village electrification using solar off-grid systems (mini/micro-grids) as an integral component of its long-term strategy. In this strategy concerning the electrification of remote communities, only an independent off-grid system is feasible from both a financial and technical perspective. Therefore, MESTPU is looking for a partner to realize a pilot project to get a proof of concept for future off-grid electrification projects.

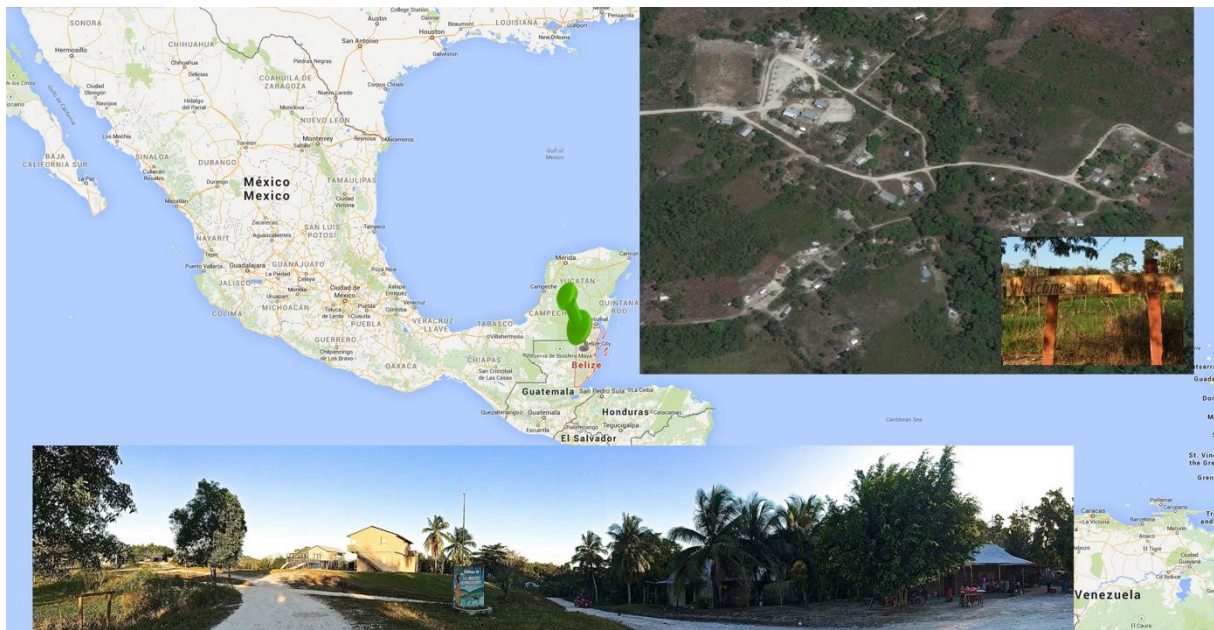
- Project content**

This is a pilot project to proof the concept of ZENNA's *Smart Solar Off-Grid* system in Belize. Within this project ZENNA will do the system engineering and plan the "smart part" of the *Smart Solar Off-Grid* system in cooperation with zhaw and the Belizean company Solar Energy Solutions Belize Ltd. (SESB), who will act as a local counterpart for construction and maintenance. This pilot project is necessary to gather data during the time of 6 months and to define parameters to optimize the system.

The main target of this project is to provide renewable, stable and affordable electricity to Belizeans living in remote communities by implementing a *Smart Solar Off-Grid* system. This system, which is constructed in a modular design, will provide solar energy on a production base. It will increase the yield by storing energy in batteries as well as by controlling the distribution well timed. In addition it will automatically start and switch off consumers depending on the available energy. The distribution will financially be handled on a pre-paid base. The MESTPU will benefit from the proof of concept of the *Smart Solar Off-Grid* system as well as from the accompanying business model for future off-grid electrification projects. To take advantage of a part of the financial means from the National Indicative Programme (NIP) of the European Union, MESTPU is required to present a proofed concept for the electrification of remote villages. For this particular project in La Gracia, the NIP does not participate with financial support. The Belizean company SESB will profit from the know-how transfer by this cooperation. SESB is likely to increase its growth and create employment opportunities in Belize.

- **Approach**

ZENNA will develop and install a sustainable *Smart Solar Off-Grid* system. In this project ZENNA will cooperate with zhaw experts in renewable energies to compose existing components and technologies in a modular construction. The Belizean enterprise SESB will translate the system design technically. SESB will build, run, maintain and service the *Smart Solar Off-Grid* system during the operating time. To realize this project we will build on already existing technologies such as polycrystalline solar modules, GLP-generator and lead-acid-batteries, which the local villagers are already used to handle. After the successful completion of the pilot phase, the ownership of the *Smart Solar Off-Grid* system will be transferred to the Belizean Government. The Belizean Government will also be the responsible actor for the payment traffic (on a pre-paid base) between energy consumers and the producer. Following the pilot phase, the *Smart Solar Off-Grid* system (thanks to its modular construction) and the accompanying business model is likely to be scaled throughout Belize, and eventually, other developing and transition countries.



Picture 1: La Gracia, Belize, Central America

3. Needs covered by the project

- **The present starting point / On-site situation**

Geographical location

Belize is situated on the Caribbean coast of the Central American peninsula with Mexico and Guatemala bordering on the landward side to the north, west and south, respectively. Belize forms a portion of the Yucatan Peninsula. The total land area of Belize is 22,960 km² country, 95% of which is registered mainland and the remaining 5 % distributed among more than 1,060 islands (coastal cayes). Belize's coast extends for 280 km and is host to the Belize Barrier Reef Complex - the second largest in the world and the largest in the northern hemisphere. The total national territory, including the territorial sea is 46,620 km². The subtropical country Belize with a direct solar radiation between 3.0 to 4.5 kWh/m²/day is predestined for solar energy solutions. The country's total land mass is divided into six administrative districts, namely Corozal and Orange Walk (North), Belize (East and Central) and Cayo (West and Central) and Stann Creek and Toledo (South). Approximately 69 % of the country remains under natural vegetation cover with 39.1% of its terrestrial area is protected forest.

Political/economical situation

Since its independence 1981 Belize is a parliamentary constitutional monarchy and retaining Queen Elisabeth II as head of state. English is the official language in Belize. Its legal system is modeled on the common law of England. Prime minister in charge, Dean Barrow was sworn in 2008 when he won the elections with the UDP (United Democratic Party). Belize is a fully participating member of the United Nations, Commonwealth of Nations, Organization of American States, Central American Integration System, Caribbean Community and is original member of the World Trade Organization. Herein Belize participates in the CARIFORUM that has concluded the full regional trade pact with the European Union.

According to the World Bank Belize had a GDP in 2013 of 1.6 Billion US\$. With a population of 331'000 the GDP per capita was 4'600 US\$. In 2013 Belize had an unemployment rate of 11.7% and an annual inflation rate of 1.6%. The foreign direct investment in 2013 was 89 Million US\$.



Picture 2: La Gracia, Aerial Photo, GoogleEarth

Climate

Despite its subtropical location, Belize's climate is classified as being tropical to extra-tropical. This is attributable to the intrusion of cooler continental air from the north during winter months facilitated by the large landmass of neighboring Mexico. Belize's climate is characterized by marked wet and dry seasons separated by a cool transitional period and temperatures ranging from 21 to 32 degrees Celsius.

Population

Belize is characterized by both ethnic and cultural diversity. The 2013 national population is 331,900 (World Bank). Approximately 44% of Belize's population is classified as urban, 49.5 % women, 41.3% poor (15.8% indigent) and 35.6% as being under the age of 15. A substantial proportion of residents live in Belize District (29.99%) followed by Cayo (23.91%).

The Village

La Gracia, the village where this pilot project will take place is located in the Cayo District. It is about one hour by car northeast from the capitol city of Belmopan and about 20 km away from the Mennonite Community of Spanish Lookout. La Gracia is composed of 45 households, two churches and an elementary school building which hosts about 80 of the children living there. The La Gracia community has about 200 inhabitants in total. There are two very small shops in the village. The villagers' income does usually come from different activities and does not arrive in a stable manner. The people are mostly farmers or work in the Spanish Lookout Community. The estimated average income of a family in La Gracia is about 500 US\$/month.

Currently, the village is using a diesel fuel generator for 80 minutes three to four times a week to pump well water up to a reservoir on a nearby hill. It is then distributed through a gravity fed pipe system. The water pump and the gasoline generator have been replaced recently. The pump was paid from the incoming funds from water sales. Every house has a water meter and the customers pay the treasurer of the water board. The generator was a donation from an US-American, representing a religious group. The church next to school has a service six nights a week, during which they run the generator to run the speaker system. To gain electricity the villagers currently use GPL Back-up Generators and small photovoltaic modules connected to 12 Volt car batteries in order to get mobile phones charged and to supply light bulbs and radio. This solution is inefficient, instable and suitable only for very basic needs.



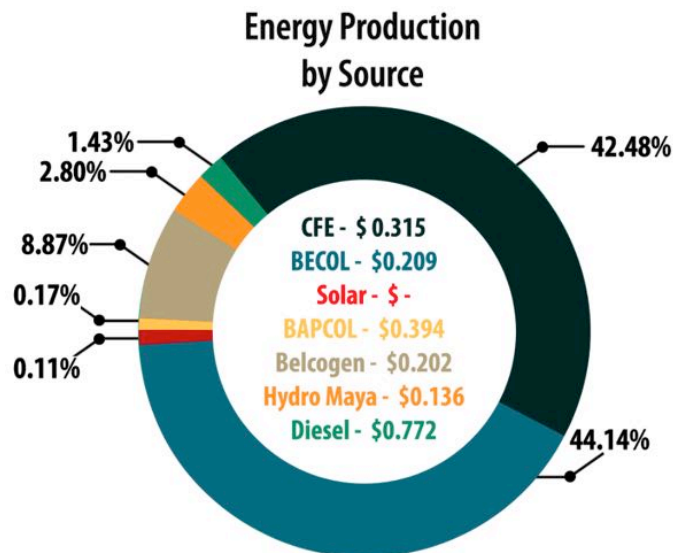
Picture 3: La Gracia, Water System 1



Picture 4: La Gracia, Water System 2

Electric energy situation in Belize

The electricity grid in Belize is run by Belize Electricity Limited (BEL) and is regulated by the Public Utilities Commission (PUC). PUC is, compared with the situation in Switzerland, the ECom; BEL would be a cooperation of energy suppliers (Energieversorgungsunternehmen EVU's) and grid operators (Verteilnetzbetreiber VNB). Following this picture, the MESTPU (Ministry of Energy, Science & Technology and Public Utilities) would be equal to the department of energy (BFE) in Switzerland. Approximately 65% of the energy distributed by BEL in 2013 was sourced from renewable energy sources. Belize produces the majority of its electricity from a mix of hydro, biomass and fossil fuels (see graphic and BEL annual report in appendix). The Government of Belize and the Social Security Board currently holds 70.2% and 26.9%, respectively, of the ordinary shares issued by the Company. In 2014, over 10'000 Belizeans remain without access to electricity. All over Belize the use of photovoltaic modules to gain energy is already well known and accepted – mostly on a do-it-yourself level. As a matter of fact, adequate knowledge in planning, designing, constructing and maintaining photovoltaic systems on a “state-of-the-art” standard is not affordable for the broad public.



Picture 5: BEL Annual Report 2013



Picture 6: Solar Power System Ex. 1



Picture 7: Solar Power System Ex. 2

The Government of Belize is not able to serve all remote areas by the national electricity grid due to economical and technical reasons. In fact, BEL is expanding the public grid in cooperation with the government and with financial help of the European Union. La Gracia was suggested by the government after several meetings between ZENNA and the MESTPU as the location for the pilot project of an off-grid energy solution with photovoltaic. The village is about 8 miles away from the next grid, which is serving Valley of Peace. La Gracia was finally chosen because it wasn't scheduled to be connected to the grid in the midterm and it is not too far away from the SESB headquarters (see appendix). To connect La Gracia to the grid, MESTPU would have to invest about US\$ 40'000.- per mile. The connection of La Gracia to the grid would cost the government US\$ 320'000.-. This is nearly equal to the investment into the *Smart Solar Off-Grid*. But the price of the *Smart Solar Off-Grid*, once the concept is proofed, will be customized. We expect a price reduction up to 40% once the system is optimized.



Picture 8: Sketch grid

- **The most important local needs**

The reaction of the chairman of La Gracia when MESTPU indicated the possibility of being chosen for a solar off-grid pilot project was a clear statement: „Our village is waiting for electricity for a long time. We are very excited to hear that there is the possibility of a communal solar system providing electricity to La Gracia. To have electricity available will be a tremendous improvement to the quality of live of all the villagers. I can assure the full support from our community should this project be awarded.“ The treasurer of the water board added: „Right now we have a small solar panel on our house, providing us with two small lights. With the second baby on the way, I would love to have a small fridge to keep food from spoiling. Especially this time of the year with temperatures up to 40°C it is a challenge. We are 20 kilometers away from the next supermarket, so we don't go shopping every day. I would like to open a small shop in the village and having electricity would allow to store a wider selection of items.“

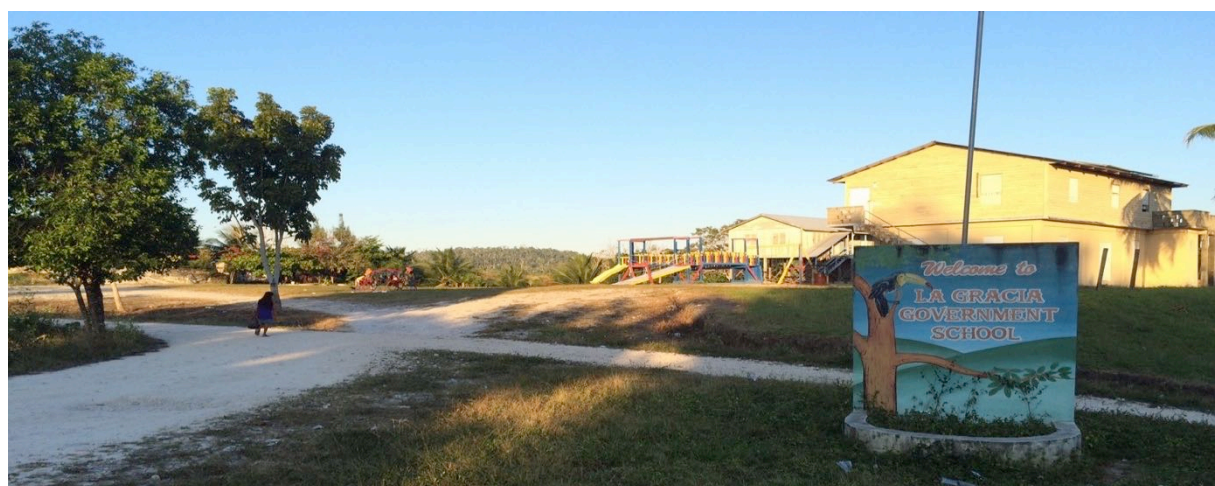


Picture 9: Solar Power System Ex. 3



Picture 10: Solar Power System Ex. 4

The most important local need is affordable electricity in a stable and sufficient condition for over 10'000 Belizeans living in remote communities. The government is interested in supporting a pilot project to proof the concept of a solar off-grid system which supplies remote communities with electricity to the usual financial conditions. The Belizean electricity market price is set by the Public Utility Commission (PUC), which intends to allow people in remote areas to draw energy under the same financial conditions as maintained in grid-connected areas. In 2010 the government created a „social tariff“ in its socioeconomic package as a part of their formal electricity pricing structure whereby profits from mid and high-end electricity consumers were used to cross-subsidize costs associated with the social tariff. The current tariff for non-commercial consumers is between 0.20 – 0.26 US\$/kWh. This price is affordable for families living in La Gracia, who calculate with an average income per family of about 500 US\$/month. With an average need of 2 kWh per day the tariff of 0.26 US\$/kWh would result in a monthly bill of 23.40 US\$ which is below 5 % of their income.



Picture 11: La Gracia

MESTPU Strategic plan; Horizon 2030 Vision; Letter of intent

The new Government of Belize, has identified the development of Renewable Energy as a top policy priority. In it's strategy until 2017 the Belizean Ministry of Energy, Science & Technology and Public Utilities (MESTPU) intends to develop a framework that will result in transitioning the energy sector and economy toward low carbon development. Photovoltaic is the energy solution of choice for island communities and other remote communities where grid expansion is not an economic option.

„In the case of PV, where there is grid power readily available, there is a valid argument against deploying PV, as they are usually more expensive than power from the grid. (...) In general, however, given that conventional energy is very costly, PV systems in the case of Belize would be very competitive. Additionally, it should be recognized that the high price of conventional energy sources and similar high prices from indigenous energy sources do not exert the same socio-economic impacts. Conventional energy systems require the continual exports of foreign exchange to pay for imported fuel. This is not the case for renewable energy, once the initial investment is repaid there are no significant export of foreign exchange and additionally, the cost from that technology is fixed for the rest of the economic life. That means a predictable price for energy services which makes for a more positive business environment for the private sector and households.“ (MESTPU; Renewable Energy and Energy Efficiency Strategy, Strategic plan 2012 - 2017)

In the "Horizon 2030 Vision" which is part of the Belizean Sustainable Energy Action Plan it is described what Belize should be like by 2030:

- Belizeans are capable of using state of the art technologies
 - Development planning is based on the principles of environmental sustainability
 - Belize has a well-balanced distribution of wealth and resources and a modern infrastructure
- In his letter of intent, Dr. Colin Young, CEO of MESTPU, declared his interest in supporting a solar pilot project with ZENNA (see appendix).

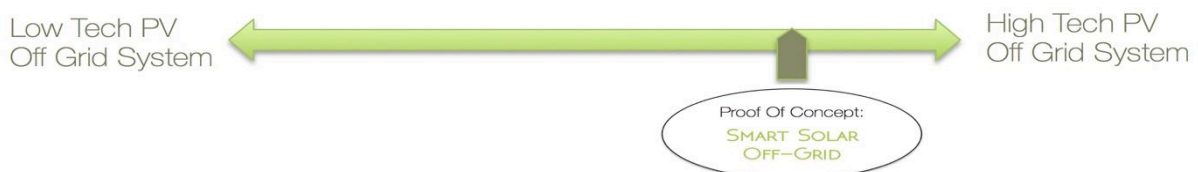
• **Specific need**

The specific need of the villagers of La Gracia and other remote communities is affordable and stable electricity. To serve this need, the Belizean Government is looking for a partner to get a proof of concept of a solar off grid system.

• **Solution approach**

This project meets the specific local need - which is having stable and affordable off-grid energy – to a 100%. The issue will be solved by the *Smart Solar Off-Grid*, system engineered by ZENNA. The Belizean Government will benefit from a reliable proof of concept under real running conditions in order to perform towards international donors and investors as well as towards the European Union and it's *National Indicative Programme (NIP)*. *Smart Solar Off-Grid* will proof that there is the necessary know-how and engineering resource for planning and constructing solar off-grid systems of similar sizes in Belize and that the „levelized costs“ (Gestehungskosten) of solar electricity are competitive to the costs of energy from other sources. The proof of this concept which will be given by the technical solution as well as by the accompanying business model will allow the Belizean Government, to continuously develop their *Renewable Energies Strategy* by applying for financial help to the NIP. With the *Smart Solar Off-Grid* the Government will be able to purchase a system for remote electrification for half of the price, than electrification by grid would cost.

The Smart Solar Off-Grid will be a solution, which integrates the well-known and approved parts of already existing systems like poly-crystalline solar panels, LPG generators and lead-acid batteries, but improving it by adding state-of-the-art components like smart prepaid meters and Sunny Islands®. Intentionally we avoid high-end components like fuel cells as secondary power source and lithium-ion batteries because villagers in remote areas are not used to these technologies. This solution is something in between low and high tech.



- **Project's local beneficiaries**

People living in La Gracia will profit from renewable energy in an affordable and stable manner. The Belizean Government will profit from the proof of concept of a solar off-grid system and the Belizean society will profit from the state-of-the-art knowledge in solar energy technologies as well as from job opportunity growth. The local company SESB will increase its ability to compete against foreign bidders in the oncoming announcements for the construction of off-grid solar systems by the Belizean Government.



Picture 12: La Gracia

- **Existing activities**

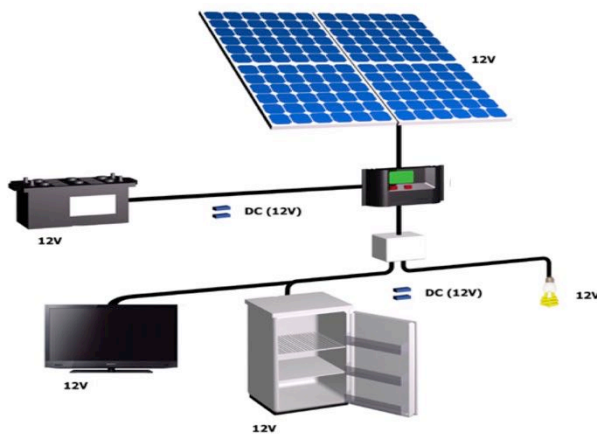
Allover Belize the use of photovoltaic modules to gain energy is already well known and accepted. The enterprises ProSolar Ltd., Computer Ranch Ltd. and Solar Energy Solutions Belize Ltd. (SESB) are the three main providers of solar applications in Belize. Belizean enterprises seem to have room for improvement when it comes to advanced system engineering, such as larger scale installations, the integration of prepaid meters and automated power regulation of end-consumers depending on the fluctuating system performance. ZENNA has already realized a solar project with SESB (see appendix). One of the co-founders of SESB, Silvan Küffer, is actually the brother of Lukas Küffer, one of the co-founders of ZENNA. ZENNA will make sure that professional project management and accounting is guaranteed within this project at all times. Nowadays SESB is the most experienced enterprise in providing solar applications for the local market. As a reference, SESB has installed over 50 off-grid solar systems in Belize, all of them are well performing. SESB is the official partner in Belize for the biggest manufacturer of solar inverters in the world, "SMA Solar Technology AG" (see appendix).

About 2 years ago, a small solar energy system has been donated to the public school of La Gracia Village. It is installed on top of the school building. This system is low tech and very small (app. 800 Watt), but it is still in good shape and well performing and will remain powering the school. This will free-up more electricity from the community system to be distributed to the households.

- **Distinctiveness**

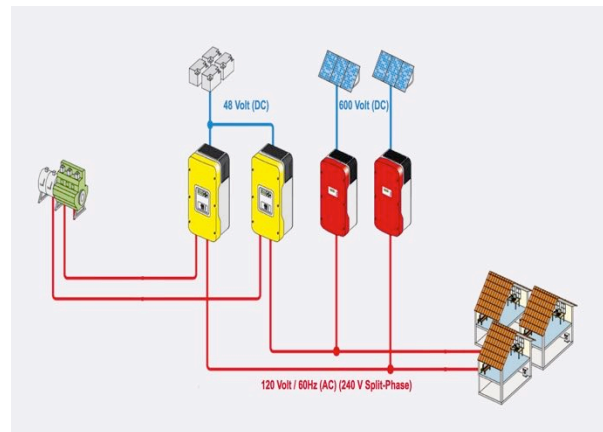
The technical translation of a solar energy plant started with a solar panel that fed direct current (DC) directly into special DC appliances. This system type (12V) is still widely spread in Belize but the technology is outdated, because of its low efficiency and it can only supply expensive, special 12V appliances. Today's solar technology is creating an alternating current (AC) network, which can power any regular household appliances like computers, TV's, fridges or radio receivers, all of which are readily available to Belizeans at affordable rates.

“Old style” solar energy system



Picture 13: Solar energy system, DC

Nowadays solar energy system



Picture 14: Solar energy system, AC

The SMA Sunny Island© bi-directional battery inverter allows to create an AC network so that consumers may use AC appliances. The *Smart Solar Off-Grid* will be a hybrid system of solar panels accompanied by a LPG (Liquefied Petroleum Gas) generator with the aim to bring the cost-mix of solar power and LPG generated power to an affordable equilibrium as well as providing a sufficient amount of energy to the villagers of La Gracia.

Technical presupposition

The whole project builds on already existing components like solar panels, inverters, batteries, power management units and power meters from different producers. The key component of the off-grid network is the Sunny Island® battery inverter (bi-directional) developed by SMA. Sunny Island® creates an alternating current network. The big advantage is flexibility and management of both, the two energy sources (solar energy system and LPG generator) and consumers. The Sunny Boy® inverter, the main element in the solar energy installation, converts direct current into network compatible alternating current, which is standard worldwide and allows customers to use standard AC appliances. Consumers and energy sources are coupled in a joint AC network. By minimally altering the network frequency and voltage, the Sunny Island® can regulate load fluctuations as necessary – the same way as a public grid does.

Innovative approach

The innovation in this project is the way *Smart Solar Off-Grid* combines already existing technologies in a way unknown to Belize. The resulting solar energy system is individually designed and adapted to the situation of 45 different households in La Gracia and will be the first of its kind in the entire country. The individual sizing of the different components, such as solar panels, inverters, batteries and LPG generator has to be customized to the specific needs of La Gracia. The concept will allow automatic connection and disconnection of consumers based on the actual energy production as well as on the battery charge level.

At times when there is no direct demand for all the electricity available, it can automatically start the water-pump and provide water resources to the villagers while cutting down on generator time for pumping purposes. The system also utilizes surplus energy to recharge the batteries. Intelligent management of the *Smart Solar Off-Grid* means that the battery bank can be relatively small and thus cost-effective. The villagers will need most of the stored energy in an estimated time of three hours in the evenings between 6 and 9pm. To extend the lifetime of the batteries and to keep the number of batteries limited, the system will not deliver electricity during nighttime between 10pm and 6am. Based on experience the temporary shutdown of fridges won't be a problem. The villagers may put frigidors into the fridges to keep the cold during a few hours. It could be even a potential side business for a village store to invest in a well-insulated chest freezer and “refreeze” villagers ice packs for a small fee.

The flexibility of the *Smart Solar Off-Grid* allows it to be adapted to increased energy demand. Both energy sources function independently of one another. Should the solar energy system fall short because of lack of sunlight, the LPG-generator will compensate the power loss. Should energy consumption increase in the future, the network can be expanded with additional solar panels and Sunny Island® converters operating in parallel.

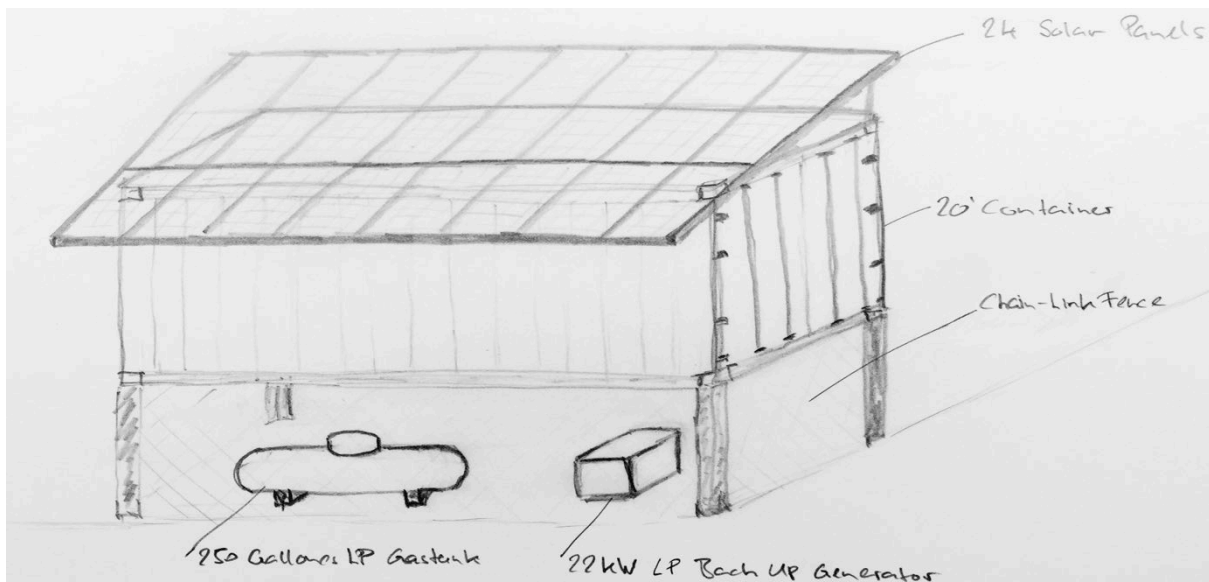
Adding prepaid meters to each household will enable the villagers to purchase the amount of energy that they can actually afford. Not having had the chance to grow up with electricity in the childhood and get a feel of what costs are associated to it, it is essential that people can deliberately choose their expenditures for electricity.

4. Project description

• Achievements

1. ZENNA will system engineer a *Smart Solar Off-Grid* system in cooperation with zhaw.
2. SESB will build the *Smart Solar Off-Grid* system in cooperation with ZENNA.
3. SESB will place the *Smart Solar Off-Grid* system in the village of La Gracia.
4. SESB in cooperation with ZENNA will put the *Smart Solar Off-Grid* system into service.
5. ZENNA in cooperation with SESB will run the *Smart Solar Off-Grid* system during the time of six months to optimize the parameters and system performance.
6. The Belizean Government (MESTPU) will take over the *Smart Solar Off-Grid* system after the testing phase.
7. SESB will maintain and service the *Smart Solar Off-Grid* system as a contractor.

All components, except the solar panels will be placed inside a freight container. The container itself will be elevated on stilts. On the ground floor the back-up generator and the LP gas tank will be installed. The Inverters, meters and batteries will be situated inside the container. By installing half of the solar panels on top of the container, an optimum of shading is created at the same time. ZENNA will combine the Web box and the Sunny Islands© to have remote control and the possibility of gathering data during the six months testing phase and afterwards. Subsequently ZENNA will exhaust the configuration possibilities of the Sunny Island©. This leads to an optimum yield of solar energy, a minimum need of the LPG generator and, as a result, in a minimized cost per kWh. With this concept the high cost for batteries can be reduced and the size of the solar panel area will be optimized. Every time the energy yield is bigger than the needed amount, the water pump will start automatically. If the energy need increases, the *Smart Solar Off-Grid* system with its modular design can be upgraded easily.

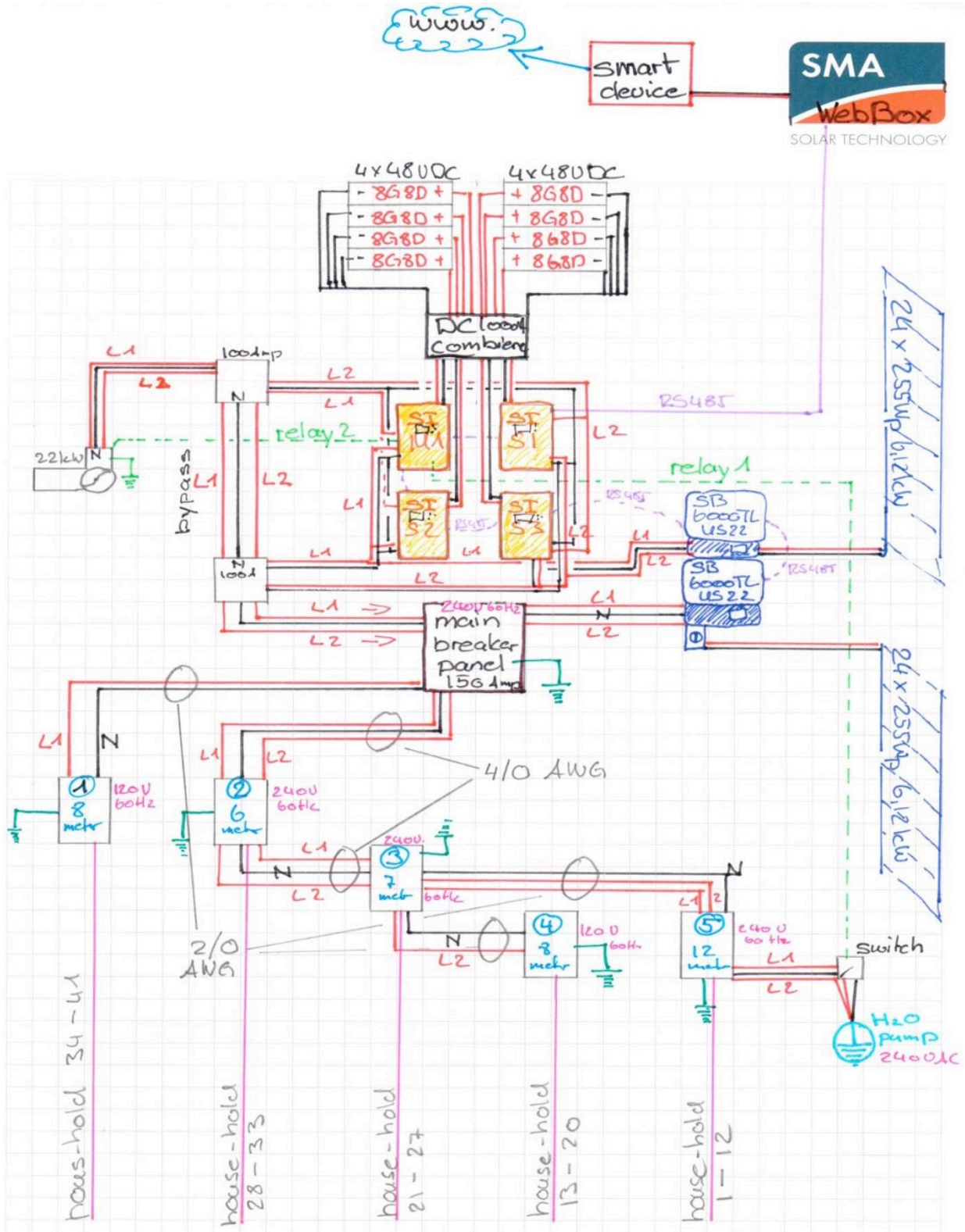


Picture 15: Sketch Smart Solar Off-Grid

The *Smart Solar Off-Grid* consists mainly of the following components:

- 12'000 Wp Solar Power (poly crystalline panels & SMA Sunny Boy)
- 24'000 Wp Battery Inverter Power (SMA Sunny Island)
- 32 kWh Battery Storage (Hoppecke)
- 22'000 Wp Back-up Power Source (LPG Generator Generac)
- Power Management / Data Monitoring Unit (SMA Webbox)

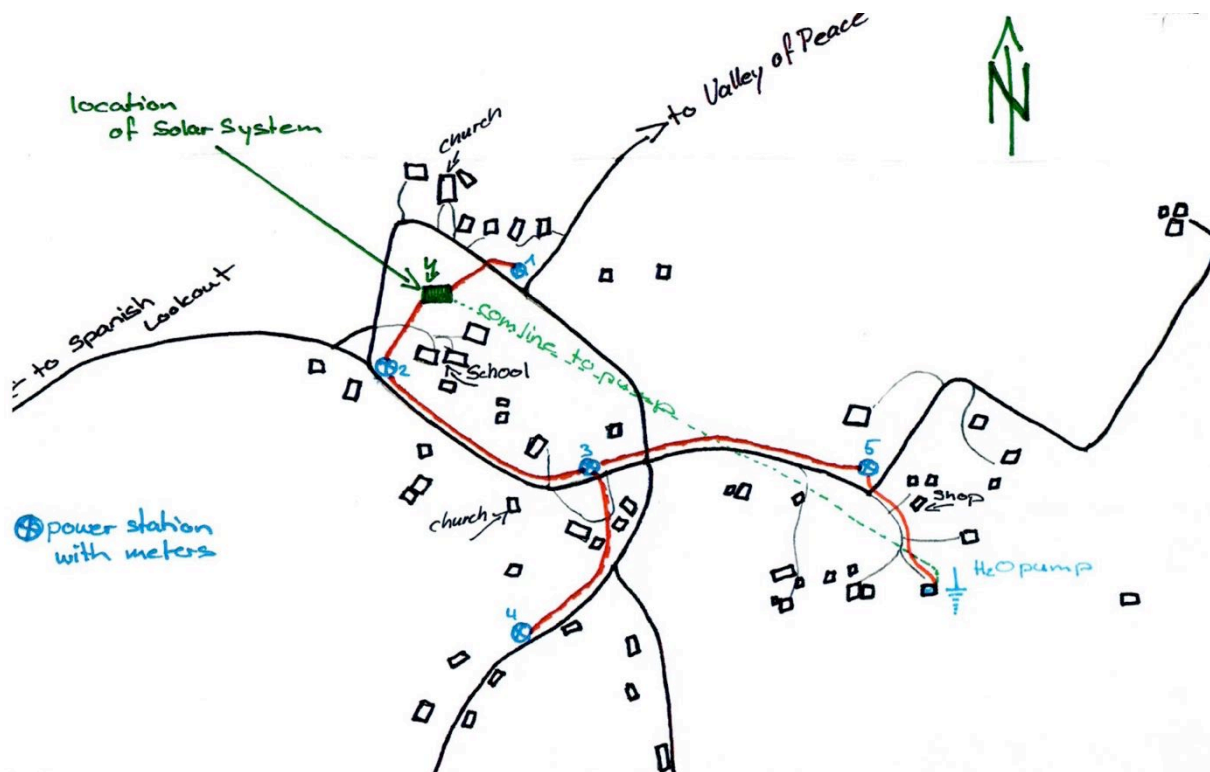
The Sunny Boys®, the Sunny Islands®, as well as the batteries and the main breaker panel will be installed in a 20ft ship container which will be placed on public ground near to the public school of La Gracia. The container itself will be set on stilts for security and practical reasons. Half of the amount of solar panels - 24 pieces – will be set on the roof of this container; the other 24 panels will be set on the roof of the public school. Under the container, protected by a chain-linked fence, the 22 kW LPG backup-generator as well as the LP gas tank with a volume of 250 gallons will be placed. LP-Gas trucks can be ordered and have easy road access to refill the tank if necessary.



Picture 16: Schematic sketch

The forty-eight 255kWp solar panels will feed direct current (DC) to two Sunny Boy© inverters. One of them is connected directly to the main breaker panel to feed accelerating current (AC) over the five power stations and the power-meters to the connected households. The other part leads the AC to the Sunny Island© bi-directional inverters which are creating a two-phase grid and model the current for feeding it to the 48V battery bank. If power is needed to feed the batteries when there is no sunshine, the generator will be started automatically. The whole system is connected to the internet through a Smart wireless-device and a Webbox, which allows the operator to gather and evaluate data as well as controlling the system remotely.

The *Smart Solar Off-Grid* (green quadrangle) will be set in the northwestern part of La Gracia, next to the public school. Connected by underground wires (red lines) five power-stations (blue circles) will be constructed, spread out throughout the village. Each power station will consist of the necessary number of power-meters (according to the sign-ins of the villagers) to be connected by underground wires to the households. The water pump will be directly connected with a communication line to the *Smart Solar Off-Grid*. This will allow starting the water pump automatically.



Picture 17: Sketch power lines/stations

• **Explanation of project objectives**

In a survey SESB performed in La Gracia, 43 households signed in, claiming their needs for electricity. Most of the interested villagers signed in for medium need, which is about 2 kWh/d. We assume an energy consumption for a fridge would be 0.5 kWh/d, for a TV would be 0.5 kWh/d (4 hours operation, 20 hours stand-by), for a radio would be 0.3 kWh/d, for a 60W light bulb burning 6 hours a day would be 0.4 kWh/d, for a personal computer operating 8 hours would be 0.8 kWh/d. We also assume that just a part of the signers will in fact subscribe for energy purchase. For that reason in a first step we will only install two of the five planned power stations and connect 9 households to observe during a six-month-trial the consumers behavior. If they need more than the predicted 2 kWh per day, the system should be adjusted for the three power stations to come. It will also be important to observe, if the villagers are able to bear the planned acquisitions of the electric appliances.

The key project objectives are:

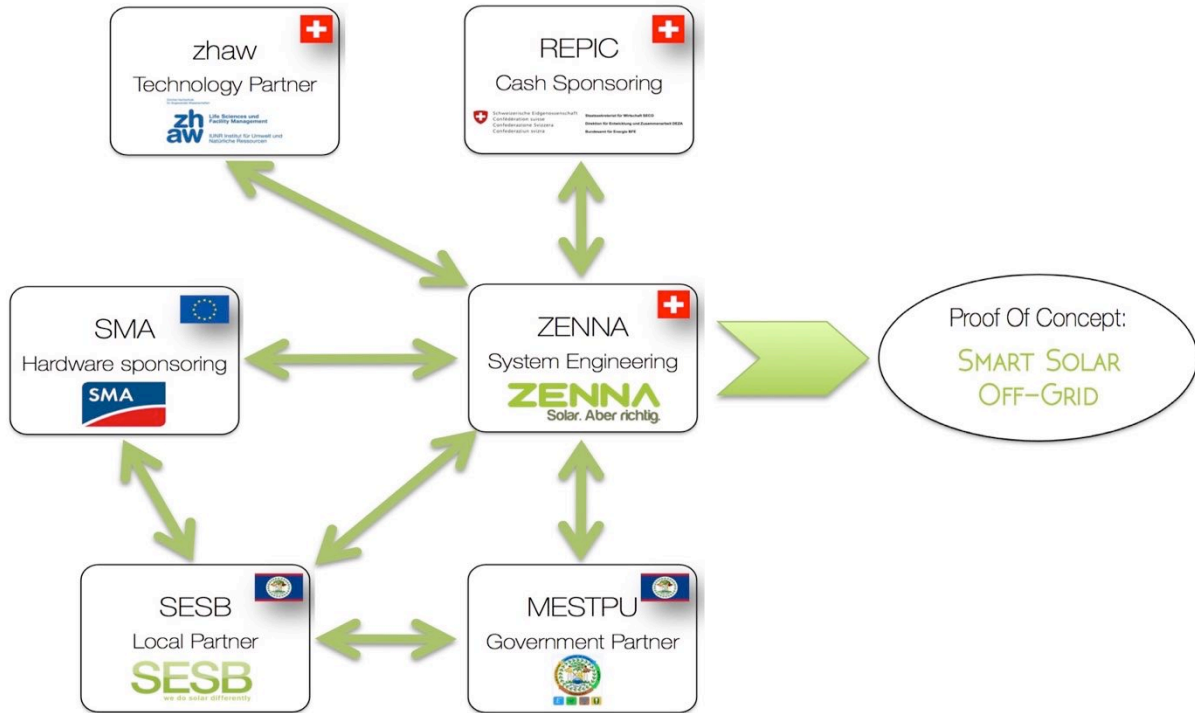
- Objective 1: Providing electricity to 9 households of La Gracia until 22.06.2016
- Objective 2: Getting proof of concept of an off-grid solar system until 21.11.2016
- Objective 3: Completion of the accompanying business model until 21.11.2016

5. Swissness and Project Organization

• **Swiss contribution and Swiss Know-How/Technology transfer**

ZENNA will cooperate with Zurich University of Applied Sciences (zhaw) and participate with genuine Swiss Know-How when it comes to planning and designing the smart part of the solar off-grid system. During this project the know-how will be transferred to the Belizean counterpart SESB. It will enable SESB to offer upgraded, smart solar off-grid solutions that can be implemented in other future projects.

• **Project organizational chart**



| Organization | Tasks | Responsible | Contact |
|--------------|--|--------------------|--|
| MESTPU | Authorization Payment | Ambrose Tillett | +501 610 2357 energy.director@estpu.gov.bz |
| SESB | Hardware Order Construction System Building and Installation, Testing and Optimizing | Silvan Küffer | +501 663 1000 contact@solar-energy- solutions-belize.com |
| ZENNA | Project Management System Design Testing/Optimizing Reporting | Lukas Küffer | +41 79 236 4940 mail@zenna.ch |
| zhaw | System Design | Jürg Rohrer | +41 58 934 5433 juerg.rohrer@zhaw.ch |
| REPIC | Sponsoring | Angela Mastronardi | +41 26 494 0030 info@repic.ch |
| SMA | Sponsoring | Matthias Beck | +49 561 952 24024 Mathias.Beck@SMA.de |

6. Project Plan

- **Work phases and activities for the project's implementation**

The structured project plan, including key related activities and schedule is added in the appendix.

| Task | | start | wd | end | % | status |
|----------------------------------|-------|----------|-----|----------|----|----------------|
| Sign REPIC Contract | AM/LK | 28.09.15 | 1 | 28.09.15 | 0% | Nicht begonnen |
| 1. Payment from REPIC 27% | AM | 29.09.15 | 1 | 29.09.15 | 0% | Nicht begonnen |
| System Design and PUC appr. | LK/JR | 29.09.15 | 24 | 30.10.15 | 0% | Nicht begonnen |
| Interim Report to REPIC | LK | 02.11.15 | 5 | 06.11.15 | 0% | Nicht begonnen |
| 2. Payment from REPIC 54% | AM | 09.11.15 | 1 | 09.11.15 | 0% | Nicht begonnen |
| Hardware Order | SK | 16.11.15 | 50 | 22.01.16 | 0% | Nicht begonnen |
| System Pre-Building | SK | 25.01.16 | 30 | 04.03.16 | 0% | Nicht begonnen |
| System Moving to La Gracia | SK | 21.03.16 | 5 | 25.03.16 | 0% | Nicht begonnen |
| Payment from MESTPU 100% | AT | 29.03.16 | 1 | 29.03.16 | 0% | Nicht begonnen |
| System Installation in La Gracia | SK | 29.03.16 | 19 | 22.04.16 | 0% | Nicht begonnen |
| Building Grid and Powerstations | SK | 02.05.16 | 20 | 27.05.16 | 0% | Nicht begonnen |
| RampUp System | LK/SK | 06.06.16 | 10 | 17.06.16 | 0% | Nicht begonnen |
| System Live | LK/SK | 22.06.16 | 1 | 22.06.16 | 0% | Nicht begonnen |
| Interim Report to REPIC | LK | 04.07.16 | 5 | 08.07.16 | 0% | Nicht begonnen |
| 3. Payment from REPIC 10% | AM | 20.07.16 | 1 | 20.07.16 | 0% | Nicht begonnen |
| System Testing and Optimizing | LK/SK | 27.06.16 | 100 | 11.11.16 | 0% | Nicht begonnen |
| Developing Business Model | LK/SK | 27.06.16 | 100 | 11.11.16 | 0% | Nicht begonnen |
| System hand-over to GOV | LK/AT | 14.11.16 | 1 | 14.11.16 | 0% | Nicht begonnen |
| Final Report to REPIC | LK | 21.11.16 | 5 | 25.11.16 | 0% | Nicht begonnen |
| 4. Payment from REPIC 9% | AM | 07.12.16 | 1 | 07.12.16 | 0% | Nicht begonnen |

Milestones with Deliverables

1. System Design and PUC appr. 30. October 2015
 - a. Mechanical drawings (CAD) and electrical schematics of the system; (document)
 - b. Public Utilities Commission (PUC) electricity approval; (document)
 - c. Interim status report with **Levelized Cost Of Energy (LCOE)**; (document)

2. System Moving to La Gracia 25. March 2016
 - a. Proof of system existence; (photos)
 - b. System testing protocol; (document)

3. System Live 22. June 2016
 - a. Proof of system in operation; (photos)
 - b. System ramp-up protocol; (document)
 - c. Interim status report with Power Payment Concept; (document)

4. System hand-over to GOV 14. November 2016
 - a. System hand-over protocol; (document)
 - b. Project documentation for marketing use; (photos)
 - c. Final report with final costing of system; (document)

Expected hours worked basis:

| | ZENNA (CHF155/h) | zahw (CHF125/h) | SESB (CHF45/h) |
|----------------------------------|---------------------|--------------------|-------------------|
| System Design | 120 | 40 | |
| Hardware Order | | | 24 |
| System Pre-Building | | | 160 |
| System Moving to La Gracia | | | 16 |
| System Installation in La Gracia | | | 160 |
| Building Grid and Powerstations | | | 120 |
| RampUp System | 80 | | 42 |
| System Live | 8 | | 8 |
| Interim Report to REPIC | 32 | | |
| System Testing and Optimizing | 60 | | 160 |
| Developing Business Model | 20 | | |
| System hand-over to GOV | 8 | | 8 |
| Final Report to REPIC | 32 | | |
| Total Hours | 360 | 40 | 698 |

7. Planned Project Replication / Project's Multiplication

- **Economic viability**

The cost for this pilot project is about 300'000.- CHF, whereby the cost for the electrification of La Gracia by grid would be nearly the same. But the price of the *Smart Solar Off-Grid*, once the concept is proofed, will be customized. We expect a price reduction up to 40% once the system is optimized. Once installed, the system will deliver electricity for at least 20 years. The government will finance the replication of the Smart Solar Off-Grid system. The energy will be distributed based on a pre-paid system. For that reason an "energy board" will be created by the inhabitants. The villagers will pay for a needed amount of energy by cash to the treasurer of the energy board who will set up the smart meters to distribute the energy. The treasurer of the energy board will be instructed by SESB. The pre-paid system will ensure that only the amount of produced energy will be sold.

The *Smart Solar Off-Grid* system (incl. LPG generator) will produce about 17'400kWh/a. Herein, 15'600 kWh/a will be generated by the 12 kWp PV-system and 1'800 kWh/a will be generated by the LPG back-up system. These 48 kWh/d would cover the assumed need of 24 households with a medium consumption of 2 kWh/d. The energy will be sold to the inhabitants of La Gracia at the local tariff of 0.26 US\$/kWh. This will generate revenues of 4'500.- US\$/a. With this income the running costs (operation, management and maintenance) and the amortization of the batteries and the LPG generator of the *Smart Solar Off-Grid* system will be paid.

- **Replication / Multiplication potential**

For the replication of the *Smart Solar Off-Grid* we expect a price reduction up to 40% once the system is optimized.

Over 10'000 Belizeans living in remote communities without electricity. Given the fact that all these villages are potentially subject to the rural electrification efforts destined by MESTPU under the Sustainable Energy Action Plan, there is great potential for replication and multiplication of the *Smart Solar Off-Grid* system.

As a part of its socioeconomic package the government created a social tariff to cross-subsidize electricity costs (MESTPU Strategic Plan 2012-2017: page 6). On Caye Caulker Island for example Diesel generators produce the electricity. This leads to real production costs of 0.6 US\$/kWh. Despite the fact of higher production costs, the inhabitants of the island pay the "social tariff" of 0.26 US\$/kWh grace to the governmental subsidization. In Belize in fact, there are many different examples where the Government is subsidizing the energy cost for the citizens.



Picture 18: Caye Caulker Island

The European Union has put in promising that the MESTPU could take advantage of their National Indicative Program (NIP) wherein 13.5 million Euros are foreseen to support the energy sector in Belize. To take advantage of these financial means MESTPU is required to present a proofed concept for the electrification of remote villages. For this proof of concept, NIP does **not** participate with

financial support. Nevertheless the Belizean Government will benefit from the subsidies of the NIP when it comes to the replication of the Smart Solar Off-Grid with which MESTPU acquires the requested proof of concept.

- **Key strategic approaches**

- The installation of the *Smart Solar Off-Grid* has to be completed without stretching the foreseen budget.
- The installed system must deliver the expected amount of energy.
- The installed system must perform in a stable manner.
- The production cost per kWh must not exceed 0.30 US\$.

- **Project sustainability**

In the 2011 study „Toward a national energy policy - Assessment of the energy sector in Belize“ it is stated:

„Undeniably, fossil fuels will remain a significant source of energy in Belize for years to come —as it will for most of Latin America and the Caribbean region. Nevertheless, it must be an imperative of the country’s energy policy to reduce its dependency on imported fossil fuels and to decouple increased energy demand from increased fossil fuels imports. A move toward renewable energy solutions is sought as the most viable solution to improve energy security and reduce the volatility of energy costs.“

Ecological sustainability

The *Smart Solar Off-Grid* will save 450 kg of CO₂ output per year compared to generating the same amount of electricity with a LPG generator. To generate 10 kWh electricity 1 m³ of LPG is necessary. The amount of LPG is factorized with 2.5 to get the amount of produced CO₂ in kilograms.

The social impact of the project will be in the creation of job opportunities not only in the solar energy sector but in small business models like shops in remote villages grace to electricity.

Social sustainability

This project supports capacity building in a developing country where electricity is one of the essential needs of a community. The know-how transfer within this project will increase the local knowledge and capability in the field of solar energy technology and solar energy system construction skills.

Economical sustainability

The Smart Solar Off-Grid will deliver affordable solar energy for a minimum of twenty years. The costs for operation, management and maintenance will be covered by the income of the energy sold. The United Nations Environment Programme (UNEP) defines ‘Green Economy’ as an economy, which results in “improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities”, suggesting an economy that embraces economic, social and environmental sustainability. Said differently, a Green Economy is a low- carbon, resource efficient and socially inclusive economy.

8. Opportunities and Risks

- **Opportunities and risks**

Opportunities

- Provide a proof of concept of an off-grid solar system to the Belizean Government
- Improve and ease everyday live of the villagers
- Spread technological know-how in a developing country
- Create job opportunities in a developing country

Risks

- Lack of governmental financial aid for the project
- Constantly falling gas prizes
- Change of governmental focus on other renewable energies (water, wind)

- **Opportunities and risks concerning the project’s replication / multiplication**

If the proof of concept can be delivered, the Smart Solar Off-Grid can be replicated in about 50 other villages all over Belize. If gas prizes constantly fall, the economic advantage of the Smart Solar Off-Grid will diminish, but the ecological advantage will remain.

9. Expected Impacts (Benefits)

- **Expected impacts**
- Impact 1: The proof of concept enables the Belizean Government to take advantage of the National Indicative Program (NIP) of the European Union.
- Impact 2: The villagers of La Gracia get affordable and renewable energy.
- Impact 3: The Belizean society benefits from affordable electricity as well as from job opportunities. The Belizean economy benefits from an increase in technological know-how.
- **Explanation of the expected impacts and benefits**

It is a declared aim of the Belizean Government to electrify those remote villages in the coming few years. As the connection of these remote villages to the grid is too expensive, the government is looking for other possibilities to bring electricity to these communities. The National Indicative Program of the European Union states three sections to support wherein the energy sector will profit from 50% of a total of EUR 27 million. (http://ec.europa.eu/europeaid/sites/devco/files/nip-edf11-belize-2014-2020_en.pdf). The MESTPU Strategic Plan has identified the lack of access to electricity as a significant cause of chronic poverty. The successful implementation and performance of the Smart Solar Off-Grid will provide a serious proof of concept for the electrification of remote villages in Belize. The government will get a proven example of the technical feasibility to electrify remote villages with affordable, renewable and clean energy. This proof of concept enables the Belizean Government to apply for financial aid through the suggested European Programme. With an investment that is way less than a grid-connection would cost, the government will be able to electrify remote villages all over Belize.

With the installation of Smart Solar Off-Grid systems in remote villages the supply with electricity for a part of the poor people in Belize is possible. Electricity is essential for the free development of communities and with the installation of a *Smart Solar Off-Grid* the Government of Belize will be able to provide capacity building (Hilfe zur Selbsthilfe) to its citizens.

This project and its multiplication will create jobs in the solar energy systems construction sector as well as in the electrified villages where - grace to electricity – small business opportunities will arise.

10. Success Control / Monitoring und Evaluation

Success control

Success control will be conducted through SESB within the regular servicing and maintenance of the *Smart Solar Off-Grid* at least during the first year of operation. It is planned that the Belizean Government will engage SESB for servicing and maintenance after the hand-over of the *Smart Solar Off-Grid*, so that SESB will be able to continuously observe the performance of the system.

Monitoring

The energy production of the *Smart Solar Off-Grid* as well as the distribution of the energy will be observed online by SESB and ZENNA. The Sunny Island© component of the system is connected through a Webbox to the internet. This allows a constant observation of the system's functions.

Evaluation

After implementing the *Smart Solar Off-Grid* in La Gracia the system will gather data during a six month testing phase. After the half-year-trial, ZENNA as the project-leader will evaluate the resources (financial means, working hours, hardware) that are being invested into the project, as well as the achievements of the project. The influence of the project to the villagers will be described and compared with to situation before. Out of this information ZENNA will also try to assume the social impact of the project.

11. Finances

Detailed Budget

| | ZENNA (CHF155/h) | zahw (CHF125/h) | SESB (CHF45/h) | |
|---|-----------------------|--------------------------|-------------------|-------------|
| System Design | 120 | 40 | | |
| Hardware Order | | | 24 | |
| System Pre-Building | | | 160 | |
| System Moving to La Gracia | | | 16 | |
| System Installation in La Gracia | | | 160 | |
| Building Grid and Powerstations | | | 120 | |
| RampUp System | 80 | | 42 | |
| System Live | 8 | | 8 | |
| Interim Report to REPIC | 32 | | | |
| System Testing and Optimizing | 60 | | 160 | |
| Developing Business Model | 20 | | | |
| System hand-over to GOV | 8 | | 8 | |
| Final Report to REPIC | 32 | | | |
| Total Hours | 360 | 40 | 698 | |
| Working Hour Costs: | CHF 55'800 | CHF 5'000 | CHF 31'410 | CHF 92'210 |
| | Flight Cost: (eco) | Hotel Cost: (14 Days) | Daily Expenses | |
| 1.Trip to Belize LK (RampUp System) | CHF 2'500 | CHF 2'100 | CHF 700 | |
| 2.Trip to Belize LK (System Optimizing) | CHF 2'500 | CHF 2'100 | CHF 700 | |
| 3.Trip to Belize LK (System hand-over) | CHF 2'500 | CHF 2'100 | CHF 700 | |
| Travel Cost: | CHF 7'500 | CHF 6'300 | CHF 2'100 | CHF 15'900 |
| Hardware Cost (see appendix): | | | | CHF 192'431 |
| Project Costs: | | | | CHF 300'541 |
| ZENNA AG | | | | CHF 31'751 |
| Zürcher Hochschule für Angewandte Wissenschaften (zahw) | | | | CHF 5'000 |
| Solar Energy Solutions Belize Ltd. (SESB) | | | | CHF 31'410 |
| Government of Belize (MESTPU) | | | | CHF 55'556 |
| SMA Solar Technology AG | | | | CHF 26'824 |
| REPIC | | | | CHF 150'000 |
| Covered Project Costs: | | | | CHF 300'541 |

The Project's Financing

The contributions of ZENNA and SESB are already committed. Recognizing the fact, that the promised contribution from the Belizean Government is likely to be reduced, postponed or even deleted, ZENNA is willing and able to replace the amount of US\$ 60'000. The calculated contribution of SMA Solar Technology AG depends on the approval of the project through REPIC.

12. REPIC Steering Group's Questions on the Project Outline

Beschluss: eintreten mit folgenden Anmerkungen und Fragen:

- Die Energieproduktion pro installierte Leistung erscheint mit 1500 kWh/kWp hoch, die Berechnung ist nachvollziehbar aufzuzeigen.
- Die konkrete technologische Lösung ist noch nicht vollständig nachvollziehbar. Wird das Netz von Grund auf neu erstellt oder bestehen bereits einzelne Komponenten? Welche Bedürfnisse werden mit der zu installierenden Leistung gedeckt?
- Das Budget wird als hoch erachtet, dieses ist nachvollziehbar aufzuzeigen.

The Questions of the REPIC Steering Group listed in the Admissions Decision are answered in chapters 4, 7 and 11. The answers are summarized as following:

- In the total of energy production, the production of the LPG generator is included (chapter 7)
- The village's grid will basically be installed within the project. It doesn't yet exist (chapter 4)
- With the installed system, more than 50% of the required energy can be provided (chapter 4, 7)
- The travel costs have been cut to half (only one person travelling). For budget details see chapter 11.

13. Appendix

- Hardware List (p 1)
- Project Plan (p 2 – 7)
- Survey La Gracia: Sign-Up List (p 8 – 11)
- Survey La Gracia: Village Map (p 12)
- MESTPU; Letter of Intent (p 13 - 14)
- MESTPU; Village Announcement (p 15)
- SESB; Letter of Intent (p 16)
- SESB; Reference Project (p 17)
- zhaw; Letter of Intent (p 18)
- SMA; Letter of Authorization (p 19 – 20)



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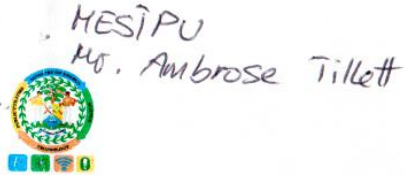
Address ZENNA AG
 Office +41 44 586 11 22
 Cell +41 79 236 49 40
 Email mail@zenna.ch
 Web www.zenna.ch
 Contact Lukas Kueffer

REPIC -
 Proof of concept: Smart Solar-Off Grid

| Amount | System Description | | |
|--------------|---|---------------|----------------|
| 4 | SMA - Inverter Sunny Island 6048US | BZD 10'950.00 | BZD 43'800.00 |
| 4 | SMA - Communication Interface for SI6048 | BZD 379.00 | BZD 1'516.00 |
| 1 | SMA - Battery Current Sensor for SI6048 | BZD 189.00 | BZD 189.00 |
| 2 | SMA - Sunny Boy SB 6000 TLUS | BZD 5'450.00 | BZD 10'900.00 |
| 2 | SMA - Communication Interface for SB 6000TL-US | BZD 379.00 | BZD 758.00 |
| 90 | Cat 6 comm. cable webbox to SB6000TL-US / ft | BZD 0.60 | BZD 54.00 |
| 200 | 20mm conduit / ft | BZD 3.00 | BZD 600.00 |
| 1 | TP-link for internet connection | BZD 280.00 | BZD 280.00 |
| 1 | Smart dongle for internet port | BZD 349.00 | BZD 349.00 |
| 60 | Monthly data for monitoring from SESB office >1GB | BZD 50.00 | BZD 3'000.00 |
| 1 | SMA - WebBox for data communication & monitoring | BZD 1'850.00 | BZD 1'850.00 |
| 2 | 100 Amp Two-way switch box for bypass | BZD 579.00 | BZD 1'158.00 |
| 5 | 10' PVC trunking 2" | BZD 45.00 | BZD 225.00 |
| 120 | Wire 4 AWG sgl black for generator bypass / ft | BZD 4.00 | BZD 480.00 |
| 60 | Wire 6 AWG sgl black / ft | BZD 3.00 | BZD 180.00 |
| 60 | Wire 8 AWG sgl black / ft | BZD 2.00 | BZD 120.00 |
| 40 | Wire 10 AWG sgl green for grounding/ ft | BZD 1.50 | BZD 60.00 |
| 4 | SESB Mounting back-sheet 4'x8' | BZD 379.00 | BZD 1'516.00 |
| 4 | 2/0 AWG battery cable 12' | BZD 220.00 | BZD 880.00 |
| 500 | PV cable sgl /ft | BZD 4.00 | BZD 2'000.00 |
| 32 | Battery deka 8G8DLTP | BZD 1'950.00 | BZD 62'400.00 |
| 4 | Battery rack 8G8DLTP | BZD 490.00 | BZD 1'960.00 |
| 24 | 2/0 AWG battery cable 6" | BZD 34.00 | BZD 816.00 |
| 16 | 2/0 AWG battery cable 18' | BZD 342.00 | BZD 5'472.00 |
| 8 | 2/0 AWG battery cable 20" | BZD 48.00 | BZD 384.00 |
| 1 | MINCB 1000/50 combiner box | BZD 2'490.00 | BZD 2'490.00 |
| 1 | 22kW Generac LP-gas back-up generator | BZD 17'490.00 | BZD 17'490.00 |
| 1 | LP gas-tank 1000 lt | BZD 2'790.00 | BZD 2'790.00 |
| 1 | Safety gas connection-set | BZD 1'850.00 | BZD 1'850.00 |
| 1 | 3'x6' Cement foundation generator | BZD 850.00 | BZD 850.00 |
| 1 | 3'x8' Cement foundation LP tank | BZD 1'090.00 | BZD 1'090.00 |
| 1 | 20' Steel container | BZD 17'500.00 | BZD 17'500.00 |
| 8 | 10"x10"x8' Cement footings | BZD 680.00 | BZD 5'440.00 |
| 100 | Chain-link fence with door | BZD 85.00 | BZD 8'500.00 |
| 1 | Metal steps for 8' elevation | BZD 2'450.00 | BZD 2'450.00 |
| 4 | Steel padlock | BZD 49.00 | BZD 196.00 |
| 48 | Solar Panels 255Wp crystalline | BZD 750.00 | BZD 36'000.00 |
| 48 | Aluminum mounting rails for 255Wp panels | BZD 150.00 | BZD 7'200.00 |
| 20 | Pairs MC4 connectors | BZD 15.00 | BZD 300.00 |
| 4 | 10' Copper ground rod | BZD 179.00 | BZD 716.00 |
| 8 | 22' / 2" Galvanised Pipes schedule 40 | BZD 385.00 | BZD 3'080.00 |
| 1 | Steel rack for 45 x 255Wp panels on 20' container | BZD 15'000.00 | BZD 15'000.00 |
| 8 | Sand and gravel delivered / cubic yard | BZD 85.00 | BZD 680.00 |
| 45 | Power meters 120Volt 60Hz | BZD 480.00 | BZD 21'600.00 |
| 2800 | Wire 6 AWG triplex 120Volt AC cable with ground / met | BZD 7.50 | BZD 21'000.00 |
| 5 | Power Station cement 6'x8' | BZD 4'890.00 | BZD 24'450.00 |
| 45 | 2" PVC pipe incl. joint and elbows / lenght | BZD 38.00 | BZD 1'710.00 |
| 1 | PUC approval | BZD 5'000.00 | BZD 5'000.00 |
| 2 | Splitter box 240V/60Hz 150 Amp | BZD 1'490.00 | BZD 2'980.00 |
| 10 | Hurrican/lightning-insurance flat rate per year | BZD 3'500.00 | BZD 35'000.00 |
| Subtotal | | | BZD 376'309.00 |
| GST | 12.50% | | BZD 47'038.63 |
| Total amount | | | BZD 423'347.63 |

*subject to availability upon order confirmation

SMA Sponsorship BZD 59'013.00



SMART SOLAR OFF-GRID

SIGN-UP LIST FOR INTERESTED VILLAGERS FOR SOLAR POWER SUPPLY IN LA GRACIA VILLAGE

| ONE LINE PER HOUSEHOLD ONLY | | | | | | | |
|-----------------------------|----------------------------|----------------------------|-------------------------------|-------------------------------------|-----|------|----------------------------------|
| NO | NAME OF FAMILY / HOUSEHOLD | AMT OF PEOPLE IN HOUSEHOLD | DISTANCE TO SCHOOL (IN YARDS) | ESTIMATED POWER USE (TICK ONE ONLY) | | | IS THE HOUSE WIRED FOR AC POWER? |
| | | | | LOW | MED | HIGH | Y / N |
| 1 | Miranda | 4 | | | ✓ | | no |
| 2 | Martinez | 6 | | | ✓ | | no |
| 3 | Castillo migel | 5 | | | ✓ | | no |
| 4 | Fuentes | 9 | | | ✓ | | no |
| 5 | Fuentes Marbin | 1 | | | ✓ | | no |
| 6 | Ramires | 6 | | | ✓ | | no |
| 7 | Zepeda walter | 3 | | | ✓ | | no |
| 8 | Flores | 5 | | | ✓ | | no |
| 9 | Zepeda Venicio | 4 | | | ✓ | | no |

LOW: Lights, Radio, Small TV, NO FRIDGE

MED: Lights, Radio, Small TV, Fridge, Fan

HIGH: Lights, Radio, Small TV, Fridge, Fan, Washer, Water pump, Power tools



SIGN-UP LIST FOR INTERESTED VILLAGERS FOR SOLAR POWER SUPPLY IN LA GRACIA VILLAGE

| ONE LINE PER HOUSEHOLD ONLY | | | | | | | |
|-----------------------------|----------------------------|----------------------------|-------------------------------|-------------------------------------|-----|------|----------------------------------|
| NO | NAME OF FAMILY / HOUSEHOLD | AMT OF PEOPLE IN HOUSEHOLD | DISTANCE TO SCHOOL (IN YARDS) | ESTIMATED POWER USE (TICK ONE ONLY) | | | IS THE HOUSE WIRED FOR AC POWER? |
| | | | | LOW | MED | HIGH | Y / N |
| 10 | otto castillo | 7 | | | ✓ | | no |
| 11 | Castillo Junior | 1 | | | ✓ | | no |
| 12 | Flamenco | 4 | | | ✓ | | no |
| 13 | Arnoldo Zepeda | 8 | | | ✓ | | no |
| 14 | Polanco | 1 | | | ✓ | | no |
| 15 | Urbina | 6 | | | ✓ | | no |
| 16 | church | 1 | | | | ✓ | Yes |
| 17 | menendez | 4 | | | ✓ | | no |
| 18 | Audelio Zepeda | 7 | | | ✓ | | no |
| 19 | Juan Zepeda | 1 | | | ✓ | | no |
| 20 | Neelali Zepeda | 5 | | | ✓ | | no |

LOW: Lights, Radio, Small TV, NO FRIDGE

MED: Lights, Radio, Small TV, Fridge, Fan

HIGH: Lights, Radio, Small TV, Fridge, Fan, Washer, Water pump, Power tools



SIGN-UP LIST FOR INTERESTED VILLAGERS FOR SOLAR POWER SUPPLY IN LA GRACIA VILLAGE

| ONE LINE PER HOUSEHOLD ONLY | | | | | | | |
|-----------------------------|----------------------------|----------------------------|-------------------------------|-------------------------------------|-----|------|--|
| NO | NAME OF FAMILY / HOUSEHOLD | AMT OF PEOPLE IN HOUSEHOLD | DISTANCE TO SCHOOL (IN YARDS) | ESTIMATED POWER USE (TICK ONE ONLY) | | | IS THE HOUSE WIRED FOR AC POWER? Y / N |
| | | | | LOW | MED | HIGH | |
| 21 | Ramiro Polanco | 3 | | | ✓ | | no |
| 22 | Miranda Junta | 1 | | | ✓ | | no |
| 23 | Jesús Polanco | 8 | | | ✓ | | no |
| 24 | Cisneros | 2 | | | ✓ | | no |
| 25 | Dimas Cisneros | 3 | | | ✓ | | no |
| 26 | Equileo Cisneros | 2 | | | ✓ | | no |
| 27 | Duartes | 6 | | | ✓ | | no |
| 28 | Peralta | 6 | | | ✓ | | no |
| 29 | Molina | 4 | | | ✓ | | no |
| 30 | Elmer Cisneros | 6 | | | ✓ | | no |
| 31 | Salazar | 6 | | | ✓ | | no |

LOW: Lights, Radio, Small TV, NO FRIDGE

MED: Lights, Radio, Small TV, Fridge, Fan

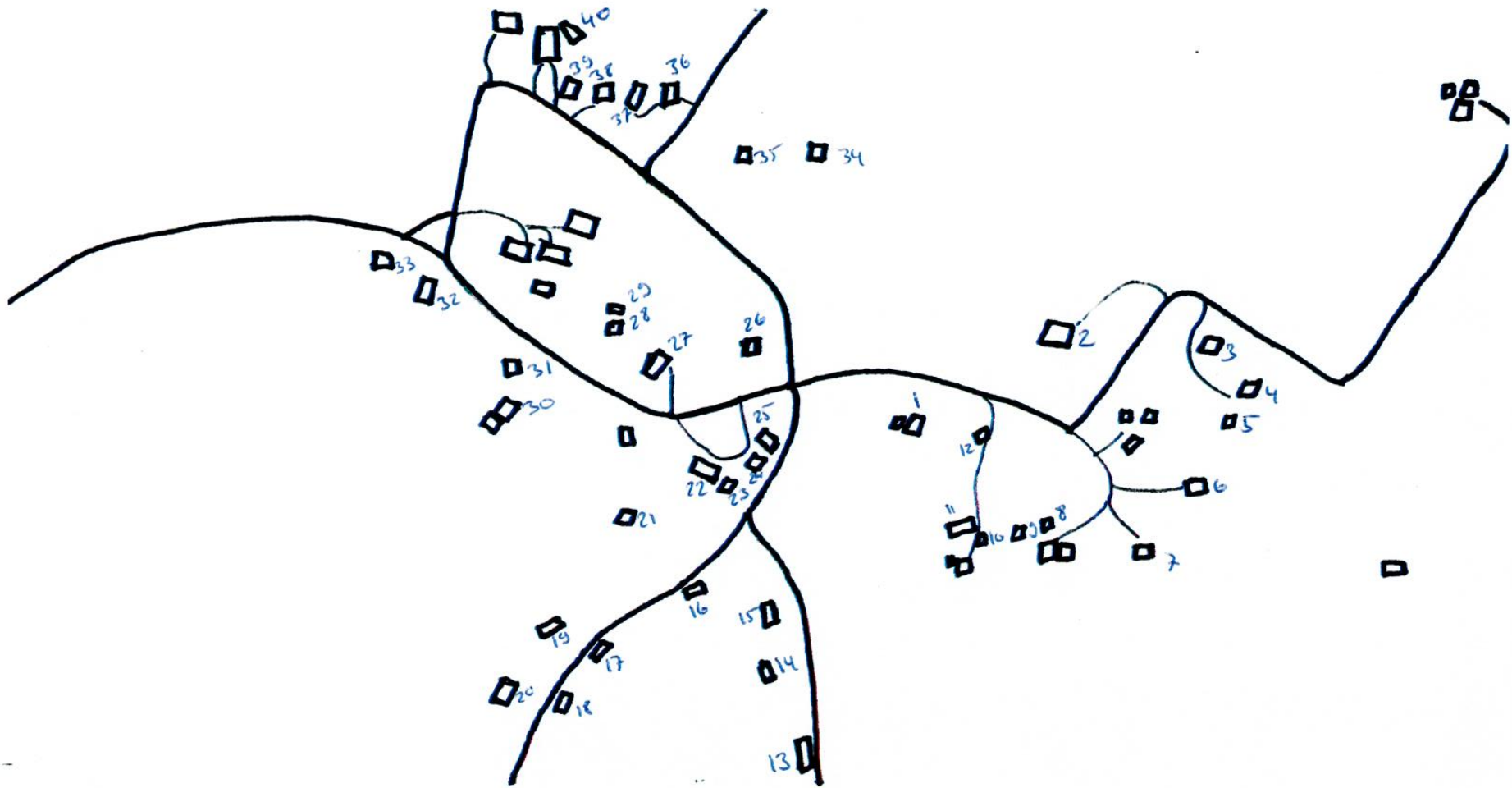
HIGH: Lights, Radio, Small TV, Fridge, Fan, Washer, Water pump, Power tools



SIGN-UP LIST FOR INTERESTED VILLAGERS FOR SOLAR POWER SUPPLY IN LA GRACIA VILLAGE

| ONE LINE PER HOUSEHOLD ONLY | | | | | | | |
|-----------------------------|----------------------------|----------------------------|-------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|----------------------------------|
| NO | NAME OF FAMILY / HOUSEHOLD | AMT OF PEOPLE IN HOUSEHOLD | DISTANCE TO SCHOOL (IN YARDS) | ESTIMATED POWER USE (TICK ONE ONLY) | | | IS THE HOUSE WIRED FOR AC POWER? |
| | | | | LOW | MED | HIGH | Y / N |
| 32 | Church Pentecostes | | | | | <input checked="" type="checkbox"/> | Yes |
| 33 | Antonio Ramirez | 6 | | | <input checked="" type="checkbox"/> | | no |
| 34 | Lopes | 3 | | <input checked="" type="checkbox"/> | | | no |
| 35 | Alfonso Ramirez | 9 | | | <input checked="" type="checkbox"/> | | no |
| 36 | Demetrio Ramirez | 3 | | <input checked="" type="checkbox"/> | | | no |
| 37 | Daniel Ramirez | 3 | | | <input checked="" type="checkbox"/> | | no |
| 38 | Samuel Ramirez | 3 | | | <input checked="" type="checkbox"/> | | no |
| 39 | Mix | 10 | | | <input checked="" type="checkbox"/> | | no |
| 40 | Rolando Martinez | 5 | | | <input checked="" type="checkbox"/> | | no |
| 41 | Albares | 2 | | | <input checked="" type="checkbox"/> | | no |
| 42 | Zesar Alvarez | 3 | | | <input checked="" type="checkbox"/> | | no |
| | Escobar | 8 | | | <input checked="" type="checkbox"/> | | no |

LOW: Lights, Radio, Small TV, NO FRIDGE
 MED: Lights, Radio, Small TV, Fridge, Fan
 HIGH: Lights, Radio, Small TV, Fridge, Fan, Washer, Water pump, Power tools





MINISTRY OF ENERGY, SCIENCE & TECHNOLOGY AND PUBLIC UTILITIES

Old Lands Building, Upper Floor, Market Square, Belmopan City

Telephone No. 501-822-0160/501-822-0162/501-822-2107/501-822-3336

Fax No. 501-822-0433

Email: energy.director@estpu.gov.bz; energy@estpu.gov.bz

REF: PUB/5/01/14 VOL. V(49)

November 25th, 2014

REPIC-Plattform
c/o NET Nowak Energie & Technologie
AGWaldweg 8
CH-1717 St. Ursen
Switzerland

TO WHOM IT MAY CONCERN

Letter of Intent to Support ZENNA Proposal for Renewable Energy & Energy Efficiency Promotion in International Cooperations (REPIC)

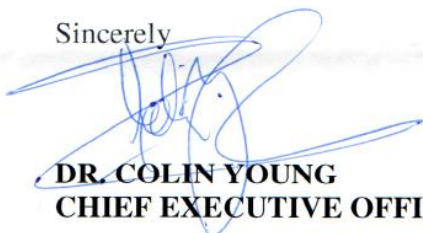
I write to confirm the Ministry of Energy, Science and Technology and Public Utilities' (MESTPU) support for a project conducted with REPIC and ZENNA to provide electricity to a rural village in Belize.

It is estimated that in 2014 over 10,000 Belizean's remain without access to electricity. The vast majority of these people reside, in remote communities where the small population and geographical location renders service by the national electricity grid both technically difficult and uneconomical. However, Belize recognizes the great economic and social benefits that can be realized through providing electricity to those villages and having these communities electrified is important to Belize's ongoing sustainable development efforts. Consequently MESTPU has identified rural village electrification using micro-grids and mini-grids as an integral component of its long-term strategy in both the *Belize, Renewable Energy and Energy Efficiency Strategy* and the *Sustainable Energy Action Plan*. Where only an independent off-grid system is feasible from both a financial and technical perspective.

The MESTPU currently lacks the financial and human resources to electrify rural villages through an off-grid network. During a meeting held on the 19th of September with MESTPU and ZENNA, ZENNA

introduced REPIC's activities and it was agreed that MESTPU would welcome and support a solar pilot project with ZENNA & REPIC. ZENNA has expressed their ability to develop an independent off-grid solar system in cooperation with Solar Energy Solutions Belize (SESB) who will act as a local counterpart for installation and maintenance. It was also agreed that a pilot project to electrify a rural village would be beneficial both improving livelihoods in the local community and to provide MESTPU a necessary pilot project for future off-grid electrification projects. Pending an agreed (by REPIC) project plan by all the parties, MESTPU agrees to contribute 20% of the cost of the project (or a maximum USD\$ 60,000) as in-kind towards this project.

Sincerely



DR. COLIN YOUNG
CHIEF EXECUTIVE OFFICER



**MINISTRY OF ENERGY, SCIENCE & TECHNOLOGY
AND PUBLIC UTILITIES**

Old Lands Building, Upper Floor, Market Square, Belmopan City

Telephone No. 501-822-0160/501-822-0162/501-822-2107/501-822-3336

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Email: minister.sec@estpu.gov.bz, senior.sec@estpu.gov.bz

Ref: GEN/32/01/15 (10)

February 18, 2015

Dear Colleagues,

Please be informed the Ministry of Energy, Science and Technology and Public Utilities has chosen the village of La Gracia for the SESB Project. La Gracia village has past experience dealing with solar panels for they had received a project from Belize Natural Energy (BNE) Trust where the primary school is being powered by solar panels and solar power.

Please feel free to contact us at telephone number 822-0160/0162 or email Ms. Loma Ogaldez at energy.secretary@estpu.gov.bz or Mr. Ryan Cobb at energy@estpu.gov.bz for further queries.

Regards,

**Ryan Cobb (Mr.)
Energy Officer**

REPIC Plattform
c/o NET Nowak Energie & Technologie AG
Waldweg 8
CH-1717 St. Ursen
Switzerland

Belmopan, November 3, 2014

TO WHOM IT MAY CONCERN

Letter of Intent to Support the Rural Electrification Project in Belize "SMART SOLAR OFF-GRID" in collaboration with ZENNA & REPIC Switzerland and MESTPU Belize

With great interest we have learned from Mr. Lukas Kuffer, ZENNA Switzerland, about the opportunity to realize renewable energy projects in developing and transition countries through the REPIC PLATFORM, Switzerland.

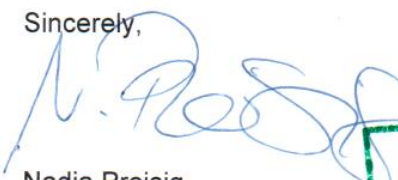
During a public meeting held by the Ministry for Energy, Science & Technology and Public Utilities (MESTPU) a few months ago, we became aware of many communities and villages that are still not electrified. Having this fact in mind, our attention was caught immediately when we heard about REPIC.

Besides of having the capacity to assist with the installation and maintenance of the proposed SMART OFF-GRID SYSTEM, we feel that SESB could significantly contribute to a successful project outcome by sharing our knowledge of local conditions such as the subtropical climate / weather conditions, local needs and mentalities, but also by outlining challenges and risks.

We would like to express our full support of this project to our best knowledge, given REPIC's approval of the project plan proposed by ZENNA, Switzerland.

Please do not hesitate to contact me at contact@solar-energy-solutions-belize.com / +501 666-1000 if you have any questions or concerns.

Sincerely,



Nadja Preisig
Director of Purchasing & Administration
Solar Energy Solutions Belize Ltd.



Off-Grid Reference Project in Belize



- ◆ This project was done in cooperation with ZENNA
- ◆ ZENNA was supporting SESB in this project, with monitoring and remote service know how



**Life Sciences und
Facility Management**

IUNR Institut für Umwelt
und natürliche
Ressourcen

Jürg Rohrer

dipl. Ing. ETH
Dozent, Leiter Fachgruppe Solartechnik &
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REPIC
c/o NET Nowak Energie und Technologie AG
Waldweg 8
1717 St. Ursen

Wädenswil, March 3, 2015
Our reference: Rohu/JR

Letter of intent / ZENNA proposal «smart solar off grid»

To whom it may concern

This is to confirm that we have been involved in the development of the proposal «smart solar off-grid». We plan to cooperate with ZENNA AG for the design of the above mentioned pilot project.

In our view, the proposal combines the expert know-how of all involved parties in an optimal way so that the likelihood of success is very high. We are excited to be part of it and look forward to starting soon.

Sincerely
Zurich University of Applied Sciences

A handwritten signature in black ink, appearing to read 'Jürg Rohrer', written in a cursive style.

Jürg Rohrer
Lecturer, Head of Research Group Solar Technology, Institute for Natural Resource Sciences



SMA Solar Technology AG · Sonnenallee 1 · 34266 Niestetal · GERMANY

SMA Solar Technology AG

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To whom it may concern

| | |
|---------------|---------------------|
| Author | Jorge Torres/KGr |
| Phone | |
| +49 561 9522- | 421243 |
| Fax | |
| +49 561 9522- | 3290 |
| E-Mail | Jorge.Torres@SMA.de |
| Date | 21.11.2012 |

Letter of authorization

Dear Sirs,

We, **SMA Solar Technology AG**, who are established and reputable manufacturers of Sunny Mini Central, Sunny Tripower and Sunny Island inverters having our factory at Sonnenallee 1, 34266 Niestetal, Germany do hereby authorize

Solar Energy Solutions Belize Ltd.

PO BOX 63
Belmopan, Cayo
Belize
Central America

to distribute the goods manufactured by us in Belize.

We hereby confirm to give necessary technical support, hardware supply and after sales support & spares (based on form, fit and function) on chargeable basis to Solar Energy Solutions Belize Ltd., and hereby extend our full guarantee and warranty for the goods and services offered for supply by the above firm as per SMA specifications and SMA factory warranty conditions.

We, SMA Solar Technology AG, are the manufacturer of solar inverters with the largest turnover worldwide. The group has subsidiaries in four continents by 19 sales and service subsidiaries as well as two production facilities. SMA employs more than 5,500



people and had a turnover of approx. 1.7 Billion Euros in 2011. The company can supply state-of-the-art solar inverters for both grid-connected and stand-alone solar installations – regardless of the type of solar module or the plant capacity. SMA has been setting new industry standards in decentralized and renewable energy supply technology for more than 25 years and has made a major contribution to the development of solar technology. SMA has over 20 giga watts of total installed capacity in the field of PV by the end of 2011 and is currently expanding its annual manufacturing facility to 11.5 giga watt capacity in Germany.

We provide factory warranty for 5 years of the products and guarantee high quality of products and its originality.

SMA has no exclusivity with any company in Belize or in any other country. Solar Energy Solutions Belize Ltd. is in no respect authorized to act on behalf of SMA nor in SMA's name. In promoting sales of SMA products, Solar Energy Solutions Belize Ltd. acts solely on its own behalf, in its own name, on its own accounts and at its own risk.

Yours sincerely,

SMA Solar Technology AG

A handwritten signature in black ink, appearing to read 'i. A. Jorge Torres', written in a cursive style.

i. A. Jorge Torres
Sales New Markets