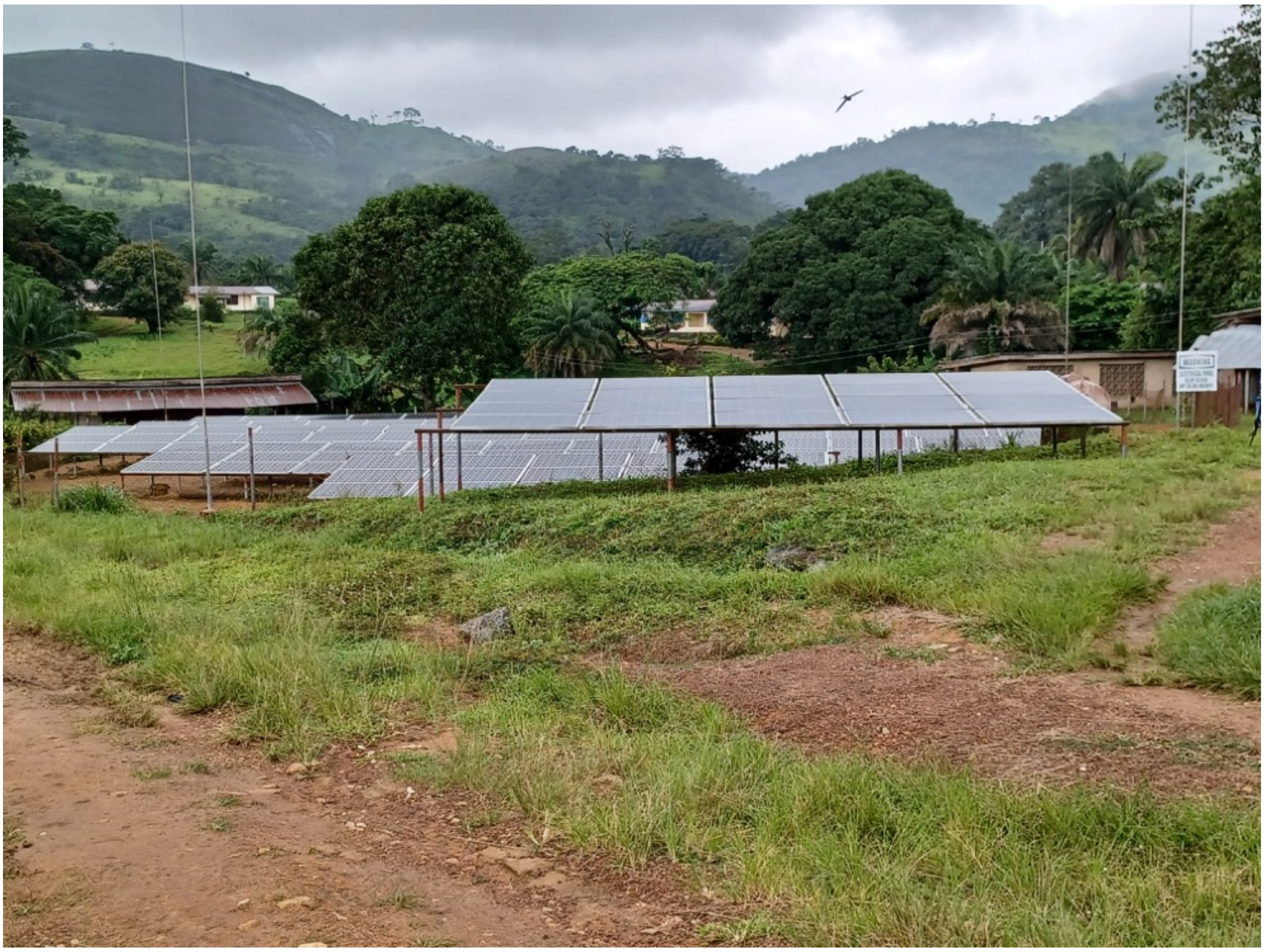
TOOL

FOR

ASSESSING INVESTMENTS IN

COMMUNITY ENERGY SYSTEMS



Prepared jointly by **SEND Sierra Leone** and **Engineers Without Borders Denmark**.

November 2022

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AC	Alternating Current
AGM	Annual General Meeting
DC	Direct Current
Km	Kilometer
kW	Kilo Watt
LE	Leone (new)
MFI	Micro Finance Institution
NGO	Non Governmental Organization
SHS	Solar Home System
VSLA	Village Saving and Loan Association
a.o.	Among others

1. INTRODUCTION

This tool is developed with the purpose to engage communities in decisions on a large investment in providing electricity to the benefit of all community members, both female and male. The tool addresses issues related to electricity use both within households and for productive use of energy in businesses. Use of the tool is not restricted to SEND, but it is encouraged to be widely distributed, enabling other organisations, private investors and donors to benefit from the assessment methodology.

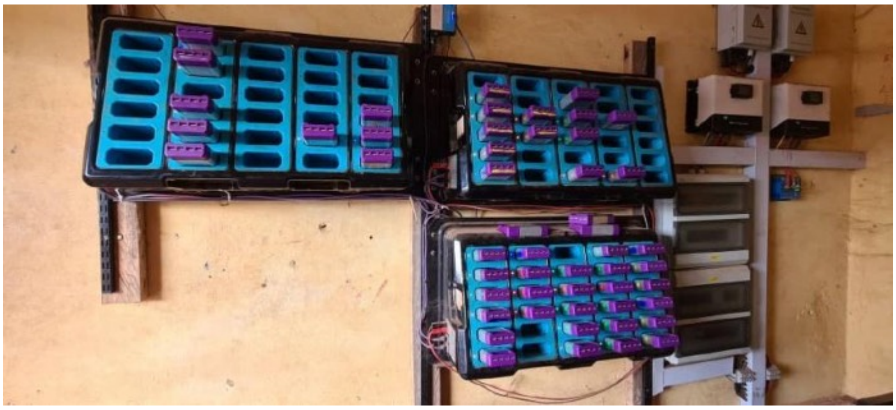
Application of the tool is not restricted to a specific technical solution. It can be used in a situation where the wish is to establish a minigrid, supplying electricity to all households from a small power plant and provision of electricity for alternative income generating activities. It can also be used where the wish is to provide electricity from a hub renting out appliances operating on rechargeable batteries. It is not restricted to a renewable energy supply (e.g. solar power), but can also be used for investments in a diesel generated minigrid system, although this requires additional analysis due to negative environmental and climatic impact. In cases where there is no specific technical solution in mind beforehand, the tool can also be used in the decision making process for the most suitable system to be invested in.

The main case used to illustrate all the considerations to be taken into account, when communities have to decide on the investment, is a community solar power hub. The community solar power hub will consist of a house with the solar power system, and it will rent out a range of appliances (e.g. lanterns or cooling boxes) to customers in the community, all running on rechargeable batteries.

This main case has been chosen for several reasons:

- Unlike the well known and often applied minigrid solution, it is an innovative technology, which can inspire others.
- It is the most suitable solution for communities in which the households are spatially dispersed e.g. where it should also serve nearby catchment areas, making it complex and expensive to establish a minigrid.
- It is solely using a renewable energy source, which is the best solution from an environmental and climate perspective.
- Considering the trend with reduction in prices of solar solutions compared to an expensive diesel based solution, it will most likely gradually become financially more attractive.

The assumption used throughout the tool is that the initial capital investment (energy system and building), which is the single largest cost item, will be provided by a donor or an NGO, as in most cases a community will not be able to raise the initial funding required. However, the considerations unveiled through the assessments made will still be applicable, if a private investor considers to invest in providing solar power to a community.



There are several methods for gathering the data required for analysis before the investment decision is made. One method is not better than another as long as the best possible and reliable data are collected. However, it is suggested that the data collection activity is done with a focus not only on statistical results, but also getting opinions and suggestions from the population, local authorities, public and private enterprises and other stakeholders in order to promote a bottom-up approach and lay the ground for a participatory project development.

As the tool will be used in many communities it is suggested that, to the degree possible, the same team is used to carry out the assessment. In this way the learning from the assessment will be fully utilized: E.g. one of the important elements in the assessment is the market analysis, so experience from other communities where an assessment has been done, followed by investment in electricity services, will shed light on the relationship between the expressed demand during the assessment phase and the actual demand when the service is made available. This information will improve the decision making on the basis of data gathered.

The following sections focus on the questions to be asked and the data to be gathered during the assessment. Sections 10 and 11 deals with the considerations when it comes to making the final investment decision on the basis of all the data gathered.

2. CONTEXT

2.1 The issue

A community in the Southeastern part of Sierra Leone, Mendekelema, has through its local authorities expressed a wish to have access to electricity. The wish has been articulated towards a NGO, with whom the community has worked closely for a number of years. Hence the NGO knows the community well. But considering the size of such an infrastructure project and the risks involved, especially to ensure its technical, environmental, social and financial sustainability, the NGO has decided to undertake an assessment of the viability of investing, before it actively seeks funding for installation of a solar power system in Mendekelema. The NGO wishes to include three nearby catchment villages in the investment, as there are many potential customers who also wish to get access to electricity.

The first area to assess is the local context for the community population, setting a framework for the remaining issues to be assessed.

2.2 Questions to be asked during the assessment related to the community context

a) What are the most important economic activities: Subsistence agriculture, cash-crops, shops, market, micro-enterprises, other?

b) What are the main agricultural activities: Which crops, vegetables and fruits are produced? Are any of these further processed, e.g in a rice mill or palm oil presser?

c) Which types of small livestock (a.o. chicken, rabbits, goats) do people keep? After slaughtering, is the meat from these consumed immediately or kept for a period after, and if kept, under which conditions is it stored?

d) Which type of employment exists: Teachers, health workers, government employees, micro-enterprises, day-laborer, other?

e) Which educational possibilities exist in the community: How many schools exist? Are children from the community attending school in another community? Are children from another community attending school in this community?

f) What is the general educational level: Number of children attending primary and secondary school? Do all girls go to school every day? Do all boys go to school every day? Have all adult women been at least 6 years to school? Have all adult men been 6 years to school? Are there adults who have never been to school?

g) Which person in the community has the highest degree of formal education? Are there persons having a technical education (e.g. mason, electrician) over and above primary or secondary school?

h) Water resources available in the community: What is the access to clean drinking water? How far do families have to walk to collect clean drinking water? Who is responsible in the family for collection?

i) Which health services are available: Clinic? Dispensary? Nurse? Midwife? What is the distance to nearest hospital?

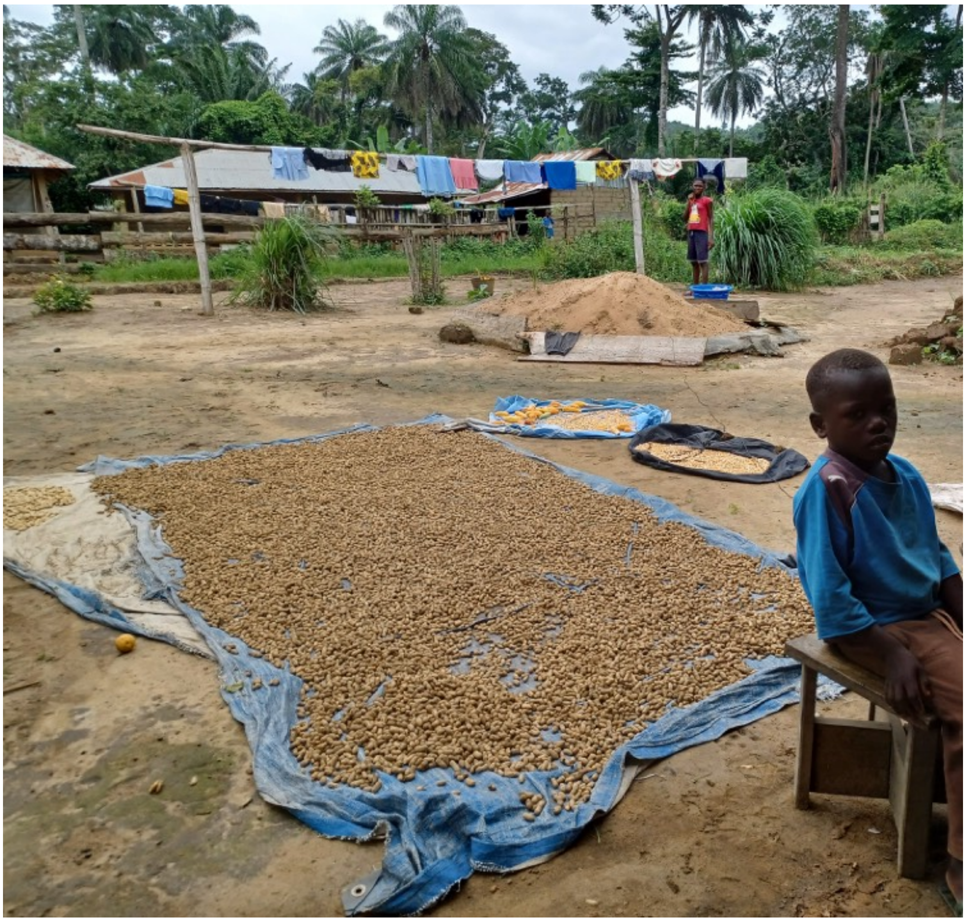
j) How many village saving and loan associations (VSLA) exist and how many members do they have? Do some of the VSLAs have linkages to Micro Finance Institutions (MFI)?

k) How many people live in the community?
- Of these, how many females and how many males (18 years and above)?
- Of these, how many girls and how many boys (below 18 years)?

2.3 Example

The most common economic activities in Mendekelema community are farming and business (charging booths, sports centers, shops, community dance, weekly market every Thursday, petty trading with food and non-food items). Hence the non-diversified agriculture sector (mainly producing rice, palm oil plants and groundnuts) and petty trading are the primary activities generating income at the household level, i.e. presently there are very few micro-enterprises. The area is also characterized by poor infrastructure, a.o. there are 42 kilometers to the district headquarters in Kenema, the nearest place where it is possible to e.g. have made a copy of a paper or document as might be required by a public office.

Social activities mainly engaged by youths that use energy in the community are disco, weddings, naming ceremonies and school events such as sports activities. Service providers existing in the community includes Gola Rainforest (protecting deforestation), Gold tree (supporting education), Welt Hunger Hilfe (promoting agriculture) and Orange Mobile money (providing money transactions through mobile phones). Orange and Africell provide mobile network coverage, with Orange having the most robust network coverage.



There are 9 teachers in the two schools in Mendekelema. Several water tanks are available providing clean drinking water to the community members. A health clinic also exists, and there are a few VSLAs with mainly female members. The Tegloma Women's Development Association VSLA group is the only group that is linked to a MFI, the Muabeh Credit Union in Gebwema community in Tunkia chiefdom.

In Mendekelema a very high proportion of the adults are illiterate. With the arrival of electricity this gives the opportunity for carrying out evening school classes for the illiterate adult population. There is one person who have been to a vocational training institute, having completed a course in electrical engineering.

The estimated population size in Mendekelema and the three catchment areas is 5.733 inhabitants in the 722 households. Of these 2.090 (36%) are adults above 18 years, indicating a flat population pyramid with the expected result that a high number of youth will be seeking employment for the years to come. On average, each family has 6 children when including young people above 18 years living at home.

3. MARKET

3.1 The issue

The size of a community power system depends to a high degree of the market for electricity in the area. It should cover the expected demand, both for households and for productive use of energy in private businesses. To estimate the demand for a service, which a large part of the population might not have known or used before, is difficult.

In determining how much electricity will be sold it is necessary to distinguish between effective demand and demand. Effective demand is the demand expressed by all buyers of the service in terms of actually buying the service: I.e. the willingness to pay expressed through actually spending money to procure electricity. Demand, not effective demand, is the expressed wishes of people, some of who will actually buy, some of who will in practice not buy, e.g. because they are not able to or willing to pay when electricity has become available. As effective demand in this specific community being assessed is not known due to the lack of electricity supply, more indirect methods need to be applied in assessing effective demand. An indirect way can be to assess how much money is presently spend on energy (a.o. diesel and batteries), especially energy which can be replaced by electricity from a community solar system or mini-grid.

3.2 Questions to be asked during assessment of the market

a) Are there families who have a Solar Home System (SHS)? If yes, how much has been paid for the SHS?

b) Which services are provided by the SHSs: Light? Radio? Television? Mobile phone charging?

c) How many families have a mobile phone? Of these, how many women have their own mobile phone? How is the mobile phone charged? How much is paid for charging a mobile phone? How much LE is used per week for phone charging?

d) Which type of mobile phone do families have (traditional (phone/SMS) or smart phone)?

e) Are mobile phones used for banking/mobile money?

f) Do all families have a battery lamp (torch/flashlight)? How much money is used for buying batteries per week?

g) Do families use candles for lightening? If yes, how much LE is used per week for buying candles?

h) Do families have a battery driven radio? If yes, how much LE is used per week for buying batteries for the radio?

i) Are there families having a television? Is there a television at a public place where people can come and watch?

j) Are there any families having a computer?

k) Are there other appliances in use in the community which run on electricity?

l) Are there enterprises which use generators run by petrol/diesel? For which use? How much money is used per week to buy petrol/diesel? What is the availability of petrol/diesel?

m) Is there potential for use of electricity driven machinery in e.g. agricultural value added activities (e.g. rice milling), in the community?

n) What are the possibilities for new business investments utilizing electricity? Selling refrigerated products? Bakery? Printing and copying? Other?

o) When deciding on how to spend money, what is most important:
- Buying of food?
- Payment of health services (medicine, treatment at clinic/hospital)?
- Payment for clean drinking water?
- Payment of school fees for education of children?
- Clothes and shoos for adults and children?
- Transport?
- Energy (kerosene/petrol/diesel/candles/batteries)?

p) Who in the family have the final say in deciding on expenditures? The woman or the man?

q) Considering that few people have experience in using electricity, is there a risk that households will spend too much on this new service? If yes, what should be done to mitigate this risk?

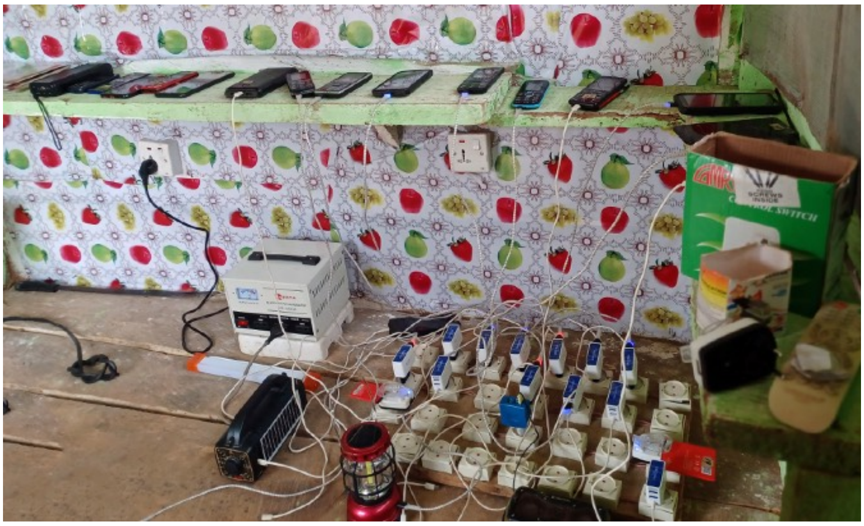
r) How much money will a family be able to use on electricity on a weekly basis?

s) How many households will use the community power system on a daily basis?

t) How much money are households using for electricity on a weekly basis in comparable communities where there already is a functioning power system?

3.3 Example

It is estimated that more than 10% of the families in Mendekelema and the nearby catchment villages have invested in a SHS, typically providing light, radio and phone charging. The costs of a typical SHS (light/radio/phone charging) is LE 640, usually being paid in weekly installments.



Around half of the families have a traditional mobile phone, which in a few occasions are also used for mobile banking. There are 10 generators used for commercial purposes in the community, mainly for mobile phone charging. The cost of charging the mobile phone has been increasing drastically due to higher fuel prices, and is now LE 3. If the phone has to be charged twice a week this means an annual expense of LE 300 for this purpose. A few families have a plasma TV, but none have a computer. Many families have a small portable radio and more families have torches, both of which runs on batteries (with some now being solarcell powered). It is estimated that these families easily use 5 LEs per week, i.e. 250 LEs annually for buying batteries.

At present, the only diesel operated machinery is a rice mill, but it is assessed that there are several opportunities for using power from a community solar energy system for productive purposes, e.g. for cooling, printing and agricultural value added activities.

There is clearly an upper limit for the money a family can afford to use on buying electricity due to the competing demands from especially food and children's education. Training of families in optimal use of electricity, both in terms of using potential future gadgets correctly to ensure a long lifetime for these and not overspending, will be required by the electricity supplier.

On a weekly basis it is assessed that a typical family will be able to use up to 10 LE on electricity (effective demand), and that up to half of the 722 families (i.e. 361) will use the provided service. The 10 LE will displace the present payment of phone charging and battery usage as well as weekly installments of procured gadgets. During the assessment some indicated a higher willingness to pay, but experience shows that this is often not possible in practice due to other pressing demands for funding. On an annual basis the gross income from the families for the electricity supplier will be 187,720 LE (10 LE per family *52 weeks *361 families). On top to this, there will be an income from selling electricity for private enterprises using electricity for productive use. Initially this is estimated to 30.000 LE on an annual basis, gradually increasing when entrepreneurs see the benefit and potential of productive use of energy. The total gross income will in this scenario be up to 207.720 LE.

4. LOCATION AND LAND

4.1 The issue

The spatial distribution of the houses in the area to have electricity coverage as well as the availability of land for setting up the power system influence the design of the system. In a town houses are close to each other making it easier and cheaper to install a mini-grid compared to a village, where there might be long distances between houses, hence another solution might be optimal. Where solar panels are to be used it requires sufficient space enabling panels to be installed on the ground, depending on the designed system capacity. The location of the system also depends on the availability and ownership of land, hence of the cost of the land.

4.2 Questions to be asked during assessment of the location and land

a) What is the spatial distribution of households and small businesses: Are they all in a densely build-up area or widely spread in the landscape?

b) Does a portion of the people targeted as customers live outside the community, e.g. in catchment areas?

c) Where is land available for installing the energy system including a suitable building, and is there sufficient land available for setting up solar panels, also in case of a later investment in increased capacity?

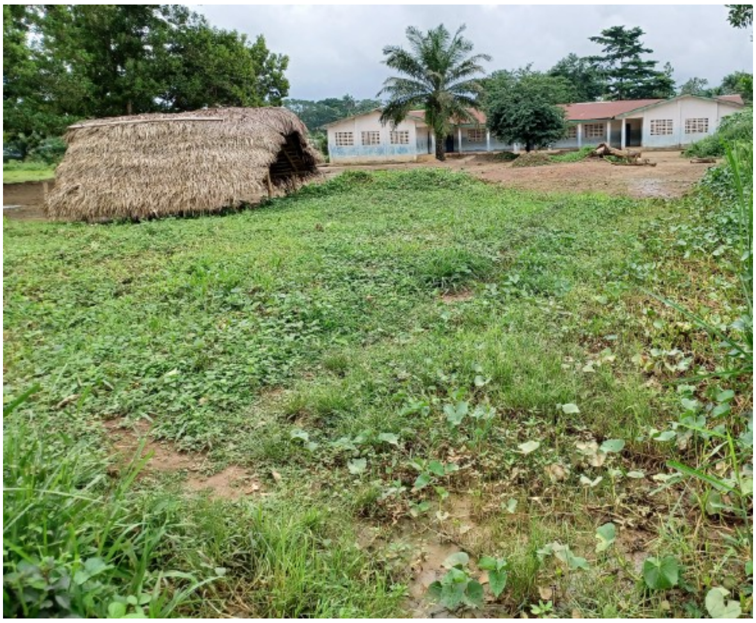
d) Is the piece of land being proposed for the system community or privately owned?

e) If privately owned, who is the owner? Does the owner have a title deed to that piece of land?

f) Will the land be provided free of charge to host the power system? If not, what will the price of the land?

g) Will the land be rented by the organisation managing the system (long term lease) or will the ownership be formally transferred to the organisation?

h) Will the land, also if it is privately owned and has to be paid for, be the contribution of the community for establishment of the power system?



i) If community owned land, who make decisions on the use of the land? Will these persons sign an agreement with the organisation/management owning the power system on permanent use of the land for the purposes of the energy system?

j) Is the piece of land for the power system close to e.g. a school or community hall, potentially enabling electric wiring to be easily made from the system to rooms to be used for common purposes in the community (e.g. education or meetings)?

4.3 Example

Houses in the community of Mendekelema are spatially distributed over a relatively small area. As one of the presently main economic activities is a weekly market drawing customers from a number of nearby catchment areas, the intention of setting up a solar energy system is that people in these areas should also get access to electricity services. Hence another solution than a mini grid should be used, e.g. a solar power system where customers can rent rechargeable gadgets (e.g. light, radios and mobile phone chargers).

There is a large area of land available between the community hall and the primary school, where the community will provide land for a solar power system. The community land will be provided free of charge to the organisation owning and operating the solar power system. This also include land for a possible later extension of the system with more solar panels, should it be required. To this effect, an agreement will be signed between the community leadership and the organisation to own and operate the system.

5. EQUIPMENT

5.1 The issue

The sizing and choice of components in a solar system is often quite sensitive to many different factors. Components should be of acceptable quality, while still known to suppliers in Sierra Leone, when they need replacement and repair. The types of appliances to be used play a significant role as well, as some require very high energy intensity (consuming a lot of energy in a short time span), e.g. welding, while others have a low energy intensity (consuming little energy over a longer time period), e.g lighting.

Typically, a solar power system will have the following major components:
- Solar panels
- Inverters
- Charge controller
- Battery
- Monitoring
- Rack or other mounting method

along with several minor components:
- DC/AC disconnects
- Junction / Combiner boxes

- Fuses
- Electric wiring

5.2 Questions to be asked during assessment of the equipment

a) What major components can be acquired from local suppliers?

b) What local suppliers can provide spare parts?

c) Are there potential local maintenance contractors?

d) Is it economically feasible to use a tracker system for changing solar tilt during the day?

e) Additional requirements for equipment to ensure extended lifetime of systems?

f) From the list below of solar powered appliances, which ones would be most needed in the community?

- Phone charging
- Lighting and lamp rental
- Refrigerators and freezers
- Food processing – milling or pressing
- Computer and IT services
- Multimedia room
- Drying
- Welding

g) Are some appliances used more on certain times of the year?

h) Will the system be AC or DC? If both, which appliances will be powered by which current type?

i) What are the other sources of appliances in the community?

j) In case of over dimensioning, what other appliances can afterwards be introduced?

5.3 Example

Sierra Leone has a few suppliers of solar systems, who are able to plan, design and dimension a solar system from the beginning. As a result, there is sufficient access to major and minor components in the area, as well as spare parts. Based on prior experiences in Sierra Leone, the first components to break down is most often the batteries. The systems are typically roof-mounted with no tracking system.

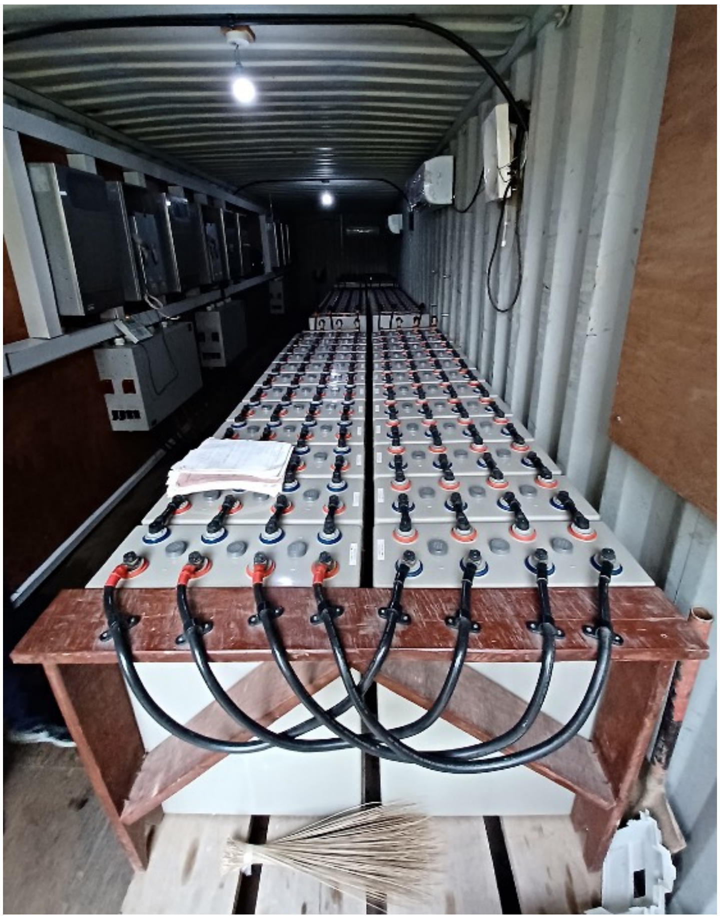
Instead of using lead batteries, lithium batteries should be installed as they have a much longer lifetime (up to 10 years instead of 4 years), and the efficiency of the system will as well be significantly higher with lithium batteries as energy losses will be smaller. Although lithium batteries are more expensive than lead batteries the benefits are clearly higher than the additional costs.

The issue of over dimensioning is a common occurrence in energy systems promoted by NGOs. Numerous examples of this phenomenon can be observed in Sierra Leone itself. On the other hand, and under dimensioned system will naturally not be able to service its users, and usage of the products will decline rapidly.

The solution is to size the system to be scalable, i.e. to gradually build it up. In solar systems, the bottleneck in increasing system size is typically the inverter, which has a maximum DC load it is able to convert to AC. One can always add additional solar panels and batteries up to the capacity the inverter can convert to AC. There are however minimal losses in sizing this component larger for potential future expansion. For example, if one designs a 6 kW system, a 10 kW inverter can be installed. If there is an increasing demand in the future, then one can simply install additional solar panels and batteries up to a cap of 10 kW. This way, the system will be straightforward to expand, without having to exchange the entire system.

The size of the solar energy system in Mendekelema should be 6 kW, as this will provide a foundation for delivering electricity services to both a significant portion of the population and for productive use of energy.

The estimated costs of the 6 kW system is 185.000 LE.



All equipment will be procured in Sierra Leone to ensure that the correct replacement parts can be sourced at any time. Presently the costs of lithium batteries, which are not produced in Sierra Leone and will need to be imported, are exorbitantly high locally, and the NGO will therefore seek international assistance to procure these at much lower prices. However, all the technical specifications will be determined by the NGO, specifications to which the supplier must fully adhere.

While the community of Mendekelema already have several options in regard to phone charging, the use of lights and lamps is not nearly as widespread. It will have to be decided by the organisation to operate the solar power hub precisely which gadgets should be provided to consumers: A total package of lamp, mobile charging and radio, or only lamps and radio with mobile phone charging taking place at the hub itself?

A total amount of 150.000 LE is budgeted for procurement of appliances.

Additionally, refrigeration and milling both appear to be high in demand, as the access to these facilities are currently either limited or non-existent. Further, the citizens in the village and nearby catchment communities will travel to Kenema for IT and printing services. Welding have given difficulties in other solar systems in Kenema and Panguma, due to its high capacity demand. Equipment for productive use of energy, e.g. cooling boxes, will be owned by the entrepreneur herself, with the procurement process being facilitated by the hub to obtain lower prices as bulk procurement is foreseen.

6. BUILDING, ENGINEERING AND TECHNOLOGY

6.1 The issue

Aside from the specific equipment to be used in the solar system, several other technical factors need to be considered. This includes the building itself where the system is to be placed in. If already existing infrastructure can be used, this is encouraged as construction can make up a significant part of total costs. It is however important that the building is able to support roof mounted solar panels if these are desired and have acceptable storage area for batteries. If any similar systems have already been installed nearby, it can be of great value to gain experience from these investments and build on the lessons learned.

Additionally, it is important to specify the procedures for maintenance of the system, and who is responsible for repairs when there are equipment breakdown. Given that these electrical systems are relatively fragile, some degree of surveillance or inspection is of key importance. This can prolong the total lifetime of the system significantly and be the deciding factor in whether or not it will be operational in the long term.

6.2 Questions to be asked during assessment of the building, engineering and technology

a) Is there already an existing building to be considered for the solar system?

b) Should a new building be constructed, or will an existing one be used?

c) How much space would be needed?

d) Which building requirements should be kept in mind?

e) Is there a good place for storing the batteries in the building?

f) Are there nearby solar systems to learn from?

g) Is there enough space for ground mounted panels?

h) Is there extra space in case for future expansions?

i) Are there local requirements/standards for installation of equipment, inspection, testing and commissioning of the system?

j) Does it require a license to establish and operate the energy system? If yes, which government office is responsible for issuing the license?

k) Who shall receive training in system maintenance?

l) For those who receive training, what tasks shall they be able to carry out afterwards?

m) What will be the required sections in a manual?

n) What is the nearest grid connection to the community? Shall future retrofitting of the system to be fitted into a grid be considered?

o) How frequently will there need to be inspection of the system?

p) Who will be responsible for the inspection?

6.3 Example

The community of Mendekelema does not appear to have any suitable existing infrastructure for a roof mounted solar system. Aside from the fact that close to all constructions are currently occupied, the construction material used is not expected to be sufficient for the weight of solar panels and the mounting rack. Since a new building will be built, it is possible to ensure all the necessary criteria will be met.

The estimated cost of the building is 240.000 LE.

To reduce costs of the building it is an option to search for and procure a used container (20 or 40 Foot) which can be used for storage of batteries as well as hosting the other equipment. This will reduce the needed size of the building which will then only need to have a room for selling and recharging appliances.

Depending on the need of entrepreneurs and the size of the land being allocated for establishing the solar energy system, the building can be the first in a series of buildings in a small scale industrial park, where the other buildings will be constructed by the entrepreneurs to host their small businesses. Provided sufficient generation capacity is available, these buildings can be directly connected to the energy hub and receive metered electricity.

A license is required to install a solar system in Sierra Leone. However, since local suppliers will be relied on for the installation of this system, this meets these licensing conditions. Maintenance will be the responsibility of the local technician, who will be responsible for contacting the contracted maintenance company in case of technical issues.

The nearest grid to Mendekelema is near Kenema, some 42 km. away. At the moment there is not any sign of a coupling to this grid in the near future, and considered very unrealistic for it to interfere with the planned solar system in Mendekelema.

7. SAFETY

7.1 The issue

Several facets exists to the question of safety when dealing with solar systems. One is the safety of the staff operating it, as it is with all electrical systems that carry a risk of electrocution if handled incorrectly. Several precautions can be taken to minimize this, and should always be present: Grounding of equipment being one. Given the geographical location of Sierra Leone and the frequency of thunderstorms, lightning protection is also vital to be included. It is also worth considering that equipment will be rented out from the hub, and users need to understand potential risks in these. Electrical devices can electrocute people, or the cooling liquid in refrigerators can be toxic when getting in contact with skin.

The second facet of safety comes to the protection of the equipment itself. Since the equipment are relatively expensive parts with a potentially high value in the local community, certain protective measures need to be in place for the building. Protective lights should be a minimum, though additional restrictions such as fences or similar should be considered.

Disposal is another facet when it comes to discarding of the old or damage parts. Currently there are challenges in relation to reuse, recycling and regeneration of old batteries. There are cases where the lead acid in the batteries are reused in the fishing net by fishermen and the metal are sold to local craftsmen to fabricate different metal products (like cooking stoves and pots).

7.2 Questions to be asked during assessment of the safety

a) Are there any requirements/standards for safety?

b) Are there required licenses or permits?

c) What is the typical application time for these permits?

d) What equipment will need to be prevented access to?

e) Where are the biggest risks of electrocution?

f) Will the system have grounding protection?

g) What lightning protection is seen on the system?

h) Will some outdoors equipment (solar panels) need security measures? (Fence or similar)

i) If solar powered tools are to be provided, should service include safety rules for equipment?

j) Which measures will be taken to secure an environmental acceptable handling of disposed equipment?

7.3 Example

In Sierra Leone suppliers are aware of relevant standards and so should adhere to these. Necessary grounding, lightning protection and similar will be specified as requirements in requests for quotations from suppliers. Instructional guides and necessary information will be given to the hub manager and technician, whom are responsible for ensuring that customers are aware of potential risks in the products.

For the safety of the building, protective lights during the evening is included in the dimensioning of the system itself. Fencing around the building perimeters will also be included, and a security guard during the night or similar safety measure is also to be additionally considered.

Disposed equipment will be recycled using the best available technology and services within Sierra Leone.

8. ORGANISATION AND MANAGEMENT

8.1 The issue

Experience shows that ownership, organisation and management are key elements for both short and long term success, hence sustainability of installed power systems. Where these elements from the start are thoroughly assessed and feasible arrangements put in place, the likelihood for success is much higher.

Community systems being handed over to government after installation will most often fail for a variety of reasons, e.g. as the responsible government agency do not prioritize small systems due to resource constraints, cancellation of maintenance contracts with private service providers due to lack of funding, funding for repair is not budgeted or consumers are paying for electricity into a non-earmarked maintenance fund. In cases where the responsibility for operating the system is vested with a community committee set-up for this specific purpose or by using the Village Development Committee, the capacity of the committee will in practice most often not be there to fulfill this complicated task on a permanent basis.

The need for someone to have a clear incentive to secure the long term sustainability must be build into the organisational and managerial set-up to secure its success beyond the initial installation and operational phases, where a NGO might be involved. Where a private company or individual undertake the investment in supplying electricity this incentive is secured: The investor will loose her money if long term sustainability is not ensured. Hence everything possible to secure this will be done.

8.2 Questions to be asked during assessment of the organisation and management

a) Do you in the community have experience in managing a project for another common purpose, e.g establishment, operation and maintenance of a water pump?

b) If yes, has there been established and registered an ad hoc organisation for this purpose, e.g. a community based organisation or is it done through the Village Development Committee or sub-committee?

Based on the experience, or in case there is no experience, discuss how the optimal organisational and managerial set-up for the power system should be to secure its long term sustainability, addressing the following:

c) Who are the members of the Board? How often does the board meet? Do all board members participate in the meetings? Are Annual General Meetings (AGM) held according to schedule? Is there a fixed agenda for the AGM? Are there minutes of meetings for all board meetings and for the AGM, signed by all board members?

d) What is the composition of the board in terms of gender? How many women? How many men?

e) Who is the day-to-day manager in the organisation?

f) How has the day-to-day manager been selected? Open advertisement? Appointed by the Board without open advertisement?

g) To whom does the day-to-day manager report? The Chairperson of the Board? A committee in the Board?

h) What should be the qualifications of the manager to be employed?

i) What will be the total annual cost (basic salary, bonus and other benefits) of employing the manager?

j) What should the arrangement be with the bank account into which funds for maintenance, repair and replacement are deposited: Who should be signatories, will double signatory be a requirement and what are the procedures for informing all board members of withdrawals?

k) Is the responsibility for all day-to-day operational activities, including maintenance, contracted to a private company with demonstrated experience in this field? If yes, why? If no, why not?

l) What will be the advantage of contracting out the responsibility of maintenance to an experienced company?

m) What will be the disadvantages of contracting out the maintenance responsibility?

n) Who will be the legally registered owner of the energy system?

8.3 Example

In Mendekelema the community has no experience from managing an investment of the size and complexity like a solar power system. Taking into account that the organisation to donate the system does not wish to support a pure private venture it was decided to establish a legally registered consumer cooperative, in which community members buying electricity can become members through paying an annual membership fee. The consumer cooperative will be the owner of the system.

The cooperative will have a board which, apart from community representatives, will have external participation by a private sector representative with thorough experience from the renewable energy sector and a representative from civil society.

Annual cost of board meetings and AGM is estimated to 10.000 LE.

The remuneration of the community solar power system manager will be a basic salary plus a bonus dependent on the technical and financial success of the solar power consumer cooperative. The manager, which must have relevant business experience, will be recruited through open advertisement under guidance by a NGO. Estimated monthly cost of hiring the manager is 4.000 LE including performance bonuses, i.e. 48.000 LE annually.

This strategy is chosen, as it will provide a framework for the cooperative of entering into a maintenance contract with a private sector supplier, as well as inviting non-community members into the board. Likewise, the need to provide an economic incentive for securing financial sustainability is addressed through an attractive and performance based remuneration package for the manager.

A maintenance contract will be signed between the consumer cooperative and a private service provider, being responsible for regularly checking the system and undertaking larger repairs and maintenance, including carry out regular remote technical system performance monitoring. This is the preferred option to secure constant maintenance, also beyond the time where the donor is providing funding through the NGO. Before the donor project is completed, a long term maintenance contract (5 years) will be entered into between the consumer cooperative and the competitively selected maintenance company. The estimated cost of the maintenance contract is 15.000 LE on an annual basis.

To safeguard funds and provide optimal transparency, an audit company will be hired by the consumer cooperative to perform the annual audit to be approved by the AGM.

9. HUMAN RESOURCES

9.1 The issue

Apart from the manager, being responsible for the day-to-day management of the system, only very few staff members are required: One technician to secure that the system is correctly operating and who can undertake minor repair and maintenance, and one part time bookkeeper who will be responsible for the accounts. To keep operating costs low, the manager as well as the technician and the bookkeeper should all be able to serve the customers. If possible the technician and bookkeeper should live within a reasonable distance from Mendekelema. The consideration should always be to keep the cost of staff as low as possible, as there is only one group of people to pay the cost, the community members.

9.2 Questions to be asked during assessment of the human resources

a) In the community, are there relevant technically skilled people, e.g. electricians? If not, are there relevant technically skilled people in the catchment area or in neighboring communities? Is there just one person with the skills or are there several?

b) How far from the site does the nearest technically skilled person live?

c) What are the practical experience of the skilled persons?

d) Where is the nearest relevant training institute for a possible upgrade of technical qualifications, if required?

e) Are there people in the community trained in bookkeeping? If not, is there a trained bookkeeper in the catchment area or in neighboring communities? Is there just one person with bookkeeping skills or are there several?

f) How far from the site does the nearest trained bookkeeper live?

g) What are the practical experience of the bookkeeper?

h) Where is the nearest relevant training institute for a possible upgrade of bookkeeping qualifications, if required?

9.3 Example

At present, there is only one person in Mendekelema community who has the required experience to be employed as technician. There might be other potential candidates living in nearly communities. It is expected that over time the supply of potential technicians will increase, as vocational training as well as the possibility to obtain a degree in renewable energy engineering at the Eastern Technical University in Kenema will graduate more students in this field. To overcome the short supply of possible technicians, an agreement will be entered into between the NGO and Eastern Technical University so students will be attached to the equipment supplier as well as the maintenance service provider, in order for students to obtain practical experience from installation and maintenance of a solar power system. In addition, the technician to be employed though an open process will be offered additional technical training if required.

The monthly cost of hiring the technician is estimated to 1.500 LE, i.e. on an annual basis the cost will be 18.000 LE.

There are a few people in the area who have been trained as bookkeeper and having subsequent experience. Through open advertisement the best one will be employed. Depending on the need, additional training will be provided, including in the accounting system to be used. The sales function in the cooperative will be fully integrated with the accounting software, reducing much of the manual work being done by the bookkeeper.

Being a part time job, one day per week, the monthly cost of employing the bookkeeper will be 300 LE, amounting to 3.600 LE annually.

10. FINANCIAL SUSTAINABILITY

10.1 The issue

Sustainability encompass both environmental, technical, organisational and financial sustainability.

This tool uses as general example a solar power system, which is an environmental very sound system after having been produced, transported and installed. Any system building on renewable energy will have the same feature, and should be the preferred choice, unless specific circumstances for not choosing this prevail. In case it is considered to use fossil fuel to power the proposed system, a specific Environmental Impact Assessment should be undertaken and the arguments for choosing a non-environmental correct solution should be clearly presented.

Technical sustainability concerns maintenance and replacement of parts (addressed in section 8), organisational sustainability the ownership, organisation and management (addressed in section 9), and financial sustainability the ability of the organisation to operate without a loss, taking into consideration all short and long term costs. This section 10 focus on financial sustainability.

<u>10.2 Financial sustainability assessment</u>

This section summarizes elements from sections 3 through 9 in terms of income, investments and operating costs, and analyse the combined effects of decisions made on each of these assessed elements:

i) Income: Determined from the market assessment (section 3).

ii) Investments: The total cost of land, all equipment and buildings, determined from the assessment of land (section 4), assessment of equipment (section 5) and assessment of building, engineering and technology (section 6).

iii) Operating costs: Cost of management, board of directors, staff, maintenance and other running cost, determined from assessment of organization and management (section 8) and assessment of human resources (section 9). In addition an amount need to be set aside for unforeseen costs.

Private investor:
If the investment in a community solar power system is made by a private investor, be it a company or an individual, it will be “for profit”. In this case the private investor will most likely have borrowed funds for the initial investment to be able to pay for land, equipment and building. In addition to the above costs there will also be an interest to be paid to the lender of funds.

When determining the tariffs to be set for electricity, the private investor will have to take into account that after some time equipment will have to be repaired and replaced, e.g. after a number of years the batteries will be worn out and need replacement for the power system to continue generating electricity. If the batteries last for 5 years, there will need to be funds available after 5 years to pay for new batteries. If the batteries have a lifetime of 10 years, funds need to be available for replacement after 10 years. The same principle applies for all other equipment and for the building as well, each having different typical lifetimes. This implies that the tariffs to be set must also include an amount for depreciation of the initial investment: If new batteries cost 50.000 LE and last for 10 years, the annual depreciation for batteries will be 5.000 LE. Therefore the tariffs must be set to not only cover the annual operating costs, but also the 5.000 LE to be set aside each year for procuring new batteries after 10 years. On top of this comes the profit as payment to the private investor for the risk undertaken by investing.

Investment facilitated by a NGO with donor funds:
If the investment in the community solar power system will be facilitated by a NGO with donor support, cost of the initial investment in land, equipment and building will typically be paid by the donor. The NGO will therefore not have to facilitate borrowing money for this purpose and there will not be interest payments to a lender of funds. And the investment will not be “for profit”, but will be self-supporting, i.e. the tariffs (the income) will be set to cover all costs, both short and long term.

When setting the tariffs for selling electricity, the same principle applies as is the case when it is a private investor: The equipment need to be repaired and replaced, and the tariffs must be set to also include an amount for depreciation of the initial investment (although not paid by the NGO, but by a donor). As in the example above, tariffs must be high enough to also cover the 5.000 LE to be set aside annually for procuring new batteries after 10 years.

Comparison of investors:
One difference between the two investors (private and NGO) is that the private investor will have to include a profit when setting the electricity tariffs. This is not the case if the investment is facilitated by a NGO.

Another difference between the private investor and the NGO supporting the investment with donor funds is that the private investor pays for the equipment, and the NGO does not. But in terms of setting a tariff for securing the financial sustainability there is no difference: Both need to include depreciation, enabling funds to be available the day it is needed to undertake repair and replacement of equipment. Otherwise financial sustainability is not secured.

A consequence of these principles is that the larger a community solar power system is, the more expensive it is, and the higher will be the depreciation, to be included in the electricity tariffs to be paid by users in the community.

Income sufficient to secure financial sustainability?
Having calculated the income required to secure break-even (all costs including depreciation will be covered by the income), is this income higher, equal to or lower than the consumers ability and willingness to pay, as determined in the market assessment (section 3)?

If the estimated total annual income from the market assessment (section 3) is lower than the income required for break-even, there are different options:
- If possible, design methods to increase the number of households using electricity services without reducing the tariffs.
- Consider different tariffs for households and for productive use of energy, with higher tariffs to be paid by enterprises as they typically use significantly more electricity than households, a principle used in the Sierra Leone electricity sector, where enterprises (larger consumers) pay a higher tariff than normal customers.
- Downscale the size of the power system, making it cheaper.
- Do not undertake the investment, as the resources will be better utilized in another place where the market is sufficiently large and consumers have a higher ability and willingness to pay to generate a break-even income.

10.3 Example

In the case of Mendekelema the annual income, investment and depreciation as well as operational costs found during the assessment are:

Annual income	**LE**
Households	187.000
Enterprises	30.000
TOTAL	**217.000**

Investment costs	**LE**	**Lifetime (years)**	**Annual depreciation**
Land	0	N/A	0
Building	240.000	20	12.000
Solar panels	65.000	30	2.100
Batteries	40.000	10	4.000
Inverter	40.000	10	4.000
Charge controller	20.000	15	1.400
Other equipment, including gadgets	170.000	4	42.500
TOTAL	575.000		**66.000**

Annual operating costs	LE
Management	48.000
Staff	21.600
Board	10.000
Maintenance contract	15.000
Other operating costs	5.000
Audit	5.000
Unforeseen costs	5.000
TOTAL	**109.600**

In this example based on data from Mendekelema and three catchment areas the total annual income is 217.000 LE and total annual operational and maintenance costs including depreciation is estimated to 175.600 LE. This results in an annual surplus of 41.400 LE, indicating that the proposed investment is financially viable.

However, the financial assessment is totally dependent on the assumptions made regarding income, investment and operational and maintenance costs. Where these assumptions turns out to be incorrectly estimated it will (positively or negatively) influence the financial sustainability.

Therefore a *sensitivity analysis* must be carried out, changing one or more of the variables in the base scenario:

1) The surplus of 41,400 LE is less than 20% of the total income. If demand falls short of expectation, e.g. because only 280 households instead of 361 households will rent appliances from the solar power hub, the situation will be as follows: Total income will be: 10 LE per week * 52 weeks * 280 households plus 30.000 LE from selling electricity for productive use of energy = 175.600 LE. I.e. there will neither be a surplus nor a deficit, but the break even income (Income equals all costs) has been found.

2) If the lifetime of gadgets to be rented out will not be 4 years on average, but only 3 years, e.g. because the gadgets are not handled properly by the consumers, the annual depreciation costs (the amount having to be set aside each year for procuring new gadgets) will increase from 42.500 LE to 56.667 LE, an increase of 14.167 LE, taking away more than one-third of the surplus.

3) If the amount of electricity being consumed by small enterprises for productive purposes in practice is higher than the estimated 30.000 LE per year, this will improve the profitability of the solar energy hub, giving the board and management an incentive to promote productive use of energy. If the productive use of energy generates 50.000 LE instead of 30.000 LE, the surplus will increase by 20.000 LE, as there is no additional costs.

4) If the surplus materializes as planned in the base scenario because the effective demand for electricity is high, especially from productive use of energy, the board and management of the energy hub might decide to increase the capacity of the energy system to be able to supply more electricity. This can be financed from the annual surplus, without having to seek external funding from the NGO or a donor. The cost of increasing the capacity of the system by e.g. 30% through buying and installing more solar panels and batteries will amount to 30% of 105.000 LE (cost of panels and batteries), i.e. 31.500 LE plus installation costs, which can be accommodated within the annual surplus. None of the other equipment needs to be changed in this situation, if the inverter is sufficiently large.

11. CONCLUSIONS AND RECOMMENDATIONS

The method to be used when making the final conclusion and recommendation is to draw on the most important elements of the different assessments made.

i) Is there sufficient effective demand for electricity in the community to justify the investment?

ii) Are there one or several feasible technical solutions, and if several, which one is the best?

iii) Is it possible to establish an organisation and employ a management that effectively can secure the sustainability of the solar power system?

iv) What are the main risks, and how will they impact on the investment?

v) Is there a positive business case, where the total income can fully cover maintenance and replacement cost of all solar hub equipment including appliances as well as salaries of all staff and other operational costs?

Taking answers to all the above five questions into consideration, what is the recommendation: Should the investment be made or not?

11.1 Example

a) The assessment of the market is that in Mendekelema and the three chosen nearby catchment villages there is a willingness and ability to pay for electricity services among a sufficiently large proportion of the households and especially among young entrepreneurs to generate a break-even income for the energy hub, provided that productive use of energy is promoted and supported.

b) The only feasible technical solution in Mendekelema is to establish a solar power hub which will be able to rent out rechargable gadgets to households and equipment to enterprises. A mini grid is not feasible due to the large distances to catchment villages. A new building structure will need to be constructed as none of the existing buildings are suitable for hosting the hub.

c) The organizational and managerial setup is to establish a consumer cooperative, in which there will be participation of a NGO and a renewable energy sector representative in the board. A qualified manager will be competitively employed and having a bonus as an important part of the remuneration to provide an incentive to secure a technical and financial viable energy hub. Maintenance is secured through entering into a contract with a private sector maintenance company.

d) Main risk factors are political or other interference in the consumer cooperative managing the solar power hub, and that the willingness and ability to pay for electricity services will be lower than expected due to external circumstances beyond the control of the solar power hub (e.g. an economic recession). The first risk can be mitigated by the having the two representatives in the board coming from outside the area. The second risk can be mitigated through seeking to penetrate the potential market in other than the three selected catchment villages to Mendekelema.

e) There is a positive business case. The financial assessment shows that in the base scenario the income will cover all operational and maintenance costs as well as the longer term equipment replacement costs. The fees/tariffs to be charged for the different services provided will have to be elaborated in detail so that the projected income will be reached.

The recommendation is therefore that the investment should be carried out.