Intelligent Energy Europe

RENDEV

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RENDEV

D16 Financial model design

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The RENDEV project

The RENDEV project aims to explore ways to link microfinance and access to renewable energy, bringing a positive contribution in rural development and poverty alleviation in Bangladesh and Indonesia by increasing access to solar energy, the development of micro enterprise, and the provision of microfinance mechanisms tailored for low income people's needs.

The project started in January 2007 and will last until December 2009. RENDEV is financed by the European Commission under its Intelligent Energy line.

The main objectives of the RENDEV project are:

- To promote development of income generating activities with renewable energy supply;
- To identify measures justifying involvement of Small and Medium Sized Enterprises in the solar energy sector;
- To build synergies between the microfinance sector, the renewable energy sector and the micro enterprises in Bangladesh and Indonesia;
- To better inform stakeholders providing pro-poor sustainable renewable energy services;
- To bring a positive impact on the quality of life in rural districts.

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Executive Summary

In Indonesia, 70 to 90 million people, most of them living in rural areas, still lack access to electricity. Renewable energy, and solar energy in particular, has been identified as a solution with a high potential for the electrification of remote rural areas in the country, and ambitious targets have been set up by the Government to promote REN technologies.

In the past decades, the GoI has implemented various programs to promote solar energy access. However, these programs were based on financial models that were not adequate enough, and their weaknesses prevented the successful expansion of solar energy technologies in the country.

Previous studies done under the RENDEV project have already allowed reviewing the strengths and weaknesses of Indonesian and Bangladeshi solar energy experiences, identifying the needs and markets for REN technologies, and assessing the potential role of microfinance institutions in both countries.

Building on the findings of all these studies, RENDEV recommends two different financial models that would be adequate for promoting solar energy access in Indonesia:

- SCENARIO 1: Replicate the successful Bangladeshi IDCOL model, adapting it to the Indonesian context. In this model, microfinance institutions have a major role to play in facilitating solar energy access by offering adapted financial products (credit schemes). To do so, they will need strong financial and technical support.
- SCENARIO 2: To reach poorer populations, improve the Indonesian social pay-for-service model. In this model, MFIs will not play a direct role in financing solar energy access, but they can be mobilised to facilitate fee collection and stimulate local development of rural areas in link with electrification.

These models should first be tested at a small-scale (in one selected province for instance), through a pilot program, before scaling up can be planned at the country level.

To design an effective national solar energy program on the basis on these financial models, RENDEV further provides the following recommendations:

- An adequate subsidy policy should be designed in order to bridge the gap between the full cost of the solar technologies and the willingness and capacity to pay of the populations. This subsidy policy should be long term, universal, carefully designed and adjusted to the varying willingness and capacity to pay of target populations according to areas' characteristics and equipment types.
- It is essential to identify relevant Indonesian and international actors and to specify their respective responsibilities within the financial schemes. Indeed, all actors should be aware of and clear about their role and responsibilities. Transparency, coordination and communication will be essential to the success of the program.
- A successful national solar energy program is one that will be stable and operating in the medium and long term in order to effectively reach a significant population. In this aim, the sustainability of the financial model should be ensured at various levels: institutional, financial, technical, social and environmental.
- It is important to keep in mind that the role that adequate financial services can play in link with rural electrification goes beyond financing the mere access to solar energy technologies. Appropriate financial services can also be promoted to support the development of REN suppliers' activities in Indonesia and to help rural populations take advantage of the new business opportunities created by electrification.

List of Abbreviations

BKD	Badan Kredit Desa *(Village Credit Boards)*
BPPT	Agency for the Assessment and Application of Technology
BPR	Bank Perkreditan Rakyat (*People's Credit Bank*)
BRI	Bank Rakyat Indonesia
CBO	Community-Based Organization
CDM	Clean Development Mechanism, for carbon credit acquiring (United Nations)
Commission	European Commission
GoB	Government of Bangladesh
GoI	Government of Indonesia
IDCOL	Infrastructure Development COmpany Limited
IDR	Indonesian Rupiah, national currency in Indonesia (USD 1 is about IDR 9,100)
KUD	Koperasi Unit Desa
MFI	Microfinance institution
NGO	Non-Governmental Organization
PLN	Perusahaan Listrik Negara (*Electricity Company of Indonesia*)
PV	Photovoltaic
PO	Partner Organization
REN	Renewable Energy
REREDP	Rural Electrificcation and Renewable Energy development Project
RES	Renewable Energy Sources
RES-E	Electricity generated from RES
SHS	Solar Home System
TPSP	Tempat Pelayanan Simpan Pinjam (*Savings and Credit Service Posts*)

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1 Introduction

In Indonesia, 70 to 90 million people, most of them living in rural areas, still lack access to electricity. Renewable energy, and solar energy in particular, has been identified as a solution with a high potential for the electrification of remote rural areas in the country, and ambitious targets have been set up by the Government to promote REN technologies.

The microfinance sector is well developed in Indonesia, with over 50,000 microfinance institutions (MFIs) operating and a gross loan portfolio ranking as the highest in the world. Microfinance could thus play an important role in promoting access to solar energy in the country. In order to do so, Indonesian MFIs would however still require strong financial and technical support to develop adapted financial services in rural areas.

Previous studies done under the RENDEV project have already allowed reviewing the strengths and weaknesses of Indonesian and Bangladeshi solar energy experiences, identifying the needs and markets for REN technologies, and assessing the potential role of microfinance institutions in both countries.

Building on the findings of these studies, this report seeks to provide recommendations on financial schemes that could effectively promote solar energy access in Indonesia, on the role of microfinance within these schemes, and on the different steps that should be taken to design and implement an adequate national solar energy program on the basis of the recommended financial models.

2 Context

Main ideas:

Electrification situation

Around 70 to 90 million Indonesians still do not have access to electricity. 80% of them live in rural areas.

Because of geographic and financial constraints, 6,000 villages will not be reached by the national electricity grid in the near future.

Renewable energy, and in particular solar energy, has a high potential in Indonesia, and could be a solution to the electrification of rural, remote areas.

Microfinance situation

Microfinance is a well-developed sector in Indonesia, but it still lacks access to capital, especially for providing financial services to rural areas.

If financial and technical support is provided, microfinance institutions can play a key role in facilitating access to solar energy through adequate financial services.

Previous studies undertaken through the RENDEV project assessed current energy needs and the state of microfinance development in Indonesia (*D8 – Needs assessment analysis and market feasibility for solar energy applications, Indonesia; D14 – Identification of Microfinance Institutions, Indonesia*). A brief summary of their findings is provided here as a reminder of the context of electrification and microfinance in the country.

2.1 Electrification situation

2.1.1 Electrification needs in Indonesia

Indonesia still has one of the lowest rates of electrification in the region. The current ratio of electrification is estimated to range between 57% (based on data from PLN, the state-owned Electricity Company) and 88% (based on a survey conducted by BPS, the National Statistics Agency). This means that **around 70 to 90 million Indonesians are still left without access to electricity**, among which 80% live in rural areas and over 50% outside of Java-Bali islands.

Access to electricity is essential to respond to the needs of the poor, improve their standards of living and enhance local economic development. In this perspective, the Government of Indonesia (GoI) has set up a high priority on electrification in its development agenda, with a **target of 90% of the households to be electrified by 2020**.

2.1.2 Grid expansion and limits

Over the past three decades, the GoI has allocated considerable resources to its rural electrification programs. This was done mainly through the Indonesian Electricity State company: Perusahaan Listrik Negara (PLN). For about two decades from 1978, PLN has shown impressive record of aggressive expansion of main grids, as well as development of new small grids in the rural and remote areas mainly using diesel power plant system.

However, in a country with roughly 17,500 islands and a length and width of 5,000 and 1,800 km, extending access is an increasingly difficult task. Outside of Java-Bali, PLN cannot be financially sustainable if applying its current universal tariff structure (TDL). In consequence, PLN strategy in these regions is limited to minimizing losses, and not to maximizing outreach. Moreover, PLN is currently experiencing financial difficulties which make it unable to expand its power generating capacity and perform significant progress in rural electrification.

Today, the available grid interconnection in Indonesia is restricted to the Jawa and Bali Islands, while other islands such as Sumatera, Kalimantan, Sulawesi and Papua are not connected yet, and still isolated on each island. Figure 1 illustrates the current and envisioned electricity network in Indonesia.

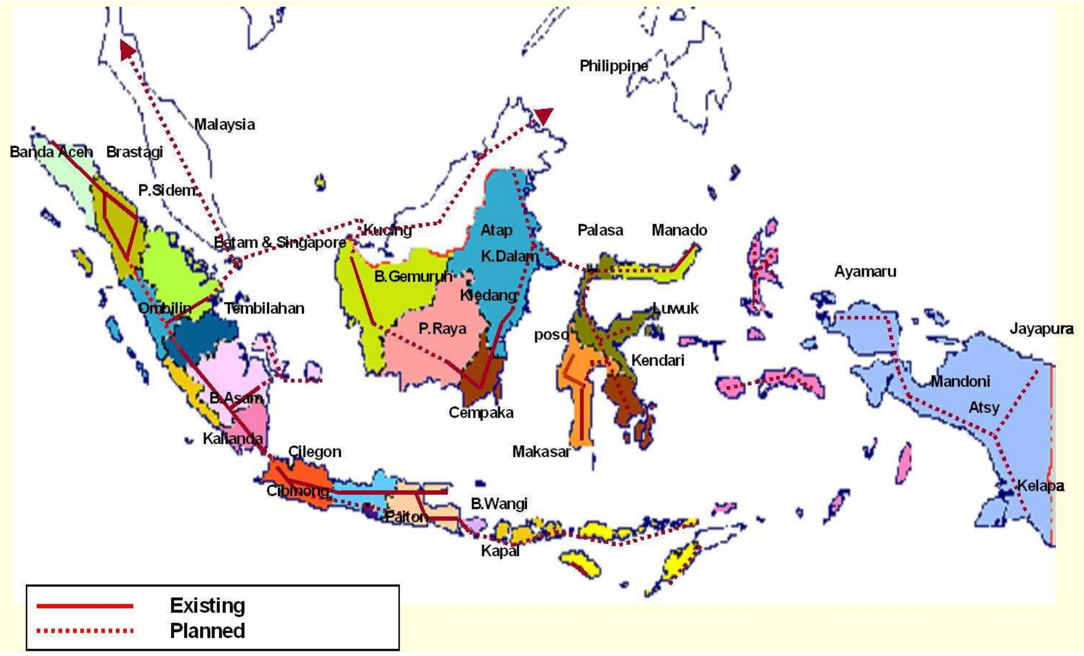


Figure 1: Existing and planned electricity network in Indonesia (BPPT)

PLN estimated that there are **over 6000 villages throughout Indonesia which will not be reached by the national electrification grid in the near future**, due to their remoteness and the scattered pattern of their houses.
Most of these villages are located outside of Java:

- 35% in Maluku and Papua,
- 28% in Kalimantan,
- 18% in Sumatra,
- 12% in West Nusa-Tenggara and South Nusa-Tenggara,
- 5% in Java and Bali
- 2% in Sulawesi.

Assuming an average of 10,000 houses per village, there are at least 62.2 million houses in isolated areas that will not be reached by the national grid in the near future.

Providing access to rural areas can no longer rely entirely on conventional power generation technologies through grid expansion. Novel and diversified ways are now required to bring electricity/modem energy to remote and poor regions, to fit the specific geography of the country and the specific social conditions of the communities.

2.1.3 Renewable energy potential

Developing renewable energy access can address the electrification problem of rural and isolated areas. **The potential for renewable energy** (solar, wind, hydro, biomass, geothermal, ocean) **is very significant**. The potential for solar energy, in particular, is major: the whole territory of Indonesia indeed receives an **average solar irradiation of 4.8 kWh/m².day**.

However, the use of renewable energy for rural electrification has been limited so far. Photovoltaic (PV) energy represents approximately 0.016% of the total numbers of houses throughout Indonesia. This can be partly explained by the government fuel subsidy, which has encouraged households in remote areas to adopt diesel powered generators. Without subsidy, the choice of technology would surely have been different, as renewable energy turns out to be more economical and sustainable in the long run.

In order to decrease its oil dependency and expand rural electrification, the **GoI has set up ambitious targets to promote the development of renewable energy**:

- Renewable energy should represent 15% of the Indonesian energy mix by 2025.
- 880 MW of solar PV should be installed by 2025.

Today, only 12 MW of solar PV are installed. The gap implies that Indonesia needs to install 58 MWp per year to meet its target.

In this perspective, the GoI has allowed a budget increase for the past 3 years. In order to use resources in an efficient way and to effectively reach the targets, the GoI has to develop relevant policies and set up adequate incentives to promote the adoption of solar energy technologies. The **design and implementation of a sound financial model for solar energy access** is therefore essential.

2.2 Microfinance situation

The **microfinance sector in Indonesia is one of the largest in the world** with over 50,000 microfinance institutions (MFIs), some in existence over 100 years. According to MixMarket (2007), **Indonesia indeed ranks as the country with the largest gross loan portfolio in the world** (USD 3.96 billion).

Indonesia’s financial system is composed of a high variety of formal, semiformal and informal institutions. It comprises approximately 6,000 formal and 48,000 semiformal units, holding some 45 million deposit accounts and serving about 32 million borrowers.

Contrary to other countries, non-government organizations do not play a significant role as independent MFIs. The Indonesian microfinance sector is mostly represented by commercial banks (such as BRI), secondary banks (such as BPR), village credit boards (BKD), pawning business, cooperatives, credit unions, savings and credit service posts (TPSP), etc.

The majority of MFIs in Indonesia are however characterized by **low growth in outreach and inefficient systems**. They cite as their main constraint the **lack of access to affordable capital**. This is particularly relevant for MFIs working in rural areas.

If financial and technical support is provided, **microfinance institutions could play a key role in facilitating access to solar energy** through adequate financial services

Next steps for Indonesia:

Identify a relevant financial model that can successfully promote access to solar energy technologies in Indonesia.

Define how microfinance could fit in such a model.

3 Identifying relevant financial schemes for promoting access to solar energy technologies

Main ideas:

Past solar energy programs in Indonesia were based on financial models that were not adequate enough. Their weaknesses prevented the successful expansion of solar energy technologies in the country.

Indonesia can learn from the Bangladeshi experience of IDCOL. The financial model implemented in Bangladesh indeed provides interesting solutions to the challenges faced by Indonesia in promoting access to renewable energy.

Indonesian stakeholders should review their solar energy policies and programs along lessons learned and best practices.

In this perspective, RENDEV recommends two different types of financial models:

1) SCENARIO 1: replicate the successful IDCOL model, adapting it to the Indonesian context.
2) SCENARIO 2: Improve the Indonesian social pay-for-service model to reach poorer populations.

In a first time, the GoI could test each model at a small-scale, implementing pilot projects in kabupaten with the highest potential for success.

3.1 Solar energy programs in Indonesia: achievements and weaknesses of past financial models

Previous studies undertaken through the RENDEV project assessed past and present renewable energy policies and programs in Indonesia (*D3 – Overview of policies, Indonesia; D7 – State of the art of solar energy applications in Indonesia*). These studies identified the overall achievements and weaknesses of the financial models that have been implemented so far to promote access to solar energy technologies. A brief overview of the main findings is provided here.

3.1.1 <u>Government programs</u>

Brief historical overview

The GoI has launched several programs over the past 40 years to electrify remote and rural villages with solar energy.
In the 1970s and 1980s, various pilot demonstration projects were implemented to promote the adoption of solar water pumping systems, solar community centres, solar energy for schools, as well as the first PV Solar Home Systems (SHS).
In the 1990s, the GoI started to implement solar energy dissemination programs. From 1994 to 1998, the President of the Republic of Indonesia established the 50 MWp PV Village Electrification Project, also known as the “One Million Houses Project.” Through this project around 35,000 PV SHS, with the capacity of 50 Wp, were distributed among villages in

Eastern Indonesia with the support of AusAID, and another 5,000 with the support of the World Bank (first semi-commercial scheme was established)
The program of photovoltaic systems started again in 2004, promoting the adoption of PV SHS and centralized PV systems. In the period between 2004 and 2007, more than 80,000 units of SHS were installed.
All these government solar energy programs have been coordinated by the Agency for the Assessment and Application of Technology (BPPT), who was appointed by the GoI to undertake the role of focal point for the development of solar energy utilization in Indonesia.

Financial scheme

The government decided to **implement a differentiated approach according to the poverty level and remoteness of villages**. The financial scheme offered was thus different for the different segments of the population identified:

Market segmentation	Target	Financial scheme
Segment 1	Rural, low income populations	**Social PV program** **SHS 50 Wp – Pay-for-service scheme** The solar system is granted free of charge by the GoI. After a two-year grace period, a monthly fee of IDR 10,000 (USD 1) was supposed to be collected by the KUD (local cooperative).
Segment 2	Intermediate populations	**Semi commercial PV program** **Lease and purchase contract** over 10 years End-users only pay the hardware, the GoI pays for installation, transportation, interest rate, training, etc.
Segment 3	High income and urban populations	**(Semi) commercial PV program** **SHS 150 Wp, hybrid PV systems** **Lease and purchase contract** over 1-4 years 20-30% down payment, local commercial interest rate, some GEF contribution for hybrid PV systems.

Table 1: Market segmentation for Indonesian government PV programs

To be eligible to the **social PV program**, villages and consumers were to be selected along determined criteria by relevant governmental departments.
The project was then tendered. The winning company would install the product, which had to fulfil qualification standards determined by the government, and would conduct training sessions for the local technicians regarding installation and after sales services.

The majority of the **systems were granted free of charge** to the end-users, on the rationale that the targeted consumers are very poor people who cannot afford down payments or monthly payments. The end-users received the systems (typically a 50 Wp module, 70 Ah battery, charge regulator, three 6W lights, a battery box) for free and were supposed to pay a monthly fee of IDR 10,000 (= USD 1). This money was to be collected by the KUD (local cooperatives) and used for setting up a revolving fund (IDR 7,000), building a reserve fund for battery replacement (IDR 2,000) and covering cooperative management fees (IDR 1,000).

Unfortunately, most of these projects ended up in just supplying and installing the PV systems, and no maintenance nor collection of fees was ever done afterwards

Achievements of the social PV-SHS programme

The government PV programs contributed to the installation of 12 MW of solar PV systems. 300-350,000 SHS were installed in the country.

However, observers state that **only a minor fraction is thought to be still functioning**. Due to different reasons (systems being distributed for free; lack of awareness, training and capacity building in operation and maintenance), systems have been abandoned or thrown away, and system components, especially modules and batteries, were simply sold. Government programs thus showed very limited success.

Strengths

- **Market segmentation**: Willingness to pay for solar energy access varies along socioeconomic situations. Adopting a differentiated approach according to the target population seems an appropriate way of promoting a greater access to solar energy.

Main weaknesses:

- **Ownership issues**: As the SHS were given for free, there was no sense of belonging, meaning the systems were taken for granted and not taken care of as if it was the user's own system.
- **Maintenance issues**: Because of the remoteness and scattered pattern of villages and consumers in rural areas, it is very costly to collect maintenance fees and to set up sustainable after-sale service centres. The lack of local skills for PV system operation, maintenance and reparation resulted in a great number of systems abandoned or dismantled.
- **Limited outreach**: The high cost of a fully subsidized program restricted the number of households which could benefit from solar equipment access.

3.1.2 Private sector initiatives: the BRI experience

Brief historical overview

Several distributors have tried to conduct commercial sales of SHS in Indonesia, generally in those regions where local communities have a steady and sufficient income (e.g. in plantation or fishing areas).

In 2005 and 2006, Bank Rakyat Indonesia (BRI – the major commercial bank of Indonesia) together with two distributors of SHS (i.e. PT Mambruk International and Shell Solar Indonesia) started to propose SHS under a credit scheme. They first operated in South Sumatra and South Sulawesi, and extended the program to other regions where BRI has branches.

Financial scheme

BRI offered access to SHS through a **consumer loan**, under the Kupedes national loan-for-housing program. The product proposed was a 50 Wp SHS, worth IDR 4 millions.
The client had to put a minimum down payment of IDR 1 million as a condition to obtain a loan through BRI. The credit was offered over 36 months, with a 15% flat interest rate. No investment subsidy was provided.

Achievements

The two distributors succeeded in selling 1,000 units of SHS each, mostly in plantation areas, where farmers receive a regular and decent income.
However, the program lasted only for one year, as BRI's operation did not manage to be profitable. Collection costs in rural areas are high, and only 10-20% of the population in a village would be eligible for the credit program. The **market density was too low to allow a fully commercial scheme to reach economies of scale and be sustainable**.

Main weaknesses:

- **No financial sustainability**: The low market density makes a sustainable business model covering all operating and marketing costs very difficult. A fully commercial credit scheme does not seem adapted to low income populations.
- **Competition between government and private initiatives**: The free SHS approach of the government directly affected the commercial market for SHS. In areas where the government SHS program was also present, BRI's clients did not want to pay their instalments (monthly loan reimbursement) as they would see neighbours getting their SHS for free.

Today, it is essential to acknowledge the various lessons learned from these experiences and to build on them in order to design more effective, better adapted financial models.

3.2 A successful financial model: IDCOL in Bangladesh

The RENDEV project was implemented both in Indonesia and Bangladesh. In the latter country, the financial model that has been used to promote access to solar energy in rural areas has proved to be very successful, and could constitute a useful model for Indonesia. Details on its functioning and achievements were already provided in the RENDEV report *Toolkit for policymakers* (D11).

3.2.1 Presentation of the model

The national solar program of Bangladesh, REREDP (Rural Electrification and Renewable Energy Development Project) has been launched in 2003, based on the wide experience of national NGOs and microfinance institutions (MFIs) in offering microcredit to rural populations. The financial model developed within the national program is based on two main ideas:

- Access to solar energy can be broadened thanks to microfinance,
- Some level of subsidies is necessary to encourage and enable rural households to adopt solar technologies.

The role of IDCOL

As part of the program, the Government of Bangladesh (GoB) provided funding to a private non-bank financial institution whose mission is to execute the national solar program: IDCOL (Infrastructure Development Company Limited).

IDCOL's provides soft loans and grants to partner organizations (POs: NGOs, microfinance institutions) so that they can in turn offer microcredits for SHS at a lower cost.

IDCOL offers soft loans of 10-year maturity, with a 2-year grace period, at 6% per annum interest to its POs. The loan amount cannot exceed USD 230 per system. Usually, IDCOL does not require any collateral or security for the loan, except for a lien created on the project accounts. Unless and until there is an event of default, POs are authorized to operate the project accounts of their own.

In addition to refinancing, IDCOL also offers a subsidy grant for each installed system. As its principal objective is the commercialization of SHS, IDCOL has adopted a policy of reducing grant with the progress of the project, as detailed in Table 2. The grant is used both for reducing the capital price of the SHS and for institutional development of the partner organisation.

There is strict policy control on the refinancing loan fund given to the NGOs, but there are no specific regulations for usage of the grant fund by the POs. Policy allows the PO to use the subsidy fund as a marketing tool for capital price reduction of the SHS. Therefore there is a competition among the participating NGOs in a particular area to satisfy the needs of the potential consumer with product and price.

Item	Amount of Grant Available per SHS/household		
	Total	Buy-down grant	Institutional Development Grant
The World Bank funds			
First 20,000 systems	$ 90	$ 70	$ 20
Next 20,000 systems	$ 70	$ 55	$ 15
Next 30,000 systems	$ 50	$ 40	$ 10
GTZ funds			
33,660 systems	€ 38	€ 30	€ 8
KfW funds			
First 30,000 systems	€ 38	€ 30	€ 8
Next 35,000 systems	€ 36	€ 30	€ 6
Next 35,000 systems	€ 34	€ 30	€ 4

Table 2: Phased reduction of IDCOL grants

Source : IDCOL website

IDCOL has established a list of criteria. Any NGO or MFI meeting these criteria and willing so can become a member of the program. Today, 18 POs are involved in the program. They range from massive organisation like Grameen Shakti and BRAC (more than 4 million microfinance members) to smaller NGOs.

Financial product offered by POs to end-users

Partner organisations (POs) extend loan to households for the purchase of SHS. Different POs extend credit on different terms and conditions. The loan tenor varies from 1 to 5 years, and interest rate varies from 8% to 15% per annum on declining balance method and 10% to 15% per annum on equal principal payment method. In all the instances, the repayment frequency is monthly. Households are required to pay a minimum 20% of the system cost as down payment.

Financial scheme

Under the program, the process to be followed by partners is the following:
1) Clients make the required down payment.
2) POs enter into a sale/lease agreement (provisions of which are approved by IDCOL), install the system (mostly on credit) and make electronic disbursement request to IDCOL for refinance and grants, as applicable.
3) After in-house checking, IDCOL conducts physical verification of the SHS installed.
4) IDCOL releases grants and refinance amount only if the inspection result is satisfactory. The refinance amount does not exceed US$230 equivalent in Taka per system.
5) IDCOL makes the disbursement within 21 days from the receipt of disbursement request.

This mechanism implies that POs need to mobilize other sources of funding to purchase and install SHS before IDCOL release the funding.

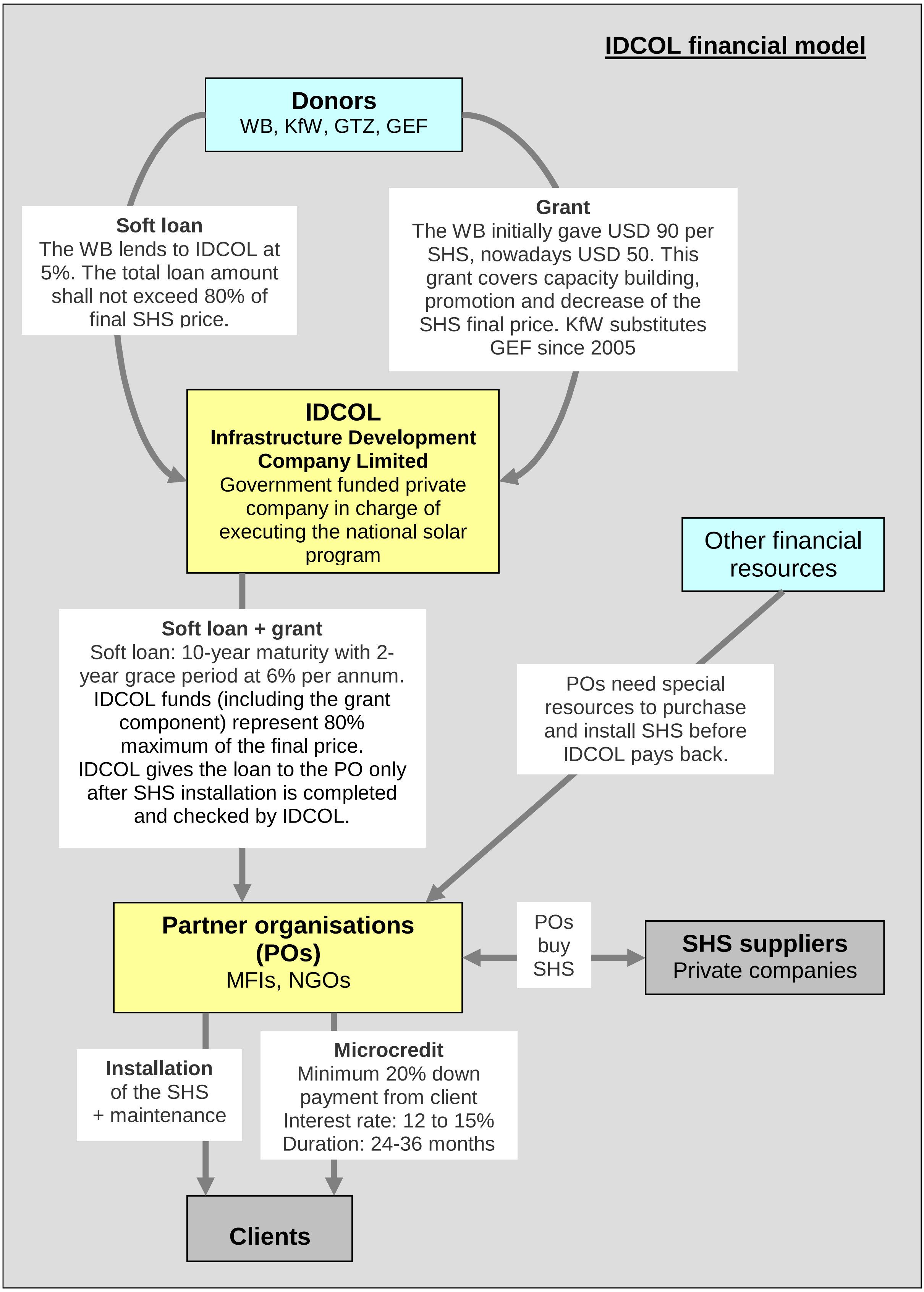


Figure 2: IDCOL financial model

Responsibilities of actors

Role of partner organisations (MFIs, NGOs):

- **Implementation**: The program is being implemented through the partner organisations (POs). The role of the POs is to select the project areas and potential customers, extend loans and install the systems.
- **Promotion:** The promotion is ensured directly by the POs themselves. Part of the grant they receive is dedicated to institutional development and can be used for SHS promotion.
- **Maintenance:** SHS are guaranteed for 3 years, during the loan duration, as an energy service by the PO, who is responsible for ensuring maintenance.

Role of IDCOL:

- **Funding:** IDCOL provides grants and soft refinancing loans to POs.
- **Technical quality control:** IDCOL sets up technical specification for solar equipment and control that quality standards are respected.
- **Promotional support:** IDCOL has developed and distributed publicity materials to raise awareness and popularize the use of SHS in different parts of the country. Posters, leaflets, T-shirts, and billboards have been distributed and more will be provided to the POs for wider publicity of solar energy. TV and radio spots have also been developed and aired.
- **Training:** IDCOL also conducts training programme to build awareness among the staff of the POs' and the consumers. Training is provided to the staff of the POs on SHS configuration, positioning of SHS, installation procedure and guidelines with measurements, maintenance and troubleshooting of SHS, guidelines for monitoring and inspection of SHS, market development, micro-credit methods for marketing, and maintenance of battery used in SHS. 80% of the total expense is sponsored by IDCOL and the rest is shared by the POs. Since SHS is entirely new to the households, consumer trainings are conducted regularly to educate them. They are trained on how to use the SHS and fix petty problems without waiting for the technician.
- **Monitoring of POs' performance:** IDCOL controls the financial and overall performance of partner organisations.

Role of the donors:
Donors support the program by providing:

- **Subsidy to: (i) decrease the selling price, (ii) support the promotion action of POs and IDCOL, and (iii) support the training of POs staff and clients**. The subsidy has never represented more than 25 % of the price of a SHS.
- **Soft loans**, at a 5 % interest rate, to IDCOL for refinancing POs/MFIs. In fine, donors are providing soft loans to the MFIs for their operations through a transparent, efficient, monitoring and financing body: IDCOL.

Relationship between the actors

Transparent operational schemes are followed by IDCOL ensuring a complete participatory role of the NGOs and MFIs through scheduled operational meeting and discussions.
A very effective monitoring process and support system has been adopted by IDCOL, including multiple functions:

- Monthly meeting of the operation committee, with mandatory participation of the POs, for discussing important ongoing issues.
- Reporting on achievements of all POs in installation of SHS on a monthly basis.

- Sharing of information on the status of refinancing and grants applications.
- Maintenance of records on loan recovery and collection rate by the POs.
- Resolving issues related to the suppliers availability and limitations.
- Technical design approval for qualifying in the national solar program.
- Providing support for marketing and promotion of SHS to potential consumers.
- Offer support for technical training of technicians and consumers of the POs.

3.2.2 Achievements

The national solar program is a very successful supplement to the national grid electrification program of Bangladesh. The first target of solar home system installation of 50,000 was achieved in August 2005, three years ahead of the project completion period and US$ 2 million below the estimated costs. **So far, the national solar program has attracted more than 170,000 customers**. Although large MFIs are major players in dissemination of SHS by virtue of their field level operational entities, it is found that smaller NGOs are effective too in regional coverage of solar electrification.

A very important performance monitoring criteria of the MFIs is the efficiency of monthly instalment collection. On the average the **POs of IDCOL have 96% collection efficiency**, which is monitored to minimize the financial risk of IDCOL.

This scheme has been successful since IDCOL has a regulatory role for quality control and financial risk minimization. The hardware used in the national program are certified by IDCOL, and the bank accounts of the MFIs which are dedicated to the solar home systems (SHS) micro-financing is subject to scrutiny by IDCOL itself. These two important criteria are essential parts of supervision and monitoring scheme for sustainability of the MFIs activities.

3.2.3 Limits

- The original program funded by the World Bank allows dedicate funding to IDCOL and MFIs only for systems over 30 Wp. Therefore, the most popular systems were 50 Wp systems, costing around EUR 400. Even under a credit scheme, this amount is **still totally unaffordable for an important segment of poor rural households**.
- SHS are not sufficient for productive uses.
- Smaller NGOs may experience difficulties for covering 20% of the capital cost for the solar home systems. International supply of solar PV modules is limited as compared to the rapid growth in demand. As a result, the Bangladesh market faces problem is scaling up at a rapid pace.
- Even under the challenging objective of 1,000,000 SHS for 2015, only 5% of those without access to electricity will be covered.

3.3 Recommendations

In the light of the above findings on past Indonesian experiences and current Bangladeshi program, RENDEV recommends two different types of scenario:

- SCENARIO 1: Replicate the IDCOL financial model, adapting it to the Indonesian context
- SCENARIO 2: Improve the Indonesian social pay-for-service model to reach poorer populations.

3.3.1 SCENARIO 1: Replicate the IDCOL financial model, adapting it to the Indonesian context

Adapting the IDCOL financial model to Indonesia

RENDEV first suggests that the IDCOL financial model be replicated in Indonesia, adapting it to the national context.

The Bangladesh national solar program had been designed very carefully by donors, in order to systematically provide an answer to all the lessons learned from former experiences and continuous discussion between all partners. It is worth noting here that the **IDCOL financial model also provides answers to the lessons learned from past Indonesian experiences** (as detailed in table 3).

The GoI could thus learn from Bangladesh experience. In order to share knowledge on good practices and transfer competences, RENDEV therefore suggests that exchange visits, training sessions and/or discussion forums be organized between Indonesian and Bangladeshi stakeholders.

It is of course essential to keep in mind that the **IDCOL financial model** cannot be replicated as it is, but that it **should be adjusted to the Indonesian context**. In this perspective, the GoI must take the time to gather stakeholders and identify how the model can be adapted to best fit Indonesian needs and resources.

Next chapters provide elements to design a subsidy policy, to define microfinance products and to specify actors' role according to the particular context of Indonesia.

Opportunities and threats for IDCOL model replication

There are very positive **opportunities** for developing an effective solar energy program on the basis of the IDCOL financial model in Indonesia:

- The GoI is very committed to developing access to renewable energy, and in particular solar energy, in the coming years. It has developed an ambitious policy and is actively working to designing adequate programs and financial schemes.
- The microfinance sector is well-developed in Indonesia. MFIs could be positively mobilized as partner organisations to widen access to solar energy.
- Through its past market segmentation approach, the GoI has already identified the target populations that could access solar technologies under a credit scheme and those who would need more support.

However, there are also **important differences with the Bangladesh context, which could constitute significant constraints or threats to the replication of the model**:

- The rural microfinance sector in Indonesia is not as strong as in Bangladesh. Microfinance institutions still do not reach remote areas. They will need strong financial and technical support to be able to provide financial services for solar energy access.

- Provinces outside of Java-Bali have quite low and sparse populations and lack infrastructures, which makes installation, operation and maintenance costs higher than in densely-populated Bangladeshi intervention zones.
- The GoI is still subsidizing fossil fuel energy, which makes renewable energies comparatively expensive.
- The renewable energy (REN) supply-side is not so well-developed in the country.
- Past experience may have affected the image that people have about solar energy systems' reliability.

These constraints should be acknowledged and solutions to overcome them should be identified when designing a national program.

RENDEV advices that the GoI, in a first time, **tests the replication of this financial scheme at a small-scale, implementing pilot projects** in kabupaten with the highest potential for success. MFIs that are strong and have already developed infrastructures and methodologies in rural areas could be targeted as privileged partners for this pilot testing phase (e.g. MBK microfinance institution in Java). If the small-scale replication of the model succeeds, scaling up could then be planned in a second phase.

3.3.2 SCENARIO 2: Improve the Indonesian social pay-for-service model to reach poorer populations

Improving the pay-for-service model

One of the biggest limits of the **IDCOL model** is that it **does not manage to reach poorer populations** who cannot afford to buy a system even under a credit scheme that is partly subsidized.

For this population segment, an alternative solution might be more adapted. In order to reach poorer populations, **RENDEV thus suggests that a pay-for-service model be privileged**, whereby a PV hybrid system with minigrid is installed in a community by an investor, and regular fees are collected from end-users. In this scheme, target beneficiaries do not become owners of the equipment, but pay regular fees for accessing electricity as a service.

This is already what the GoI tried to implement in its past social PV program, when it divided Indonesian population in 3 segments and suggested a pay-for-service scheme for the poorer segment (low-income, rural villages). Even though the program had been well designed, its implementation did not succeed. The regular fees that had been defined were actually never collected. People did not get a sense of ownership and were not made responsible for SHS care. Maintenance services were not ensured, threatening the sustainability of the system.

The GoI should therefore build on the lessons learned to overcome past weaknesses and implement an improved pay-for-service model to reach poorer populations.

Key elements for successful pay-for-service schemes

There have been previous experiences in Indonesia of PV hybrid minigrid installation under pay-for-service schemes. These experiences were implemented as pilot, demonstration projects, at a community level, for example within the Decentralized Rural Electrification project held under the E7 Initiative (cf *D3 – Overview of policies, Indonesia*).

These experiences can bring precious information on the key elements for the success of a pay-for-service scheme.

- Installation of the minigrid can be funded by the government with the support of donors. A **public-private partnership** can be set up with a REN supplier. This partnership should define the respective responsibilities of the stakeholders regarding the installation, operation and maintenance of the system.
- Remote villages in Indonesia in general are suitable for this model. Still, in order for the scheme to be implemented in various sites, research on electricity demand, social economic development for the future, willingness-to-pay for electricity, and above all **community preparation** are necessary. Failure to recognize the importance of community participation in this kind of project can lead to a disastrous end of the project. Open and responsive communication is necessary to ensure a high level of acceptance of the scheme by the users and a commitment and ability of the communities to manage and maintain the systems.
- **Village electricity management units** (after evaluation of the human resources available in the villages) can be established at the local level. These units can be **responsible for the electrification scheme** and become the focal point of all project interventions within the communities. They can be in charge of assessing the potential for customers, manage the PV hybrid system and ensure that a reliable fee collection system is in place and operating as expected (fee collection can be carried out by the local management and the money stored in local financial institutions). Part of the fees collected can eventually be used to cover the operational costs of these local management units.
- **Management terms should be decided as a consensus from the community**. The village electricity management units can be elected by the villagers, and the necessary procedures also decided by the villagers (procedures of fee collection and penalty for late payments). The **role of the traditional social organisation** is very important to take up in the process, most specifically in the preparation stage.
- The **payment terms** (level of fees, payment schedule) should be decided as a consensus of the community **depending on the ability-to-pay of the end-users** (e.g. monthly payments, fee collection during the harvest period).
- The **collected fees** are meant to be used for the **maintenance** of the various hardware systems, and eventually to cover the operating costs of the village electricity management units.
- An interesting scheme could be to equip households with **prepaid meters** that enable to control energy consumption. The consumers could go to the management unit to pay for a certain amount of electricity (Wh) and receive a code number that they have to type on the keypad of their individual prepaid meters at their house. This prepaid electricity can be used until the “individual electricity account” (2.5 kWh max) in the prepaid meter is empty. The prepaid meter could also allow a limited amount of energy per day (300 Wh/day). This scheme has two main advantages: it **avoids an overuse of the collective system** by some individuals, and it **ensures that fees will be paid**, since electricity access is here conditioned to a prepayment of the electricity consumption. The cost of each Wh should be fixed according to the ability-to-pay of consumers.
- An **installation fee / connection fee** can be asked to households willing to be connected to the system. Its amount will mostly be symbolic (e.g. IDR 25,000) and will not cover the installation cost, but such a fee will be both a signal of the commitment of the community and an incentive for the users to take care and maintain the system. For lowering burden, it can be imagined that this fee be paid in several instalments.

3.3.3 How the recommended financial models answer the challenges faced by past Indonesian government programs

The table below provides some more details on how the 2 recommended scenarios provide answers to the challenges faced by past Indonesian government programs.

These ideas are essential to keep in mind for designing an adequate, effective national solar energy program.

Table 3: How the 2 recommended scenarios provide answers to Indonesian challenges

Weaknesses of past Indonesian financial models	**Main causes**	**Recommendations**	**SCENARIO 1 solutions – IDCOL model –**	**SCENARIO 2 solutions – pay-for-service model –**
Limited outreach	Target populations: poor rural households cannot afford a fully commercial scheme, and largely remain out of the reach of adapted financial services. Fully subsidized scheme: very costly, outreach is quickly restricted to available government budget	Find an **equilibrium between commercial financing and subsidy** for promoting access to renewable energy: ▪ Avoid fully-subsidized financial schemes ▪ Develop adapted financial services (leasing, loans) for rural populations. Introducing microfinance for solar energy access can contribute to scale up rural electrification without requiring such a high level of subsidy.	The Bangladeshi national solar program adopted a microfinance approach, with the development of specific credit lines for SHS made attractive thanks to subsidized interest rates and costs.	▪ Avoid a fully-subsidized scheme by collecting regular fees used for operation and maintenance of the systems and collecting a symbolic installation fee / connection fee. ▪ Limit this highly subsidized scheme to the poorest populations.
Unequal access Access to the social PV program is limited to the target populations that have been selected by government departments. **Social jealousy** can spread amongst the part of the community which was not chosen, and result in interferences with the deployment of the project, even to the point of inflicting damages to the material. The process and procurement procedures can also be prone to **corrupt practices**.	Fully subsidized scheme: selection of a limited number of target beneficiaries	Adopt a **universal policy**: ▪ Promote a financial scheme that will not select beneficiaries according to some eligibility criteria, but rather **adapt the subsidization rate according to well-defined and transparent criteria** (setting an incentive where it is needed, at the level it is needed). ▪ **Lower the overall level of the subsidy** so that more households can benefit from the policy. ▪ **Include all stakeholders** (MFIs, technology providers) as eligible partners in the policy as long as they meet minimum standards requirements.	Universal policy: ▪ All MFIs and providers are eligible as long as they meet standards ▪ The same financial product is offered to all MFIs ▪ One single scheme is available in the whole country. There is no discrimination between the places nor any possible deformation factor.	The program here only targets the poorest populations but avoids social jealousy by setting up a payment scheme.

Weaknesses of past Indonesian financial models	Main causes	Recommendations	SCENARIO 1 solutions – IDCOL model –	SCENARIO 2 solutions – pay-for-service model –
Ownership issue As the SHS were given for free, there was no sense of belonging. The systems were considered as entirely government funded and taken for granted. In consequence, they were not taken care of as well as if they had been the user's own system, and compensations for maintenance were difficult to obtain from users.	Fully subsidized scheme	▪ Make end-users become the effective **owners of the SHS**: experiences in Bangladesh, Sri Lanka, Indonesia, India and on other continents have shown that the occurrence of defaults on the system is lowered down significantly as soon as the beneficiaries own the system. RENDEV recommend that the ownership of the system be transferred to the end-user through leasing or loan financial schemes. In both cases, the beneficiary is the direct owner of his system and he pays a **regular instalment**. Consequently, the family is very interested in the proper functioning of the system and pays a lot of attention to its maintenance. ▪ Require **minimum down payments** in line with the ability-to-pay of end-users. Down payments can both signal the initial commitment of the beneficiaries (moral guarantee) and act as an incentive for the borrower to repay following instalments and maintain the system.	▪ End-users become owners of their material through microfinance. ▪ They pay monthly instalments to repay their loan over a 2 to 3 year period. ▪ They have to pay a down payment amounting to a minimum of 20% of the total cost of the SHS, prior to equipment installation.	When end-users cannot afford to effectively become owners of the systems, other solutions to ensure sense of ownership can be found: ▪ Collection of an installation / connection fee. ▪ Collection of regular fees for operation and maintenance. ▪ Grace period for a maximum of 1 month, as it is usually done by the national electricity provider PLN. ▪ Rental contract clearly defining the responsibilities of end-users in systems' care and maintenance. ▪ Collective commitment and responsibility of the communities to maintain the shared system.
Lack of commercial market The free SHS approach affected the development of a commercial market for solar energy. Less than 20 suppliers are currently involved in PV business, only 2 are dealing with commercial retail market and offering after-sales services. Government programs have a commercial approach and tended to negatively affect private sector initiatives. Thus, dedicated sales and distribution networks have not been adequately developed.	Fully subsidized scheme inducing market distortion	Promote the **development of a commercial solar energy industry:** ▪ By avoiding fully-subsidized financial schemes ▪ By defining a durable, reliable, policy framework that ensures the validity of a multi-year business model for private investors. ▪ And by **assisting SHS distributors to gain access to financial services** in order to increase their working capital. Linkages can be facilitated between REN developers and commercial banks with the support of the donor community, benefiting of the financial tools provided by ADB, KfW and others.	▪ The microfinance approach enables a competitive, commercial solar energy sector to develop. ▪ The government does not launch competing programs and therefore ensures that the rules under the program remain fair for all the players. No market distortion occurs.	Avoid creating market distortion by: ▪ Carefully selecting communities that will benefit from the social pay-for-service program. ▪ Avoiding a fully subsidized scheme. ▪ Positioning the social program on a type of equipment less dedicated to individual ownership (minigrid systems).

Weaknesses of past Indonesian financial models	Main causes	Recommendations	SCENARIO 1 solutions – IDCOL model –	SCENARIO 2 solutions – pay-for-service model –
No credit facility at the meso level The banking sector is reluctant to engage in financing rural electrification and REN projects for the following reasons: - Unreasonably high perceived risks toward these types of projects; - Limited access to equity financing.	Credit risk National policies on lending	▪ Set up **guarantee funds** to reduce the perceived risks towards those types of projects. Such tools are already available in Indonesia. ▪ Set up **credit lines** / provide soft loans to financial institutions to somewhat reduce the cost of lending in rural areas. Such credit lines can be sought in the donor community.	IDCOL provides soft loans and grants to partner MFIs for funding SHS microcredits.	
No credit facility at the household level To purchase SHS for rural households: the full subsidization of SHS has not encouraged financial institutions to develop financial products and services adapted to solar energy access (no existing market). The banking sector can also be reluctant to engage in financing rural electrification and REN projects for the following reasons: - Unreasonably high perceived risks toward these types of projects; - Inefficiency of costs of administration, monitoring and credit collection in comparison to the amount of loan; - Incapability of rural people to meet bank requirements on additional collateral; - Limited access to equity financing.	Fully subsidized scheme Remoteness of target villages and populations Lack of infrastructure Credit risk Lack of MFIs reaching remote rural places (existing MFIs are mostly operating in the urban centers of rural areas).	▪ Develop a **rural microfinance** in Indonesia ▪ Design, test and implement innovative schemes to provide financing solutions at the village level by leveraging existing organizations in the community. ▪ Reinforce the capacities of the Rural Banks and build showcases that will encourage the owners of the banks to shift from their traditional urban customer base to farmers and fishermen.	The network of MFIs in rural Bangladesh was vibrant before the design of IDCOL project. Its outstanding outreach has encouraged the move to renewable energies. This means that **for Indonesia, more efforts will be needed to support the development of a microfinance sector that will be strong enough to provide access to solar energy**.	

Weaknesses of past Indonesian financial models	Main causes	Recommendations	SCENARIO 1 solutions – IDCOL model –	SCENARIO 2 solutions – pay-for-service model –
Cost of fee collection Government programmes were initially well designed in that they had defined monthly fees to cover operating and maintenance costs of the systems. However, because of the high costs of operating in remote and hilly areas with a disperse population, fees were not collected. In consequence, the sense of ownership was low, no maintenance services could be provided, and the systems quickly started to break down.	Remoteness of target villages and populations	▪ **Piggyback on microfinance providers** networks already located in the area to reduce the costs of recovering loan instalments and fees: develop innovative community based collecting schemes with the existing BPRs, cooperatives and BRI network.	IDCOL builds on the developed microfinance sector in Bangladesh.	Develop innovative community-based collecting schemes, eventually linked to existing microfinance providers' networks.
High cost of service centers In low-density, remote areas, the number of consumers in one central location is usually insufficient to fund service centre costs. This is why there is a lack of maintenance service centres in Indonesia. SHS are not repaired and remain non-operational. This lack of service centers threatens the sustainability of solar energy provision.	Remoteness of target villages and populations	▪ Support **microentrepreneurs' activities** for SHS installation and maintenance ▪ Set up **training centers** for SHS installation and maintenance ▪ **Collect maintenance fees** from end-users for each maintenance and repair intervention	SHS are guaranteed for 3 years as an energy service by the MFI, who is responsible for ensuring maintenance.	Fees collected are used to cover maintenance costs.
Lack of maintenance skills As people do not know how to correctly operate and maintain the SHS, systems are likely to break down and become useless. People may then stop paying fees on the non-operating systems.	Lack of awareness and capacity of end-users for operation and maintenance	**Train end-users** on basic operation and maintenance practices	Part of the grant received by IDCOL from donors is dedicated to training MFIs and clients on SHS technology.	

Weaknesses of past Indonesian financial models	Main causes	Recommendations	SCENARIO 1 solutions – IDCOL model –	SCENARIO 2 solutions – pay-for-service model –
Inappropriate use of the systems In developed market regions such as West Java and Lampung, some potential consumers seemed to have unreasonably high expectations of the SHS. The risk is then that people overuse the systems and accelerate their deterioration through an inadequate use.	Lack of awareness of end-users on system capacities and limitations	**Raise awareness** on the capacities and limitations of the technology, and on its appropriate uses.	The promotion is ensured directly by the MFIs themselves. Part of the grant they receive from IDCOL is dedicated to that purpose.	
Quality issues Despite the definition of accreditation standards by the Government, the product quality often did not fulfil common technical standards (e.g. in Aceh and South Sumatra). Systems often ended up breaking down quite quickly. End-users would thus refuse contributing to maintenance fees. The lack of quality thus threatens the sustainability of solar energy provision.	Quality standards supervision and monitoring	Ensure the implementation of sufficiently high and strict **national standards and certification procedures** to guarantee the quality of the systems provided	The hardware used in the national program are certified and controlled by IDCOL.	

Indonesia should thus build on the above identified lessons learned and good practices in order to define an effective national solar energy program.

Next chapters provide useful insights on the different steps required to design an adequate program based on the recommended scenarios: designing a subsidy policy, defining microfinance role, identifying actors' roles and responsibilities, and ensuring the sustainability of the financial models.

Next steps for Indonesia:

Review policies and programmes building on lessons learned and best practices.

Share knowledge and transfer competences from Bangladesh: exchange visits, trainings, etc.

Review market segmentation for solar energy access and assess which recommended financial model (SCENARIO 1: IDCOL model; or SCENARIO 2: social pay-for-service model) is most adapted to which population segment.

Adapt IDCOL financial model to the Indonesian context, by designing a subsidy policy, defining microfinance products and specifying actors' roles according to the particular national context.

For the poorer population segment, improve the existing social pay-for-service program to overcome its past weaknesses.

Test the different financial models at a small-scale first, through pilot projects in areas with the most potential for success.

4 Designing the subsidy policy

Main ideas:

Solar energy technologies imply a relatively high initial cost.

The willingness and ability to pay for solar energy of the target population is limited and varies across provinces and socioeconomic levels.

In order to bridge the gap between the full cost of the solar technologies and the willingness to pay of the populations, a subsidy policy is needed.

This subsidy policy should be carefully designed and adjusted to the varying willingness and capacity to pay of target populations in Indonesia.

4.1 Solar energy technologies: types and costs

Previous studies undertaken through the RENDEV project identified the solar energy technologies that can provide access to electricity in rural areas (*D7 – State of the art of solar energy applications in Indonesia* and *D11 – Toolkit for policy makers*). A brief reminder of the different types of technologies and their respective costs is provided here.

4.1.1 Products

❖ ***Typical products designed for poor and wealthier rural population (scenario1)***

In this part, we will briefly summarize the technical description of SHS standard kits and its components, which are systems with power ranges from 10 to 130 Wp that are adapted to poor and wealthier rural populations' needs.

General composition of a SHS standard kit

For a Solar Home System, nominal power of solar panels ranges from 10 Wp to 130 Wp. "Wp" (Watt peak) is the common unit of solar energy: a Wp is the output of a solar module under nominal conditions, ie insulation of 1000 W/m2, temperature 20℃ and pressure of 1 atmosphere.

The common solar home system in Indonesia consists of:

- a **50 Wp** photovoltaic module
- a lead acid battery with a capacity of **70 Ah**
- a **12 V, 10 A** battery charge regulator
- three fluorescent lamps (**6 W**) and one DC outlet socket for low power consuming appliance
- the battery box
- PV module support structure.
- switches and interconnecting wires

The daily energy output of this system is about **225 Wh**, on the average irradiation of **4.8 kWh/m2day.**

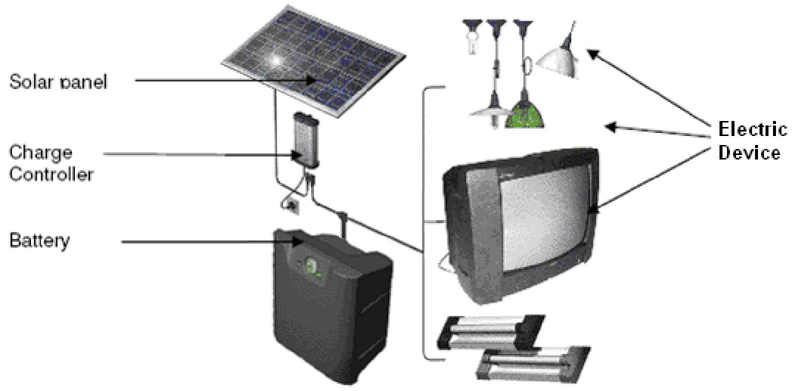


Figure 3: Solar Home System main components

Photovoltaic module

The solar panels are the source of energy. **They transform sun rays into electric energy thanks to photovoltaic effect**. The average efficiency is 12%. The output of a solar panel is direct current while most of other energy sources produce alternative current, transforming mechanic energy in electric energy.

The majority of PV modules are not produced locally, except of PT LEN Industry, which is working on PV module framing and laminating with limited capacity. Most of the PV modules are imported from international market such as BP Solar, Shell Solar, Solar world, Sharp, SET and unknown Chinese products.

Battery

As solar panels only produce energy during sunny hours, **energy is stored into batteries** so that it can be used by the user accordingly to its needs. Batteries are **designed to last 3 days** without any power input, i.e. very cloudy weather for three consecutives days.

Most of Solar Home Systems use 70 Ah lead acid SLI (Start, Light and Ignition) batteries or modified automotive batteries for storage. These batteries have currently the best price / kWh ratio while requiring little maintenance. However, depending on the type of lead-acid battery, the lifetime in a solar application can vary widely, between 2 and 10 years. Batteries should be of type "open" which means it requires periodic additions of water. Three types of opened battery are accepted:

- Thick batteries, flat plates type generally called “solar battery "with a lifetime between 3 and 4 years.
- Tubular batteries, lifetime between 8 and 10 years.
- Stationary tubular batteries with low antimony rate, lifetime exceeding 10 years.

Specific batteries for PV applications are also available on the market and improve the outputs of the system.

Battery Charge Regulator (BCR)

The charge / discharge regulator is a key component to **optimize the lifetime of the battery**. The regulation enables to avoid the overload of the battery while ensuring sufficient recharge to maximize battery life. It also disconnects the user in case of deep discharge of the battery to prevent irreversible sulfation. These are pre-set values from the manufacturer indicated through some LED lights. The system installer needs to explain the status indicators of a charge controller to the system user so that proper action is taken as needed.

Generally green LEDs indicate the charge in the battery is enough to use in loads. The red LED indicates the state of charge when it's below a good level. Similarly there are other LEDs to indicate different charging states.

BCR is a basic electronic device and can easily be designed and produced locally but there are also imported BCR used by suppliers.

Devices and lamps

In order to save energy, energy efficient devices have to be used. Availability of lamps in the remote area is a key to the success of a project, so it must be ensured that DC devices will be available widely on the field.

Tubes and their integrated inverters:[1]

Tubes are widely available in developing countries while inverters are easy to manufacture locally. For instance in Bangladesh, Grameen Shakti is manufacturing its inverters locally.
Lifetime: 5 000 h

CFL Bulbs[2]*:*

Special CFL bulbs are manufactured for DC applications.
Lifetime: 5 000 h

LEDs[3]*:*

Special LED lamps are also manufactured by international manufacturers.
Lifetime: 20 000 h

Usually a 50 Wp system can light up to 3 CFL lamps for 6 hours a day.

Battery box

The battery box is made of injection-melded plastic or combination of plastic with metal. The enclosure contains the battery, charge controller, charge indicator, and switches. The electronic elements are isolated from the battery, and the battery enclosure has ventilations to disperse gases and channels to divert any acid overflows. There is no exposed wiring and the battery can be checked and filled easily.

Availability of spare parts

In remote areas, the availability of spare parts(batteries, lamps, BCR) is critical. To ensure the availability of basic spare parts, **microentrepreneurs might be a good alternative as the project will promote and encourage them to become retailer of these parts in location close to the beneficiaries**. For major components, the project will have to design an adequate network according to the usual damage occurrence of the component.

[1] Picture : Grameen Shakti
[2] Picture : Philips
[3] Picture : Osram

❖ ***Products for microentrepreneurs and communities***

In this part, we will propose others kits and technical solutions more adapted to microentrepreneurs and communities.

Kits for microentrepreneurs (scenario 1)

Here, we may consider two different cases:

- Microentrepreneurs who want to generate incomes with activities linked to solar energy (recharging batteries, cell phones, lamps…)
- Microentrepreneurs or cooperatives of entrepreneurs that are working in the same sector (agriculture, livestock, transformation and conservation, handicraft) and that may be interested in buying a more powerful system to use community tools or appliances to both facilitate work and improve productivity and consequently, incomes.

In these two cases, systems can range from 200 Wp to 1 or 2 kWp depending on the power needed to run the income generating activity.

The configuration will be almost the same than for a SHS except that the number of module and batteries and the capacity of the regulator will increase, and an inverter may be needed to produce alternative current in case of AC powered appliances.

PV hybrid systems for communities (scenario 2)[4]

It can also be considered to put a community PV hybrid power plant in place, with a mini grid at the scale of a village. Many configurations of implementation are possible, depending on the village geography:

- Centralised hybrid systems

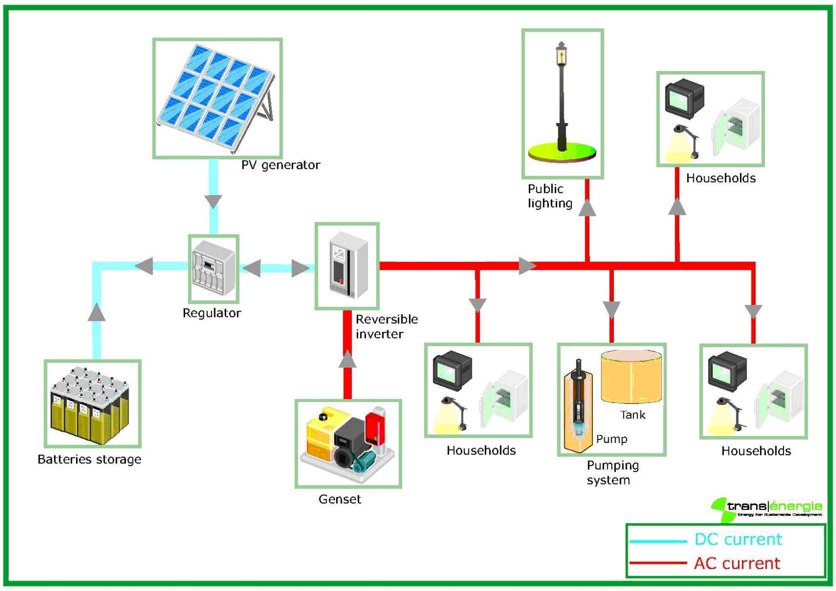


Figure 4: Centralised hybrid system design

➔ *In this configuration, there is one PV array and one battery park for the whole village. It is necessary to put social rules in place as the system is a community system and the energy produced needs to be fairly shared between the villagers.*

[4] *Activity 13 - Best practices in PV hybrid project design,* IEA PVPS task 11 - PV Hybrids and Mini Grids, Transénergie 2009

- Decentralised hybrid system

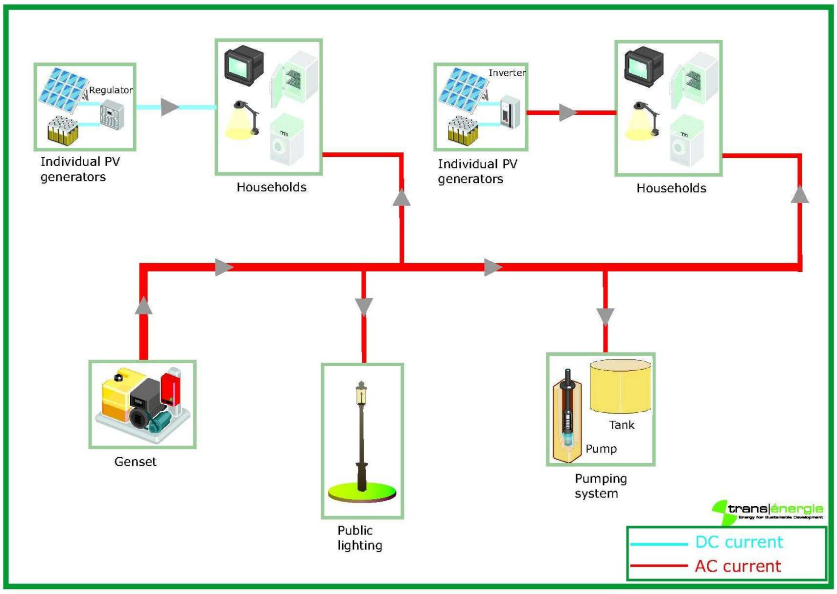


Figure 5: Decentralised hybrid system design

➔ *In this configuration, each household has its own SHS but there is one community diesel genset that can be used in case of lack of solar irradiation or when households need more power*;

For each type of system (centralised or decentralised), many configurations exist. Here it is a general presentation, so we won't go forward in details. But generally speaking, here are some advantages and drawbacks of PV hybrid system.

Advantages and drawbacks

In terms of service

- ➚ Possibility to power common utilities such as public lighting, water pumping ... which is impossible with a set of SHS with no community grid.
- ➚ Flexibility in power can be used to have community working utilities that will enable to develop income generating activities at the village scale.
- ➚ Availability of electricity 24/24 in the voltage range fixed by contract.
- ➘ Incomplete autonomy of the system (use of fuel).
- ➘ Solutions only for compact village without spread households with favourable and available location for solar panels.

In terms of operation

- ➚ Reduced operating costs of the generator justifying the additional cost of investment compared to the "diesel only" solution.
- ➚ Centralization of the maintenance.
- ➚ Reduced consumption of gas-oil and maintenance (operating time of group limited to a few hours per day).
- ➚ Increased lifespan of the generator.
- ➚ Operation of the generator at full load during its period of operation optimizing the consumption of diesel and maintenance and increasing lifespan of the generator.

For more details and example of such community systems, see D3 - Policy Review - Indonesia, case study 3 on page 33.

4.1.2 Investment and operating costs

❖ ***Products designed for poor and wealthier rural population (scenario1)***

Investment costs:

PV module
Typically, 50 Wp PV modules can be purchased in the range of price IDR 2.8 million to IDR 3.2 million (between 195€ and 225€).

Batteries
As said previously, SHS use 70 Ah lead acid SLI (Start, Light and Ignition) batteries or modified automotive batteries for storage. The price of these batteries varies from IDR 500 000 to IDR 700.000 (between 35€ and 50€). Quite often some suppliers offer the Valve-Regulated Lead Acid batteries (VRLA) for the price of IDR 1.2 million (84€).

BCR
The price of a BCR varies from IDR 250 000 to IDR 400 000 (between 18€ and 28€).

Lamps
The 6 W fluorescent lamps using electronics ballast/inverter are made locally. The price of the electronic ballast is in the range of IDR 70 000 to IDR 120 000 5 (between 5€ and 8.5€).

Battery box
The battery box price is IDR 100 000 to IDR 200 000 (between 7€ and 14 €).

The following graph provides breakdown prices of SHS, based on data from the Indonesian Association of Photovoltaic System Suppliers (APSURYA)

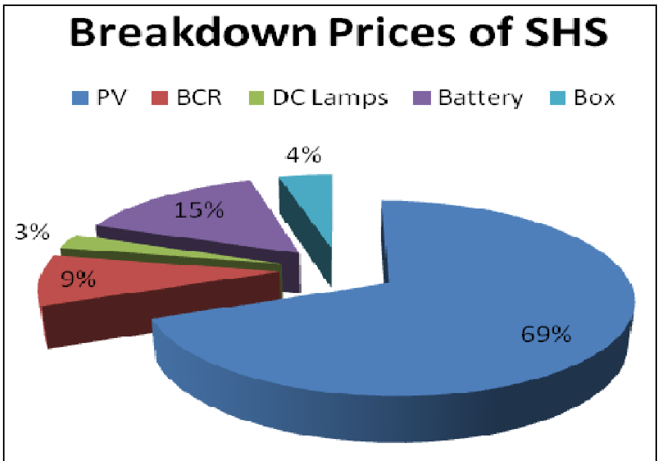


Figure 6: Breakdown prices of SHS[5]

Listed below is a table that presents the different kits proposed by Grameen Shakti and that can be used as a reference for Indonesian market. The package prices shown here are not the real prices proposed by GS.
Indeed, considering that GS has its own assembly factory for small components and that the size of the NGO is such that they can have interesting prices as they ordered big amount of modules, 20 % of the original price has been added to reflect real market prices.

[5] Data provided by *Association of Photovoltaic System Suppliers (APSURYA)*

Remark: Conversion rates used: 1 € =100 Tk = IDR 15 000

System power (Wp)	Battery capacity (Ah)	Components	Package Price			Target Population
			IDR	Tk	€	
130	2*100	11 * 6 W Lamps & 20 "BW Tv Point	11 700 000	78 000	780	wealthier rural population
120	2*100	10 * 6 W Lamps & 20 "BW Tv Point	11 304 000	75 360	754	wealthier rural population
85	130	7 * 6 W Lamps & BW 1 17" Tv Point	7 650 000	51 000	510	wealthier rural population
80	130	7 * 6 W Lamps & BW 1 17" Tv Point	7 200 000	48 000	480	wealthier rural population
75	130	6 * 6 W Lamps & BW 1 17" Tv Point	6 912 000	46 080	461	poor rural population
65	100	5 * 6 W Lamps & BW 1 14" Tv Point	6 030 000	40 200	402	poor rural population
60	100	5 * 6 W Lamps & BW 1 14" Tv Point	5 670 000	37 800	378	poor rural population
50	80	4 * 6 W Lamps & BW 1 17" Tv Point	5 022 000	33 480	335	poor rural population
40	55	3 * 6 W Lamps & BW 1 17" Tv Point	4 050 000	27 000	270	poor rural population
30	47	2 * 6W Lamps	3 240 000	21 600	216	poor rural population
20	23	1 * 7 W CFL Lamp & 3 LED Lamps	2 682 000	17 880	179	poor rural population
10	18	1 * 5 W CFL Lamp & 2 LED Lamps	1 602 000	10680	107	poor rural population

Source: Grameen Shakti

Table 4: Package prices for SHS kits

Operating costs:

Two main factors occur cost wise:

- **price of spare-parts**
- **cost of maintenance** (human cost)

Spare parts

In part VII.3.2., maintenance operations to perform will be detailed. Concerning spare parts, batteries and lamps have the shortest lifespan, around 5 years against 25 years for the module and 10 years for the regulator.

If we consider a running period of 20 years for the SHS, it will be necessary to change:

- The battery: 3 times
- The regulator: 1 time
- Lights: 8-10 times (6 hours of functioning per day; lifetime of 5000 hours that means it will be necessary to change them almost every 2 years)

Example:

For a 50 Wp kit, if we consider the breakdown prices described on the previous diagram, the cost of spare parts over 20 years will be the following:

System power (Wp)		50
Breakdown Prices (IDR)	PV (69%)	3 450 000
	BCR (9%)	450 000
	Lamps (3%)	150 000
	Battery (15%)	750 000
	Box (4%)	200 000
Total 1: System price (IDR)		5 000 000
Cost of spare parts over 20 years	PV	0
	BCR	450 000
	Lamps	1 500 000
	Battery	2 250 000
	Box	0
Total 2: Spare parts cost (IDR)		4 200 000
Total 3: Global cost of the system over 20 years (IDR)		**9 200 000**

So we can estimate, based on the hypothesis above, that **the cost of spare parts over 20 years is almost equal to the investment costs**

Figure 7: Cost of spare parts for a 50 Wp kit

Cost of the maintenance

To minimize this cost, preventive actions such as training end-users to good use of their system is the most cost effective option and must be part of any project.
The other issue is to launch projects of a size such as a team of technicians can be trained and operating at an affordable cost compare to the project size.

Financing the maintenance cost

Although small compare to investment cost or other technologies maintenance cost, maintenance cost is a vital issue as it is often underestimate in project planning. Moreover, as populations in project's area are mainly very poor, they don't have dedicated budget to ensure the maintenance.

To sustain the project, maintenance cost must be planned so that it will be ensured. An alternative is that **MFI implied in the projects provide microcredits for the purchase of high cost spare parts such as batteries in order to fit to people's income**. REN service centres will be in charge of the maintenance

For more details about operating costs of a REN service unit, see D11 – Toolkit for Policy Makers, box 8 on page 43.

❖ ***Products for microentrepreneurs and communities***

Kits for microentrepreneurs

The investment costs for systems ranging from 200 Wp to 1 or 2 kWp will be pretty much proportional to costs of systems with small power listed in table 4.

Concerning operating cost, we will keep the same ratio for spare parts:

cost of spare parts over 20 years ~ investment cost

PV hybrid systems for communities

As explained before, different architectures are possible for hybrid systems, so it is complicated to generalize. Nevertheless, to have an idea about investment and operating costs of such systems, a case study will be exposed. It concerns a community system installed in the transmigration village of Kalumpang *(Sulawesi)* in 1998 as part of an initiative of the *Ministry of Transmigration and Forest Squatter Resettlement*. The system has been sized and installed by the French consulting firmTransenergie[6].

Figure 8: Case study of a community PV hybrid system in Indonesia

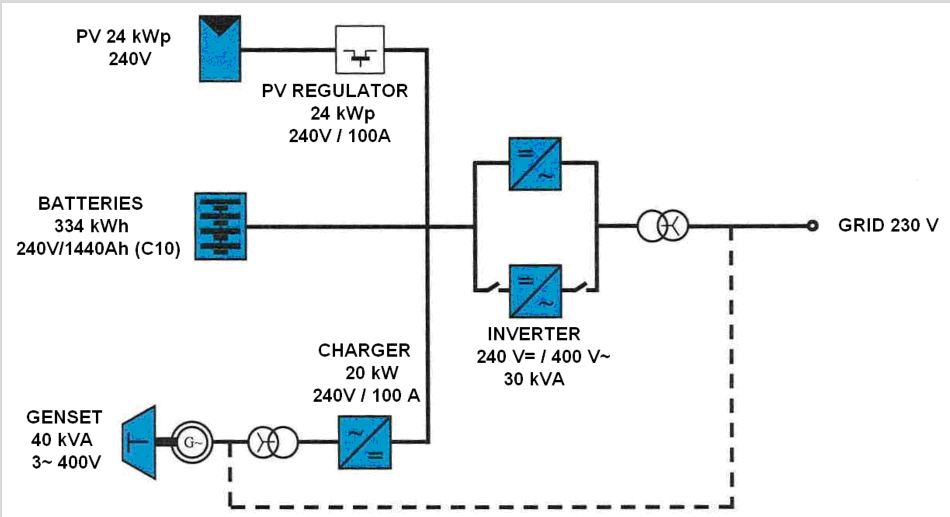
Context

To cope with problems caused by the overpopulation of Java and Sumatra (poverty, health problems, lack of arable land), the Government has encouraged the people of these islands to settle in Sulawesi or Kalimantan, by allocating plots of land that enable them to live more decently. Thus, entire villages were formed each year in the middle of the jungle of Sulawesi and Kalimantan, populated by farmers called transmigrants. The following system which brought electricity to one of these remote rural villages, has been supported by a French program.

General project data

Name of the electrified village*: Kalumpang (Sulawesi)*
Accessibility*: difficult*
Population: *1 500*
Number of connected households: *300*
Type of hybrid system: *centralised*
System configuration:
- *PV Power: 24 kW*
- *Genset power: 40 kVA*
- *Other source and power: No*

Diagram:



Power control and limitation

Each household was equipped with prepaid meters named “Suncash” that permits the control of energy consumption and power in amount by using a prepayment system. The consumers go to the local administrator (“Powervend”) to pay for a certain amount of electricity (Wh), and receive a code number that they have to type on the keypad of their individual “Suncash”. This prepaid electricity can be used until the “individual electricity

[6] *Rural PV diesel hybrid systems in Indonesia, socio technical analysis two years after implementation,* Presentation done by Transénergie at the Photovoltaic Hybrid Power Sytems conference, IEA PVPS task 3- Use of photovoltaic power systems in stand-alone and island applications, Aix en Provence, Sept 2000

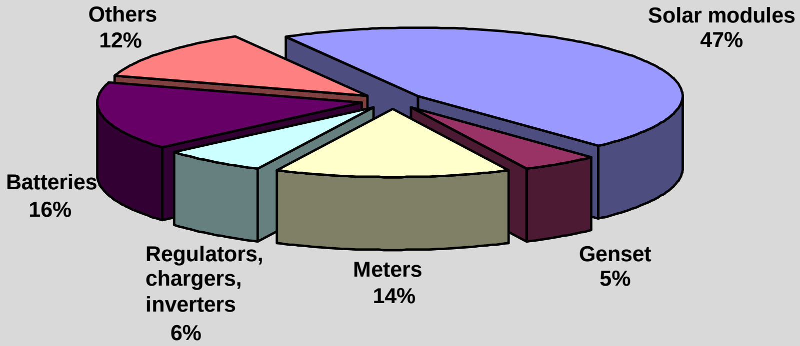
account" (2.5 kWh max) in the "Suncash" is empty with the limitation that the "Suncash" only allows to use a fixed amount of energy per day (300 Wh/day).

The electrical demand is essentially for the lighting (3 9W fluorescent lamps per home), and sometimes radio, TV set and more rarely fridge. The system has been sized to provide a total of **80 kWh/day**: it encompasses individual consumption of the 300 households, a surplus for community applications (cold production) and auto consumption of the installation (Suncash = 1 W/each and ~ 300W for the inverter).

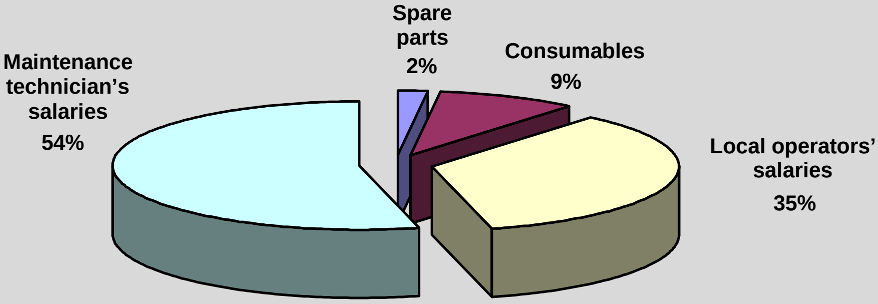
The estimated average solar irradiation was **4.5 kWh/m².day**.

Tariff
Each household had to pay an installation fee of IDR 25,000 (1.76 €) before consuming. For lowering burden, it was agreed to accept payment in 5 instalments. The first month of operation, electricity was for free, as it is usual for the Indonesian public electricity company PLN. Then the price was fixed to IDR 4,500 / kWh (0.3 €) while the price in Jakarta was 4 times cheaper.
It makes a total of around **IDR 11,000 per month**, compared to instalment for a 50 Wp kit under IDCOL project which is **IDR 97,500.**

Investment costs
Initial investment costs represented around IDR 3,750,000,000 (250,000 €) and was divided as follows*:*



Operating costs



Consumables are the diesel, waste oil for the genset and distilled water for batteries, and the spare parts include filters, belts…Local operators are two directors who collect the settlement of users and technicians who ensure the maintenance of the installation. The most important cost is the technician who comes from Jakarta to perform more complicated maintenance.

Taking into account the initial investment, the lifespan of various components of the system and the operating costs, the **overall cost of installation over 20 years is IDR 9,150,000,000** (610,000 €), that is to say around **IDR 457,500,000 per year** (30,500 €)**.**

Successful outcomes

- ❖ Energy service with PV-hybrids is evaluated as good: the energy dispenser is well accepted by users and considered as a very necessary and useful device.
- ❖ Social acceptance of this technology is highly favoured by clear contractual framework and adapted tariff systems. The energy guarantee is especially well accepted by the users.
- ❖ The user participation in the load management of the system by adapting their consumption, saving energy and monitoring important indicators such as the battery state of charge, is very high. The main factor for this high rate of participation is the remote display, which was mentioned by most users as a very simple and clear tool to do monitoring. Even if the level of formal training is not high, there has been success in the knowledge transfer of the basic elements of interacting with the system.

Barriers encountered

- ❖ Difficulties for co-financing exist as normally rural users do not have sufficient income to finance the installation. So, public funds have to be raised depending on the regional context. There must be an average of 75% financing from public institutions.
- ❖ Extensive social work is indispensable for long-term sustainability of the service. The main difficulty in the design phase is to deal with complex socio-economic situations and the communication to the future users explaining them the features of this electrical service and its implications

General conclusion

➔ *Solar energy technologies thus imply a relatively high initial cost as well as recurrent maintenance costs that require identifying adequate financial schemes.*

4.2 Willingness to pay of the target populations

A good understanding of people's willingness-to-pay for solar energy access is necessary for designing suitable tariff and subsidy policies.

4.2.1 Target populations: rural households in remote areas

The first step when developing a national solar program is to identify the target population, which has already been done by the GoI in its past programs.

In order to avoid inefficiency and market distortion, **solar energy access should be promoted and supported by a national program only where it represents the most economical solution for electricity access**. This is the case in **rural, remote areas**, where populations are sparsely located, and where no alternative to energy access is feasible in the near future.

The geography and topography of Indonesia have created many such rural and remote areas. PLN, the Indonesian Electricity State Company, indeed identified 6,000 villages that will not be reached by national electricity grid in the near future, representing around 62.2 millions households.

Past government programs had set up criteria to select the villages that could benefit from the social PV-SHS project. A village was eligible if:

- It was located in a remote area
- It would not be connected to national grid in the near future
- It had no potential for micro-hydro

- Its people were committed to maintain the system.

These criteria would ensure the relevant targeting and the efficiency of the program.

Understanding what is the willingness to pay for solar energy access of these target populations, is essential to design an adequate and efficient subsidy policy.

4.2.2 Limited willingness to pay

Poor populations have a limited purchasing power

Target areas for solar energy access are remote, rural areas, where people have low and generally highly fluctuating incomes. Their purchasing power is therefore limited.
A 40-50 Wp system at the cash price of IDR 5 million is beyond the buying capacity of most of these villagers. Even if credit support is provided to finance the purchase, a maximum average of 15% of rural un-electrified households would be willing to by a PV-SHS at a fully commercial price (World Bank PSG Survey, 2001).

Willingness to pay is usually limited to current energy expenses

The willingness to pay for solar energy is furthermore limited by the fact that people are ready to spend in renewable energy as much as they are currently spending on kerosene (substitution), but not more. In Indonesia, because the government subsidizes conventional energy, the commercial price of SHS appears comparatively expensive.
This pattern is likely to change though in the medium term. Renewable energy is becoming more competitive as the current low oil price on the domestic market is gradually increased by the government, which seeks to reduce its fuel subsidies. Willingness to pay for solar energy could thus increase slightly in the future.

Promotion strategy can increase willingness to pay

Willingness to pay can be slightly increased too if the economic benefits of solar energy access are demonstrated to end-users through an adequate promotion strategy. If people understand that, in the medium and long run, solar energy is a much more economical solution than conventional fuel energy, and if they understand that solar energy can generate more power than conventional energy and thereby quickly create new opportunities for developing income-generating activities, poor people in rural areas will be more willing to invest in renewable energy.

4.2.3 Differentiated willingness to pay

Willingness to pay varies across provinces

Indonesia is a very diverse country, with 34 different regions and a great number of islands. The demographic and economic situation varies significantly between the different provinces. This also means that the willingness and ability to pay for solar energy varies from one province to the other. Indeed, a market survey realized by the World Bank in 2001 showed that 3 Indonesian regions demonstrate a better ability to pay on average. These three regions are the province of West Java (Jawa Barat), Lampung (South Sumatera), and South Sulawesi. Regional variations should thus be taken into account when designing a subsidy policy.

Willingness to pay varies across socioeconomic levels

Within a particular village, willingness to pay for solar energy may vary greatly too according to the socioeconomic levels of the people.
This is already demonstrated by the World Bank survey (2001), which identified that on average 15% of rural households in a village (in wealthier provinces) would be willing to buy a SHS at a fully commercial price, under a credit scheme. These 15% represent the wealthier segment of the population within the village. Poorer populations will need greater support in order to be able to purchase a SHS.

The market for solar energy can indeed be divided into different segments:

- **Poor rural populations**, with a limited ability and willingness to pay. Among this population segment, some households might still be able to afford becoming owners of small SHS under scenario 1 (IDCOL financial model), while others will not have the capacity to do so and should be provided support from the government under scenario 2 (pay-for-service model).
- **Wealthier rural populations**, with a greater ability and willingness to pay, and who could even increasingly be interested in buying bigger systems (100-200 Wp), which can run TVs and other devices, provided suitable and affordable consumers credit scheme is available. This segment would be able to afford SHS under scenario 1 credit schemes.
- **Microentrepreneurs**, whose willingness to pay can be relatively high if they expect a direct economic benefit from accessing solar energy (increase in their activity thanks to extended work hours, efficiency gains thanks to upgraded technologies). This segment would be able to afford SHS under scenario 1 credit schemes.
- **Communities**: in some not-so-poor villages with a quite high density of housing, communities may be willing to pay for the installation of a PV hybrid minigrid system, which in this situation would constitute a better financial option than individual SHS. This will need support from the government under scenario 2.

4.3 Subsidy policy

4.3.1 Bridging the gap between energy access full cost and willingness to pay

The need for subsidies

Solar energy technologies imply a high upfront cost that is not affordable by target populations. In order to support the development of solar electrification in the country, it is thus necessary to design a subsidy policy that will bridge the gap between the technology full cost and the ability to pay of rural households.
Subsidies for renewable technologies are even more needed as the price of conventional energy is still being subsidized by the GoI.

Finding equilibrium between commercial financing and subsidies

The unsuccessful experience of BRI, who tried a credit product for SHS access on a fully commercial price, demonstrated that a financial scheme without subsidies is not likely to be sustainable and to reach rural, poor populations in Indonesia.
On the other hand, the problems of lack of ownership and maintenance experienced through Indonesian government programs indicated that a fully-subsidized scheme is not effective neither (low outreach, material break down) and can generate negative secondary effects (social jealousy, market distortion).

As demonstrated by the Bangladeshi IDCOL experience, the solution lies in combining a commercial and a social approach. To be efficient, a national solar program has to find equilibrium between households' contributions (for sense of ownership, outreach and sustainability) and subsidies (for affordability).

What to subsidize

In scenario 1 (IDCOL financial model), the subsidy can be applied at two levels:

- Subsidize the **cost of capital** by providing **soft loans** to MFIs, who can in turn offer microcredits to end-users at a lower interest rate. This type of subsidy reduces the total cost of the technology for the borrower, and is usually relatively cheaper and more sustainable than a direct subsidy on material.
- Subsidize part of the **cost of material** by providing a **grant**. This type of subsidy may still be necessary in order to expand the market segment for SHS, allowing more households to access solar energy technologies. In the IDCOL model, the grant provided to MFIs enables to **decrease the price of the SHS**, as well as to cover **promotion and maintenance expenses**, which are essential to the sustainability of the financial model.

In scenario 2 (pay-for-service model), the subsidy can be applied at the following levels:

- Finance the **installation costs**: even if some small installation fees can be charged to the customers, they will be mostly symbolic only. The bulk of the installation costs will have to be financed by an investor. It can in some cases be a private operator. Most likely, it will have to be the government, with eventual support from funding partners.
- Subsidize the **operation and maintenance costs**: regular fees will be collected to cover operation and maintenance costs. These fees should be adjusted to the ability to pay of customers. In the case that the collected fees cannot be high enough to cover the real costs of operation and maintenance, some subsidies will be required to fill the gap.

4.3.2 Defining an adequate level of subsidy

What is the appropriate rate of subsidy?

No single solution can be given to the question of the adequate level of subsidy. Successful programs around the world have applied very different rates of subsidy to support solar energy development, as demonstrated in the table below.

Program	Subsidy
Bangladesh IDCOL	20% (on average)
Bolivia ANED	45%
Sri Lanka SEED	66%

Table 5: Subsidy level in solar energy programs

The adequate level of subsidy has to be defined in the specific context of Indonesia, according to the following considerations:

- the **costs of operation** for renewable energy providers: the subsidy can be used to encourage solar energy suppliers to undertake promotion campaigns and provide maintenance services in areas where they would not have gone because of high operating costs.

- the **willingness to pay** of end-users: the subsidy level should be defined so that the remaining cost to be paid meets the ability to pay of the end-user. This implies having (updated) estimations on the willingness to pay of rural populations.
- the **budget available** for subsidy (from the government and/or from donors): there is a clear trade-off between level of subsidy and outreach. Within a limited budget, the higher the subsidy, the lower the number of households which will benefit from it. The choice of the subsidy rate should thus be defined according to the outreach objectives set up for the program too.

Adapting the level of subsidy to target areas' characteristics

When dividing villages in 3 segments for its past solar energy program, the GoI had already in mind that populations have different ability to pay for renewable technologies and that government support should be dedicated to the ones that need it most.
Following this idea, **RENDEV also recommends that the level of subsidy vary according to target areas' characteristics**.

An essential condition of success is that **rules be the same for all players in a particular area**. In this aim, the first **necessity is to define clear and simple criteria** to be eligible to a certain level of subsidy.
Criteria for determining the level of subsidy could be chosen among the following:

- Poverty rate
- Average income
- Remoteness from urban centres
- Electrification rate
- Population density
- Etc.

By crossing the data, decision makers will be able to shape a subsidy matrix as showed in the table below. According to the capacity to pay of the end-user (poverty rate) and the cost of operations for the REN service provider (remoteness), the level of subsidy will be more (III) or less (I) important.

Remoteness / Poverty	+	++	+++
+	I	I	II
++	I	II	II
+++	II	II	III

Table 6: Example of subsidy matrix according to areas' characteristics

It would be important for the GoI to **reflect upon what would be the most appropriate geographic level for determining the rate of subsidy**. Should the subsidy matrix be done at the village level, at the kabupaten level, at the provincial level?

So far, Indonesia has implemented this differentiated approach **at the village level**. This approach is the best to ensure good targeting of poor and remote populations. However, as the awarding of subsidy was binary, neighbouring villages with slightly different characteristics have been declared as eligible or not (threshold effect). As a result, social jealousy could emerge between neighbouring villages and in few cases the selection of subsidized villages could be prone to corruption practices.

Adapting the subsidy rate **at the provincial level** would have the advantage of providing a clearer, simpler and more transparent framework for subsidy determination. It may even increase efficiency of the program in case of the budget allocated to subsidies is managed by provincial authorities.
However, it may not provide a sufficiently well-adapted market segmentation. In fact, one of the major, if not the major cost drivers in a REN service business are the duration of transportation between the service centre and the customers/beneficiaries, and the total number of beneficiaries potentially reached by the service centre. In an archipelagic country, with a hilly landscape and subject to heavy rains, some villages are locating hours away from the first urban centre. Those villages are the ones where people need the more dramatically solar systems, but sound business planning will identify them as a low priority target for any commercial operator that will rather seek a comfortable return in areas much more accessible. Thus, if the subsidy rate applied is the same for the whole province, the program will target mainly areas close to the urban centers (those who might have access to the grid in a near future) and neglect the more remote and poorer populations.

In consequence, RENDEV recommends the **adoption of a subsidy matrix adjusting subsidy rate at the village level**, as it has been done previously by the GoI, since it is the best solution to give incentives to REN suppliers to reach remote populations. However, in order to overcome the social jealousy and other side effects experienced before, RENDEV advocates for setting up a **continuum in the different rates of subsidy applied** (instead of a threshold approach).

Adapting the level of subsidy to equipment type

For scenario 1 (IDCOL financial model), a **second level of subsidy matrix** can be established **according to equipment type**.

Indeed, within an area, the ability to pay for solar technology may vary greatly according to market segments (poor households, wealthier households, microentrepreneurs, communities).

In order to provide greater support to the populations that need it most, the level of subsidy can also be adapted to the type of equipment. This solution is based on the assumption that **poorer people, with a low ability to pay, will opt for smaller technologies, whereas wealthier people or microentrepreneurs, with a greater ability to pay, will prefer bigger systems**. This is an idea which has already been considered in Indonesia when BPPT defined market segmentation for renewable energy and attributed different technologies to target groups (SHS 50 Wp for low income households, SHS 150 Wp for middle income households, grid for high income and urban households), with a higher government support for smaller equipments.

In Bangladesh, IDCOL provides a grant amount which is the same for all types of equipment. This means that the relative rate of the grant is higher for smaller, cheaper equipments, and lower for bigger, more expensive ones.

Here too, a subsidy matrix can be shaped by decision makers according to hardware type: a higher subsidy rate can be provided for smaller equipments (target: poor people), a lower subsidy rate for bigger equipments (target: wealthier people, microentrepreneurs, communities). The objective is that each segment of population can find a type of hardware that will meet both its needs and capacity to pay.

	System price (IDR)	**Subsidy** (IDR)	Final price (IDR)	Monthly payment (3 years)	Monthly payment (5 years)
20 % subsidy on 100 Wp	10,000,000	**2,000,000**	8,000,000	266,000	178,000
40 % subsidy on 50 Wp	5,000,000	**2,000,000**	3,000,000	100,000	67,000
60 % subsidy on 20 Wp	3,000,000	**2,000,000**	1,000,000	33,000	22,000

Table 7: Combining subsidies and loans according to equipment type

Assumption: interest rate 12% p.a., declining balance.

In this example, the absolute amount of subsidy remains the same for each hardware (IDR 2 million), but the relative rate of subsidy increases along smaller equipments (from 20 to 60%). Such a solution would have the advantage of being clear and transparent, and facilitating communication and promotion around the national program.

Finally, decision makers should at any time keep in mind that the **subsidy policy should be**:

- **long term,**
- **universal,**
- **transparent,**
- and **effective.**

Next steps for Indonesia:

Identify the willingness and capacity to pay of target populations thanks to disaggregated, updated market studies.

In collaboration with all stakeholders, define sounds indicators to segment the different target areas.

Define simple, clear and transparent subsidy policy that will stimulate the commercial development of the PV industry in order to facilitate access to solar energy.

Design a subsidy matrix per area and per type of equipment.

5 Defining microfinance role

Main ideas:

Microfinance has a different role to play according to the recommended financial schemes.

In **scenario 1** (IDCOL financial model), microfinance institutions (MFIs) have a major role to play in facilitating solar energy access by offering adapted financial products.

Appropriate microfinance products should be developed according to the characteristics of the target populations and the main credit risks that the MFIs face.

In order to encourage MFIs to offer solar energy microcredits, it is essential to set up a dedicated revolving fund.

In **scenario 2** (pay-for-service model), MFIs will not play a direct role in financing solar energy access, but they can be mobilised to facilitate fee collection and stimulate local development of rural areas in link with electrification.

5.1 Microfinance role under scenario 1 (IDCOL financial model)

5.1.1 Commercial financing of solar energy access: the role of microfinance

Microfinance potential

Rural populations do not have the financial capacity to pay in cash the high initial cost of renewable energy technologies. Providing them with suitable and adapted credit schemes can be a good solution to overcome this barrier.

Microfinance has a key role to play in this perspective. Microfinance indeed has a proven track-record throughout the world of providing financial services to the poor and has demonstrated all over the world the very fact that the poor have the financial capacity to pay back their debts and save for their future as long as they are empowered to do so. Furthermore, the most successful institutions have proven their ability to provide these services on a sustainable basis, so that they are becoming less and less dependent from donors for their funding.

In Indonesia, the banking sector is quite well developed and reaches a large part of the population. The existing 2000 rural banks are spread throughout the country and represent a network on which microfinance can piggyback. However, the microfinance sector itself remains limited to few experiences, the large majority of them implemented on Java and Bali. Recent initiatives, such as the USD 30 million granted by the Bill and Melinda Gates Foundations to create a wholesale bank dedicated to the development of rural banks (Bank Andara) are reinforcing the long time involvement of major development players such as the World Bank, the ADB, the GTZ and Cordaid, and will contribute to shape one of the biggest microfinance industry in the world. Thus, while only some MFIs can be ready for implementing and testing small scale projects as of now, **the microfinance sector could become a key promoter of solar energy access in Indonesia in the medium term if it is gets financial and technical support to develop adequate financial products**.

One-hand vs. two-hand approach

Microfinance can be involved in solar energy financing along two types of approach:

- **One-hand approach**: one single company provides PV systems and offers credit solutions to its potential customers. This company markets the system, sends its sales officers in the villages, offers a credit, installs the system, trains its customers, collects the monthly fees during the duration of the credit, and ensures maintenance and spare part availability.
- **Two-hand approach**: a microfinance institution (MFI) develops a specific credit line for solar energy access and sets up a partnership with an operator.

The first approach is only feasible if there are large enough institutions or companies operating at the grassroots level in the country. In Indonesia, the two-hand approach appears to be better adapted.

5.1.2 Microfinance products for solar energy access

When designing microfinance products for solar energy access, MFIs have to keep in mind two key rules: **duration should be long and interest costs should be kept low**. As for other aspects of product design, MFIs can choose between various options (concerning the type of product, the choice of the contractor, the modalities of repayment, the requirements, etc.). No single type of product can be promoted as the best solution. MFIs should thus design their financial products according to their objectives, clients' characteristics and main credit risks.

Duration should be long

Investment cost for renewable energies are high, whereas running cost are low, and most renewable energy sources are cost-wise more effective compared to fuel energies on a long term basis (usually 10 to 20 years).
In order to reflect the particularity of their cost structure, renewable energy projects require amortizing the investment cost on the long term. It is thus essential that the solar energy financial product offered by MFIs has a long duration **(usually 2 to 4 years).**

Interest costs should be kept low

As the length of investment is long, the actualized interest cost is a major cost component of the system. In order to keep the cost of capital affordable enough for rural poor populations, interest rates offered by MFIs for solar energy access should be kept low. This can be done by subsidizing part of the capital cost.

Credit vs. leasing products

MFIs can opt between two types of solar energy financial products:

- **Credit**: a credit is provided to the end-user, who becomes the owner of the material directly and immediately. A specific credit line can be created for renewable energy access, or the product can be offered under a "consumer credit" or "credit for housing" line.
- **Leasing**: the material is purchased by the MFI and leased to the clients, who pay regular instalments and may have a purchasing option. The MFI remains the owner of the material during the leasing contract, which constitute a better guarantee but at the same time a higher risk for the institution. Moreover, if opting for a leasing product, an MFI should make sure that clients will still get a strong sense of ownership of the material in order to ensure its good care and maintenance.

Choice of contractor

MFIs can tailor financial products according to the type of contractor they target:

- **Consumer loans for households**: the contractor is the end-user of the solar energy system. This type of loan can be defined as non-productive, and therefore bears a higher credit risk for the MFI. This market is however the most important in Indonesia.
- **Productive loans for microentrepreneurs**: in villages with a high density of households, a loan can be provide to a microentrepreneur so that he becomes owner of solar energy material and sells a service to households in the village.
- **Institutional loans for cooperatives, community-based organisations, schools, dispensaries**: the contractor is an institution. A credit can be provided for installing a minigrid system using solar or hybrid energy at a community or cooperative level. This option was not the most popular under past government programs but could however be a good financial solution in villages where there is a quite high density of houses, or for producers' organisations which need electricity to create added value on their members' production. As there are over 130,000 cooperatives in Indonesia (WB, 2005), the potential market for this type of loan is significant. The concerned institution (community-based organisation or cooperative) would first need to gather some funding from members (or donors) to pay the down payment, and would then get a loan for the rest of the cost. CBO or cooperative members could be asked to pay regular fees for services, which would cover the cost of the loan, administrative costs of the CBO/cooperative, and costs of maintenance and depreciation of the system. . In the case of farming and fishing cooperatives, these fees could be directly taken out of the wages that members receive from the cooperatives, making it easier to ensure a full repayment and lower operating costs. **The amounts needed here for minigrid systems may be too high for microfinance institutions to provide such type of loan**. Moreover, MFIs generally do not include institutions as part of their target clientele. **Instead, commercial banks or development banks could be mobilized** to provide institutions with solar energy credits. In Bangladesh, this option has not been integrated in the IDCOL program. It is however an interesting good solution to explore for promoting access to solar energy.

Credit risk management

When introducing commercial financing for solar energy access, it is essential to be aware of the main credit risks and the way to mitigate them. Indonesian MFIs should assess what are the main credit risks they face in their area of intervention, and consider necessary mitigation measures for designing appropriate financial products and services.
The following table presents some credit risks and mitigation solutions to be explored:

Credit risks	Mitigation
Low income populations	▪ Adapt fees and instalments to cash flow structure ▪ Long term loan ▪ Low interest rate ▪ Support the development of income-generating activities along electrification: credit risk will decrease as new activities start providing new sources of revenues
Irregular / seasonal incomes	▪ Adapt fees and instalments to cash flow structure ▪ Provide loans to households who have non-seasonal revenues sources as well
Long term loan	▪ Regular repayments ▪ Close follow up of borrowers

Non-productive loan	▪ Ensure that households have sources of revenues that will enable them to repay the instalments
No guarantee / collateral	▪ Use the equipment as collateral ▪ Ask end-users for a down payment that can act as a moral guarantee ▪ Set up a guarantee fund existing guarantee mechanism such as ASCRINDO could be mobilized
Material breakdown ⇨ no more repayment	▪ Ensure quality certification of the material ▪ Ensure availability of maintenance services ▪ Provide free maintenance during the loan repayment period ▪ Raise awareness on equipment good uses ▪ Provide end-users with training on system maintenance
Disappointment with the technology capacity ⇨ no more repayment	▪ Develop a good marketing and communication strategy, raising awareness on technology capacities and limitations

Table 8: Credit risks and mitigation solutions for financing solar energy access

Competition should be promoted

The national solar energy program should set up standards and criteria for financial institutions to be eligible to the subsidized program, as it is the case in Bangladesh. These standards are necessary to ensure that government and donors' funding provided to these MFIs for developing solar energy access will be used in an effective and transparent way.
However, the GoI should not impose a single financial product to be offered by MFIs to end-users. It is better to let some competition develop between financial institutions by letting them define the interest rates, durations, and modalities of their solar energy loan products. This will incite the microfinance sector to seek solutions to optimize its operating costs and will consequently stimulate competition between REN providers, as MFIs will seek to partner with suppliers than provide the cheapest equipment while still meeting quality requirements. **In the end, it is the client who will benefit from more economical commercial offers**.

5.1.3 The need for a revolving fund for MFIs

As MFIs are currently experiencing difficulties in raising fund, they will not try to mobilize funding to enter in a business slightly different from their core operations, especially if credit risks and costs are likely to be higher than in other activities.

In order to encourage them to provide financial products for solar energy access, it is necessary to **set up a special wholesale fund in charge of providing soft loans to MFIs for REN products**. The funds will be used as revolving funds for MFIs proposing solar energy solutions to their clients.

As demonstrated in the successful example of IDCOL in Bangladesh, it is essential that **access to this fund is available, transparent and reliable** for MFIs involved in the national program. The modalities of access to the fund have to be defined for the whole duration of the program. RENDEV thinks that this condition is key, since MFIs' operations on the field can be considerably harmed if access to funding is not secured.

Several donors (AFD, KfW) have included in their agenda the financement of renewable energies solutions in Indonesia and are looking for strong, propoor projects to finance. **The GoI should coordinate with them** to feed the wholesale fund and ensure the continuous support of contributors throughout the program.

5.2 Microfinance role under scenario 2 (pay-for-service model)

Under the pay-for-service scenario, microfinance does not have a direct role to play in financing solar energy access.
Microfinance institutions can however play an important role at two other levels:

- They can be mobilized to **facilitate the collection of service fees**. MFIs can either be responsible for directly collecting fees from end-users (individually or organized in groups), for which they would receive a commission. Or they could play a role as depositors of the collected fees, that can be saved on a specific account and used only when maintenance expenses have to be made.
- They can **help people take advantage of the new business opportunities brought by electrification** by providing adapted financial services in remote rural areas. More details on this issue are provided in chapter 8.2 of this document ("Leveraging electrification benefits by supporting the development of income-generating opportunities in rural areas").

Next steps for Indonesia:

Within scenario 1 (IDCOL financial model):

1) In one province selected as a showcase, identify MFIs that will be willing to develop the project and assess their capability to serve microfinance in rural areas. Provide them with technical assistance to develop the financial products and contracts for solar energy access that would best suit the local context, taking into account the measures necessary to reduce credit risk.
2) Identify the modalities of implementation of a revolving fund for MFIs and the potential opportunities of financing.

Within scenario 2 (pay-for-service model):

1) Assess how existing microfinance providers' networks can be associated for facilitating fee collection.
2) Support the development of microfinance services in rural areas.

6 Identifying relevant actors and their responsibilities

Main ideas:

In order to set up an effective solar energy program, it is essential to identify relevant Indonesian and international actors and to specify their respective responsibilities.

The GoI has to define clear and adequate policy frameworks, ensure coordination and communication of the solar energy program, appoint dedicated entities for financial and technical management, define procedures and standards of the financial schemes, mobilize partners, and ensure monitoring and evaluation of the program.

Funding partners will be needed to finance part of the revolving fund dedicated to MFIs under scenario 1 (IDCOL financial model), part of the installation investment made under scenario 2 (pay-for-service model), and to provide support to capacity-building activities.

Under scenario 1 (IDCOL financial model), MFIs will have the significant responsibility of developing, offering and managing financial products to promote access to renewable energies. They will set up strategic partnerships with REN suppliers, who will be in charge of providing adapted, good quality solar equipments to rural populations in Indonesia.

When needed, technical partners will be mobilized to strengthen the capacities of the different stakeholders involved in the financial model.

All actors will have to be aware of and clear about their respective responsibilities. Transparency, coordination and communication will be essential to the success of the program.

In order to set up an effective national solar energy program, relevant Indonesian and international actors have to be identified and their respective responsibilities have to be specified.

6.1 Government

Responsibilities of the Government:

<u>Policy definition</u>

- Make sure that the **institutional and legal framework** is adequate for microfinance development and renewable energy promotion. In Indonesia, the Government should be particularly aware that its fuel subsidy policy hinders the development of REN technologies because it makes them relatively expensive compared to conventional energies.
- Establish **one single national solar energy program**, instead of multiplying REN projects at different government departments' level (such as DGEEU, Depdagri and PDT). An integrated and programmatic approach (long-term, multi-year, cross-sectoral) is required and needs to replace the individual project approach implemented so far. With only one harmonized program under Government supervision, better coordination will be ensured between government departments as well as between central and provincial governments.

- Create a steering committee including representatives of all stakeholders involved in the national solar energy program (central government departments, provincial governments, donors, MFIs, REN suppliers, etc.) and eventually appoint a Minister for Renewable Energy to **ensure good coordination and communication**, both internal and external.
- Define a clear, transparent, well targeted, universal and long term **subsidy policy**.
- Ensure regular **monitoring and evaluation** of the whole program.

Material certification

- Create or appoint a **specific institution to be responsible for certifying and controlling the quality of solar energy material and providers**. Usually, in Indonesia, solar systems are accredited by the Laboratorium Sumber Daya Energi (LSDE). The GoI needs to assess whether this institution is doing this work effectively, whether it would need to strengthen its capacities, and in what ways.
- Define the **standard requirements for REN suppliers to be eligible partners** in the program: certification of material quality, provision of maintenance services, etc.

Credit carbon certification

- Integrate carbon credit certification in the project design so that the same monitoring system will be used to monitor the appropriate allocation of the funds and the carbon emission reduction credits.
- Mobilize support from different international agencies (e.g. UNEP) to build capacities for setting up this mechanism.

Under scenario 1 (IDCOL financial model): Revolving fund for MFIs

- Create or appoint a **specific institution to be the coordinator and manager of the revolving fund for MFIs**. The GoI needs to identify what entity could be the Indonesian equivalent of the Bangladeshi IDCOL. Could BPPT, the Agency for the Assessment and Application of Technology who was appointed by the GoI to undertake the role of focal point for the development of solar energy utilization, handle these responsibilities? Could PNM, the agency who was appointed to promote Microfinance with its financial experience be more appropriate? Should it be decentralized and managed at the provincial level by Provincial Development Banks? Should a new entity, public or private, be created?
- Define the exact **procedures** for the revolving fund disbursement for MFIs.
- Define the **level of management** of the wholesale fund for MFIs: at the central government level? Or at the provincial level, which may be more adequate for a widespread country such as Indonesia? Set up a revolving fund under the Provincial Development Bank or any other interested institution
- Define the **standard requirements for MFIs to be eligible partners** in the program: good governance, transparency, financial sustainability.
- Dedicate part of the **central and/or provincial governments' budget to finance the wholesale revolving fund** for MFIs offering solar energy loans. Reducing the fossil fuel subsidy could for instance make funds available for subsidizing renewable energies.
- Identify and mobilize **funding partners** who will contribute to this revolving fund for MFIs. Set up partnerships with them.

Under scenario 2 (pay-for-service model):

- Develop **public-private partnerships** with REN suppliers who will be in charge of systems' installation in remote rural villages. Clearly define the repartition of responsibilities for installation, operation and maintenance of the systems.

- Ensure **promotion** of solar energy solutions towards target populations. Ensure **social acceptance** of the technology and of the financial scheme, and **communities' commitment** for the good care and maintenance of the systems.
- Define with communities the **responsibilities of the village electricity management units**.

Financial and technical needs of the government:

- Financial resources for the revolving fund for MFIs (scenario 1), the installation investment costs (scenario 2), and for eventual capacity-building activities.
- Technical assistance:
  - for learning from Bangladeshi experience (exchange visit, trainings),
  - and for strengthening implementation and managerial skills of the entities in charge of managing the revolving fund for MFIs and of certifying solar energy equipments and providers.

6.2 Funding partners

If the GoI does not have the financial capacity to bear the whole cost of the national solar energy program, it will have to mobilize funding partners.

Responsibilities of funding partners:

- Under scenario 1 (IDCOL financial model), contribute to a **special wholesale revolving fund for MFIs** that offer REN credits:
  - By providing **soft loans and grants**
  - Through a long term, reliable commitment.
- Under scenario 1 also, mobilize **guarantee funds for MFIs** that offer solar energy credits if needed. If getting access to subsidized credit lines is not a sufficient incentive for MFIs to launch new solar energy loans, funding partners may further encourage MFIs by providing guarantees that will mitigate the credit risk.
- Under scenario 2 (pay-for-service model), contribute to the **investment costs of systems' installation** in remote, poor, rural areas.
- If needed, contribute to the **financing of capacity-building activities** for supporting GoI in developing and implementing its national solar energy program.

What funding partners?

- Donors with relevant funding assistance programs (for microfinance, rural electrification, renewable energy, etc.), such as the Asian Development Bank or the European Commission. These donors should be able to commit to a medium or long term contribution.
- Commercial banks
- State banks
- Provincial development banks
- Carbon credits under the Clean Development Mechanism (CDM) of the United Nations or on the voluntary market (Gold Standard). This option has not been explored in Bangladesh at the national level while some players have applied individually. It could eventually provide a more stable and sustainable source of funding to the program, once the complexity of the carbon credit application has been overcome.
- Guarantee funds such as ASCRINDO

6.3 REN suppliers

Responsibilities of REN suppliers:

- Adapt **current supply** to poor rural households' and microenterprises' needs.
- Offer **maintenance services**.
- Develop **strategic agreements with MFIs** under scenario 1 **and with the government (public-private partnerships)** under scenario 2 to find solutions for financing solar energy products.
- Clearly define with partner MFIs and the government what their respective **responsibilities are in installation and maintenance** of the systems.

What REN suppliers?

All suppliers are eligible to the national program as long as they meet minimum standards requirements for material and service provision quality.
The long term involvement of the REN suppliers, which is totally necessary for a proper provision of after sale services, will be promoted.

Financial and technical needs of REN suppliers:

- Access to financial services to enable them to increase their revolving fund, develop their activities and thus respond to the demand for REN equipment that will increase thanks to the supporting national program.
- Technical assistance for meeting quality standards.

6.4 Implementing partners

6.4.1 Under scenario 1: MFIs

Responsibilities of MFIs:

- Develop, offer and manage **new financial products**, with low interest rates and adapted duration and modalities, to support REN adoption
- Set up **partnerships with reliable REN suppliers**
- Clearly define with partner REN suppliers what their respective responsibilities are in **installation and maintenance** of the systems.
- Ensure **promotion** of solar energy solutions towards target populations.

What MFIS?

- All MFIs should be eligible to the national solar energy program as long as they meet minimum standard requirements concerning good governance, transparency and financial sustainability.
- The provision of microfinance in remote areas of Indonesia is very limited. The development of rural microfinance products and services for both farm and non farm activities is indeed very challenging because of income seasonality and higher operational costs. Microfinance practitioners, among them PlaNet Finance, are defining rural microfinance as one of their top priorities and advocating for its integration in food security policies. Successful MFIs in this field will be the perfect vectors for disseminating REN technologies.

- In Bangladesh, the IDCOL model implies that MFIs are capable to pre-finance the installation costs of solar energy material, since IDCOL only provides the subsidized funding after SHS have been installed and checked. This procedure implies that MFIs manage to access other sources of funding for pre-financing the systems. It is important to assess whether MFIs in Indonesia would have the capacity to mobilize external funding in this perspective, and which of them would manage to do so.

Financial and technical needs of MFIs:

- Subsidized financial resources to develop specific credit lines for REN equipment at a low interest rate.
- Technical assistance for developing adequate financial products for solar energy access.

6.4.2 Under scenario 2: village electricity management units

Responsibilities of village electricity management units:

- Assess the potential for customers in the village
- **Manage the community minigrid system**, ensuring electricity provision and system maintenance
- Ensure the **collection of service fees** and payments.

What village electricity management units?

- Village electricity management units should be created in communities with a strong understanding and acceptance of the solar energy project, and a high commitment to ensure the good management of the system and of the payment recovery procedures.
- Village electricity management units should be elected by villagers, in line with the existing social structure of the communities.

Financial and technical needs of village electricity management units:

- Some financial compensation for the operation costs of the management units.
- Technical assistance for building management capacities for fee collection, system maintenance, etc.

6.5 Technical partners for capacity-building

When needed, technical partners will be mobilized to strengthen the capacities of the different stakeholders involved in the financial model.

Responsibilities of technical partners:

- Provide technical assistance to stakeholders who need to strengthen their capacities:
  - Government: capacity-building for adapting the Bangladeshi financial model to the Indonesian context, for improving managerial and implementation skills of the entities in charge of the revolving fund and the material certification, etc.
  - MFIs: capacity-building for designing adapted financial products, promoting REN energy, and eventually installing and maintaining solar systems.
  - REN providers: capacity-building for providing quality and adapted equipment and maintenance services.

What technical partners?

- One possible solution is that the appointed institution in charge of coordinating and managing the program (that is, the Indonesian equivalent of IDCOL) could be the first recipient of capacity-building activities and could in turn train its partners. For instance, the coordinating agency could be trained to develop adapted financial products for SHS end-users and then it could in turn directly provide assistance, when required, to its new partner MFIs in designing such products.

In the end, what is essential is that all actors are aware of and clear about their respective responsibilities. Transparency, coordination and communication will indeed be essential to the success of the program

Next steps for Indonesia:

Identify the actors involved in the financial schemes.

In collaboration with them, specify the roles and responsibilities of each stakeholder in the schemes, and how coordination and communication will be ensured. Promote as much as possible market mechanisms to ensure this coordination.

Identify the needs for financial resources and capacity-building of each stakeholder within the scheme and the solutions to answer these needs.

Set up partnerships.

7 Ensuring the sustainability of the financial model

Main ideas:

A successful national solar energy program is one that will be stable and operating in the medium and long term in order to effectively reach a significant population. In this aim, the sustainability of the financial model should be ensured at various levels: institutional, financial, technical, social and environmental.

Considering the technical level in particular, Indonesia can learn from interesting solutions that have been implemented elsewhere, and especially in Bangladesh, for ensuring solar equipment quality and maintenance services.

In order to achieve its rural electrification targets, the GoI not only needs to implement a national program with an adequate financial scheme, it also needs to ensure the sustainability of this program. Indeed, in whichever recommended scenario, it is only if institutional, financial, technical, social and environmental sustainability of the program is ensured that a significant part of the Indonesian population can effectively be reached and benefit from renewable energy solutions.

7.1 Institutional sustainability

The sustainability of the financial model cannot be achieved without tackling governance issues. Institutional sustainability requires:

- **Long term stability in policy settings**
- **Good coordination and communication** between government departments, and between central and provincial governments
- **Clear repartition of roles and responsibilities** and good coordination and communication between all stakeholders.

Measures to ensure good governance should be adopted since the design of the program and regularly reviewed and adjusted throughout its implementation.

7.2 Financial sustainability

The financial models promoted by RENDEV are models which remain largely dependant on the funding, and especially the external funding, that can be mobilized. Their sustainability thus relies on long-term budgeting and **long-term commitments from contributors** (both government and donors).

An interesting option can be explored in order to reduce dependency on donors and provide a more sustainable source of funding for the program: mobilizing funds through **carbon credits** under the Clean Development Mechanism (CDM) of the United Nations. The agency in charge of the national solar energy program coordination could for instance apply to the CDM and value the amount of greenhouse gases emissions saved through the adoption of renewable energy solutions throughout the country. Provided the eligibility criteria and procedures of CDM, this will only be feasible when significant amounts of supplied systems are reached.

In the medium term, **improvements in solar energy technologies, economies of scale reached by REN suppliers, increased competition between REN suppliers and development of a domestic production of PV components** could make **solar energy equipments available at a relatively cheaper price** in the country. In consequence, the level of subsidy required to promote access to such equipments could be reduced, which would contribute to a better sustainability of the financial model. The GoI should thus identify whether it can have a supporting role to facilitate and accelerate such determinants.

Finally, financial sustainability of the program will be enhanced if the Government actively supports local **economic development of rural areas**. Indeed, by building infrastructures and providing social services such as education and health care, the GoI can contribute to trigger the economic development of remote poor areas. It will result in an increased purchasing power of local populations and thus in a better ability to pay for renewable energy access. The market share for solar energy will be increased, credit risk somewhat reduced (for scenario 1), and the needed level of subsidy lowered. It is actually quite clear that economic development is essential to increase the outreach and sustainability of solar energy solutions.

7.3 Technical sustainability

Technical sustainability is also essential to the success of a national solar energy program. Two issues are of particular importance: guaranteeing the quality of the material, and ensuring the good operation and maintenance of the systems.

7.3.1 Quality standards[7]

Quality problems were experienced in past programs in Indonesia. If quality is not ensured, credit and fee payment schemes cannot work properly. How can we ensure that quality products are provided?

❖ ***National standards***

Anticipating the growth of application of solar energy, especially SHS, the GoI, supported by the World Bank, established the PV Component Test laboratory accredited by ISO 17025.

This effort created the National Standard for the SHS component such as Battery Storage, BCR, small fluorescent lamp and general requirements of SHS.

There are 4 National Standards (SNI) on the Component of the SHS, namely:

1. SNI no 04 – 6391 – 2000, BCR - Test Procedure and electric requirements.
2. SNI no 04 – 6392 – 2000, Battery for PV System, General Requirement and test methods.
3. SNI no 04 – 6393 – 2000, System fluorescent lamps for the SHS, Requirement and Test Performance.
4. SNI no 04 – 6394 – 2000, the procedures for the classification of SHS, General Requirements.

The Agency for The Application and Assessment of Technology (BPPT) is also working on the standard of PV-Diesel Hybrid systems, as well as the centralized Photovoltaic system. These standards are expected to be finalized by the end of 2009.

❖ ***International standards***

To ensure the system reliability and sustainability, it is recommended to meet the international standards related to solar technologies. Listed below are critical criteria to check while implementing SHS (*a comprehensive document is provided in appendix*)

PV module

- The number of cells per module should be at least 36 for a rated voltage of 12V and cells should be in crystalline silicon.
- The polarity of the terminals of the module should be clearly identified.
- The nominal power of a module should be between 20 and 80 Wp.
- Each module must have a plate providing detailed information (see appendix).

Batteries

- Rated voltage of the battery: 12 V
- Nominal capacity for solar batteries (flat plates or tubular) given for two regimes of discharge (C10, or 10h with stopping threshold equal to 1.8 V and C100, or 100h with arrest threshold to 1.85 V / item). [Note: The procedure for the analysis of initial capacity is specified in IEC 61427].
- Duration of life of the battery must be superior to 3 years. This depends on the depth of discharge as shown in the table below:

[7] *Activity 13 - Best practices in PV hybrid project design,* IEA PVPS task 11 - PV Hybrids and Mini Grids, Transénergie 2009

Depth of Discharge-DOD-%	No. Of Battery Life Cycles produced	Battery life time taking one battery cycle in one day throughout the year
80%	1200	1200/365 = **3.28 Year**
50%	2400	2400/365 = **6.57 Year**
20%	3600	3600/365 = **9.86 Year**

Table 9: Battery lifetime function of the depth of discharge

- As for the module, each battery should have a plate with detailed information (see appendix)

BCR

- Rated voltage: 12 V.
- Input current and maximum output: 12A.
- Parasite consumption of regulator <10 mA at a voltage of 12V nominal.

For detailed information about BCR (load regulation, threshold voltage, protection against overvoltage…), see appendix.

PV module support structure

The modules are assembled on the supporting structures, which must then be set at the most appropriate place. The structures should meet the criteria listed below:

- These assembly structures and module support should be made in corrosion-resistant material, preferably aluminium or stainless steel, with a lifespan greater than or equal to 15 years (see IEC 60815).
- It should include device to limit the possible theft of modules (special screws with complex head for example).
- The supporting structures should be able to withstand winds of 120 km / h.
- The angle from the horizontal should be 15 °.
- The structure should be designed to be fixed either on the terrace or in front.

Battery box

The battery box could contain both batteries and electronics devices, and is locked so that the components are not accessible by users. It should meet the following criteria:

- Volume: the box should, in addition to electronics, be large enough for a second identical set of batteries to allow the scalability of the system.
- Material: the box must be made with material resistant to flame, acid and ultra-violet rays.
- Ventilation: the box must have two openings, one at the bottom and the other on the top to evacuate the exhaust products at the end of charge (at least 1 cm2 per kWh capacity). The holes should be fitted with grid strainer to prevent the penetration of insects (minimum IP24 protection).
- Layout: the box is equipped with a lid fitted with an anti-crime closure or with a closure that can be condemned by the operator. The regulator is placed in a watertight compartment adjacent to the box or included in the box, with inaccessibility of electrical wiring.

Wiring

PV systems should be provided with all the cables adapted and sized for their optimal operation.

Cables

The maximum voltage drop allowed in the cables, which corresponds to the maximum current, should be limited to 3% between the solar panel and the regulator and 1% between the regulator and batteries. Accordingly, here are some standard lengths:

- PV module <-> controller = 10 m,
- Controller <-> battery: <0.5 m.

The connection between solar panel and battery box must be made from flexible cable, resistant to ultraviolet radiation and with a double insulation (type HO7RNF) and complying with IEC 60811.

NB: A fuse protection will be placed on the route battery / regulator.

Connectors

The connectors should have good mechanical strength and low electrical resistance causing a voltage drop of less than 0.5% of the rated voltage for maximum current. They should tolerate at least 150% of the maximum value of current passing through them

7.3.2 Operation and maintenance

O&M: difficulties

In the past programs, the distribution of the system was carried out by the suppliers, even to the very remote areas and the suppliers were working together with their partner in the Provincial region to execute the projects.

Since the deployment schemes of SHS from the government were free, it was difficult to handle the maintenance of the systems. There was a lack of management in the area: who will look after the systems. Therefore, some of the suppliers were encouraging the villager to establish an operation management. This operation management has been used by the suppliers as a contact institution to send some spare parts, and monitor sustainability of the systems.

O&M: technical instructions

Operation:

Generally speaking, the output of the system is closely linked to the operating temperature and will decrease as the temperature increase.

For example, the batteries have an optimal functioning at 25 °C and every 8°C rise in temperature will cut the battery lifespan in half. Consequently, **it is very important to ensure a good ventilation of the battery box** as explained in the previous part.

Similarly, the power of the panel will decrease as the temperature rises: - 0.35 %/°C

Maintenance:

Operation and maintenance are quite simple but very important. Indeed, it has often been the weak point of the system due to a lack of money or knowhow. Ideally, the following tasks must be performed:

- For the PV module, it is very important to **clean the modules** and the area (high grass, trees). Indeed, a shadowed or dirty module doesn't produce current anymore It is also relevant to check the wiring and the structure.
- At the battery level, **electrolyte level control** and distilled water addition if necessary (in case of open batteries), boost charge, control of the wiring.

With a correct and efficient operation and maintenance organisation, components lifespan can be extend and reach the following values:

- Batteries' lifespan can be estimated **around 5 years**. As said before, the smaller the temperature of use is, the longer the battery will last. Moreover, the lifespan is also function of the degree of discharge. When deeply discharged, the battery will bear fewer cycles.
- PV module and structure can run for **25 to 30 years**.
- BCR: it depends of the quality and technology but a lifespan **between 5 to 10 years** can be expected.

Periodicity

PV

Weekly	Visual check
Monthly	Check the modules: solidity,cleanness (if needed, clean with water without soap)
Yearly	A detailed inspection of the installation is highly recommended. One day of detailed measures, controls, tightening of the screws and testing, done by a technician

Table 10: Maintenance of the PV modules

Batteries

Every 3 months	Check the electrolyte level. If refill is needed, only put de-ionized water to reach the max of each element.
Yearly	Check the wiring

Table 11: Maintenance of the batteries

O&M: organizational instructions

Availability of skilled technicians

Even more than in the case of installation of the system, having well-trained technicians on the field is a major issue. As a matter of fact, during most projects, dedicated teams installed the system in a remote area and then returned back to an urban centre, sometimes hundreds of kilometres away while nobody stood close to the system. In a defect case, the cost of repair was so high that the system was never repaired and failed forever. This damaged twice the renewable energy projects:

- First because the project failed
- Second because renewable energy were known as poorly reliable while they are more reliable than casual diesel generators if run properly.

To ensure the success of the project, training a network of skilled technicians is a high priority.

Who will be the skilled technicians?

Ideally, the idea would be to have service centres for maintenance. But this system is too costly as in this rural isolated areas, the population density is very low so technicians will spend to much time and money to reach beneficiaries.

The second option is to have decentralized training centres. It this case, there are two possibilities:

- Train clients for maintenance

If end-users are trained for maintenance, they might be educated as well to the usage of their renewable energy system. A designed manual, including specific needs for non-literate populations, could be given to every beneficiary. Then, the trained client can spread its knowledge to the others beneficiaries of its village. **This is the idea of implement training centres to train trainers who will then train villagers**. Such experiences have shown that population are more implied as trainings on the field are ran by one of them. Moreover interventions of current users of the system are very helpful during training sessions.

- Support microentrepreneurs for installation and maintenance

In order to lower maintenance costs, in the particular case of SHS, a network of microentrepreneurs specially trained might be a very good option. These microentrepreneurs will retail spare parts and ensure basic maintenance with the main advantage of being located very close to the end-user. Moreover, as they will have their own microenterprise, they might have another activity ensuring as well a correct income for them and their family.
These technicians may be in charge of collecting instalment for MFI as well.
In this perspective, there is also a need to develop **training centres** for these microentrepreneurs, **at district level**.

Here are two examples of training centres that have been put in place in Bangladesh:

Case study: Experience of PSL as trainer in Bangladesh
A major training program on solar electrification is offered by PSL for the past 10 years from the private sector of Bangladesh. Following the inception of the national solar program, IDCOL has used PSL's qualified technical training experience. Other government agencies like LGED, REB have also used the training expertise of PSL at various times. Typical training of PSL include multiple topics that cover the range of operational requirements for SHS and other solar applications.

Solar training program of PSL constitute of:

(1) Training on project management

(2) Training of trainers and technicians

(3) Training of consumers.

Technical Training of PSL include :
- *Basics of PV system design and sizing.*
- *Wiring procedure for SHS*
- *Proper SHS Installation, wiring and grounding*
- *Indicators of a charge controller*
- *Capacity and limitations of PV system components*
- *Minimization of line loss in a 12 V SHS.*
- *Knowledge and practice of safety rules*
- *Understanding basic operation, capacity and limitations of batteries used in solar electrification*
- *How to measure specific gravity of acid solution*
- *How to measure voltage and current in batteries*
- *Evaluating condition of battery and steps to be taken for correction*

- *Maintenance and inspection of SHS.*
- *System trouble shooting*

Consumer training at the premises of the consumers include:
- *Basic care and maintenance of the SHS*
- *Function of each components of a SHS, eg. solar module, battery, charge regulator and appliances.*
- *Understanding the benefits, limitations and design of a SHS.*
- *Function of a charge regulator and understanding the display signals.*
- *Basic care for SHS battery with refill of distilled water.*
- *Safety and environmental issues related to battery usage.*
- *Impact of shading on the performance of solar modules.*
- *Potential damage to SHS caused by additional loads.*
- *How to use autonomy of a SHS for rainy days without damaging system.*
- *Warranty of parts and labour in purchasing a SHS.*
- *Financial commitment and liabilities with contractual agreements.*
- *Monthly instalment collection scheme.*
- *Reporting system malfunction to the sales and service providers*

Figure 9: Experience of PSL as a trainer in Bangladesh.

A larger experience : Grameen Shakti – since 2007

Grameen Shakti has 370 unit offices and 21 operational GTCs (Grameen Technology Centers) in Bangladesh. Grameen Shakti has plans to establish a total of 30 Grameen Technology Centers to provide training to rural women on renewable energy technology. It is expected that these centres will serve as a tool for poverty alleviation of rural women. The plan is to initially train 1000 rural women on maintenance of solar home systems and other electronic equipment like mobile phones and other related accessories. It is anticipated that the GTCs will create employment opportunities to the rural communities.

GS also plans to train 5000 female household members using solar home systems. Such training will ensure proper use and maintenance of the systems within the households and provide an opportunity for the rural women to make an earning. The GTCs have also created women technicians for construction of improved stoves that require less biofuel.
Some of the trained women are engaged in maintenance of solar home systems and improved cook stoves, while others do marketing and assembly of accessories for the solar homes.

All GTCs are managed by women, and they also contribute to awareness building for solar power. GTCs and unit offices provide training among customers. They also provide training to school going children (children of classes 9-10). The teachers are also present on those training programs.

Figure 10: Experience of GS as a trainer in Bangladesh

➔ As for maintenance, trainings of both technician and end-users must be included in the project planning and therefore budgeted.

O&M structure for community systems

In case of PV hybrid systems being implemented, it is very important to have a clear and efficient organizational framework for implementation and maintenance. This is compulsory to ensure the sustainability of the system. Hereafter is a general scheme of the framework (“C “means actors are contractually linked):

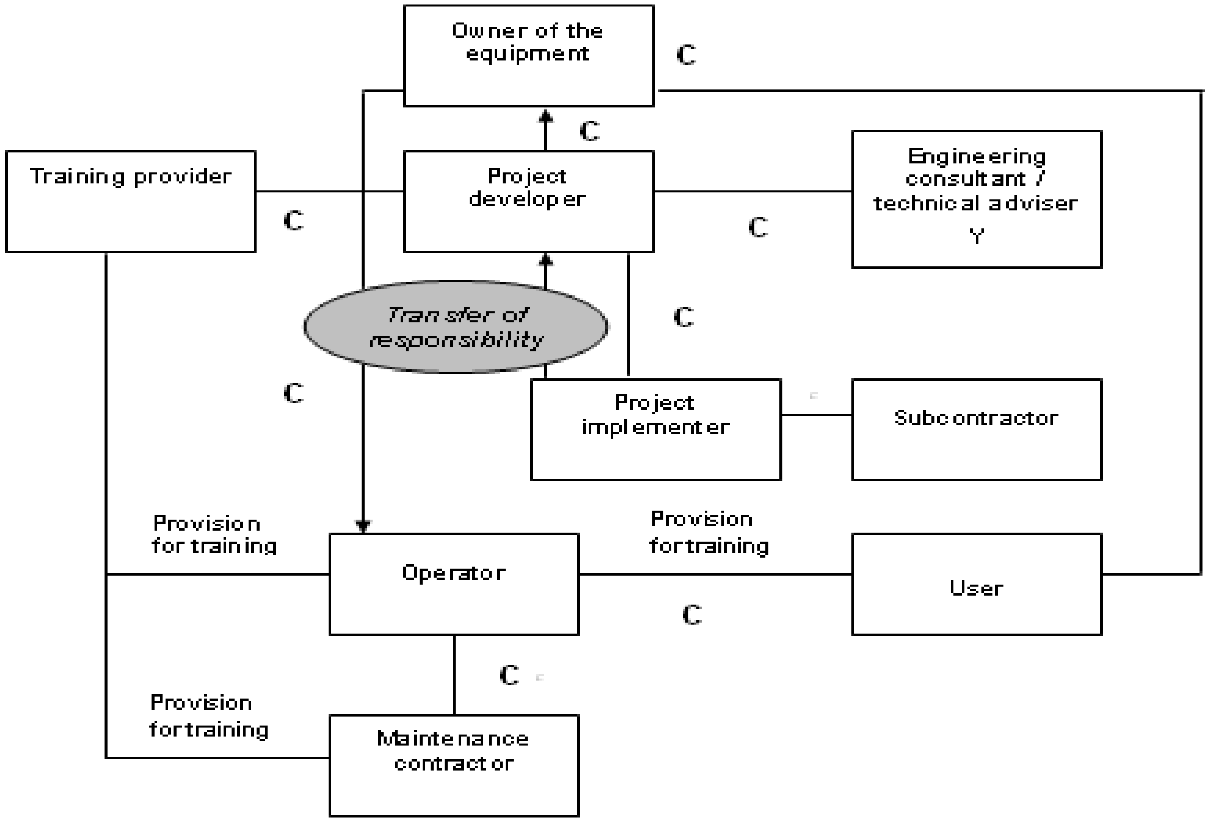


Figure 11: Organizational framework for a community system[8]

7.4 Social sustainability

The adopted financial model can only be sustainable if it is well understood and taken up by target populations. **Technologies and financial products offered to them have to be socially and culturally adapted and accepted**. Feasibility studies for REN projects should therefore always include social issues. Provision of **awareness and training sessions on renewable energy benefits and limitations, and on microfinance opportunities and requirements** may also be helpful in this sense.

7.5 Environmental sustainability

Solar energy is by definition a renewable energy which is not concerned with worries about natural resource exhaustion. On the contrary, solar energy holds the promise of having a positive impact on the environment by reducing the use of fossil fuel and thus the emission of greenhouse gases.
However, when promoting access to solar energy equipment, one environmental issue should still be considered: **material waste management**. Batteries, in particular, can be highly polluting components if they are thrown away improperly after expiration of their life duration. A national solar energy program should therefore include measures to ensure the **collection and recycling of used batteries** throughout the country and raise awareness of the target populations on this issue.
Here again, the Bangladesh ICDOL model sets a good example as it has made battery recycling mandatory. Battery manufacturers pay salvage value (estimated value of an asset

[8] *Generic Guidelines for Decentralised Electricity Service Operators,* DOSBE project, IEE Coopener program, 2008

at the end of its useful life) to MFIs within 45 days of battery collection in the collection point, and no new battery will be sold without collecting the older one. These processes constitute good incentives to ensure proper collecting and recycling of batteries.

Next steps for Indonesia:

Identify the measures to be taken to ensure the institutional, financial, technical, social and environmental sustainability of the national solar energy program.

Do not postpone the design and implementation of such measures to a second phase but include them from the early stages of program design and implementation.

8 Going beyond solar energy access financing

Main ideas:

The role that adequate financial services can play in link with rural electrification goes beyond financing the mere access to solar energy technologies.

Appropriate financial services can also be promoted to:

1) support the development of REN suppliers' activities in Indonesia
2) take advantage of the opportunities created by rural electrification and support the development of income-generating activities in rural areas.

8.1 Supporting the REN supply side

Financing facilities should also cover the 'supply side' of the PV business chain. It should provide dedicated vendors, system integrators, local component manufacturers and after-sales service providers with means to make their operations viable and worthwhile to sustain.

Up to now, in Indonesia, the REN supply side has not been able to develop its activities due to the market distortion induced by past government fully-subsidized programs and the lack of access to financial services.

Yet, supporting the supply side would bring various benefits:

- Increased working capital will enable REN suppliers to adequately **respond to increasing demand** and to offer 12 or 24 month credit schemes (which will be better adapted for market development).
- Developing the REN sector will **create job opportunities and support local development**. Local technicians can for example develop their own business as maintenance service providers.
- Supporting the development of local businesses for REN **maintenance and repair** will contribute to **enhancing the technical sustainability** of the solar energy equipment and thereby reduce credit risk.
- Development of a commercial REN sector, with an increased competition between suppliers and eventually a local production of material, can enable economies of scale, optimize operating costs of the industry, and thus **decrease the cost of solar energy equipment** while still ensuring that quality is produced.

In order to support the development of adapted financial products for REN suppliers, it may be necessary, in a first time, to set up specific credit lines and/or guarantee schemes.

8.2 Leveraging electrification benefits by supporting the development of income-generating opportunities in rural areas

A REN program brings electricity to remote, rural areas. Beyond increasing standards of living, **electrification also create new opportunities for income-generating activities**.

Thanks to extended hours of business activities, electrification first enables microentrepreneurs to increase their existing activities (handicraft, night markets, night activities such as those linked to beauty care, etc.).

Second, electrification brings the opportunity to add value to existing agricultural productions, by enabling the use of upgraded technologies for transformation and conservation activities for instance (e.g. through the use of multifunctional platforms or cold generators).

And third, electrification can create opportunities for new businesses. In the particular case of Solar Home System, RENDEV has identified that the following activities could be developed: mobile phone charging station, community TV, TV and radio as marketing tools for restaurants, etc.

Microfinance can have a strong role to play in villages that gain access to solar electricity **by helping people take advantage of these new business opportunities**. Beyond the mere access to electricity, it is the whole local economy that can be fostered.

Furthermore, if people see that their current activities (agriculture, livestock, transformation and conservation, handicraft) can gain from access to electricity, they will be more likely to invest in REN technologies and they will pay greater attention to the good care and maintenance of their equipment. Demonstrating the clear economic benefits of electrification is thus important to ensure the success of a national solar energy program.

Opportunities should therefore be identified by the national program and promoted during awareness raising campaign and end-user training, in order to deepen the impact of the program on the rural economy by generating additional sources of income for the communities. The **development of microfinance services in remote, rural areas should be strongly promoted** in this perspective.

Next steps for Indonesia:

Promote the development of financial services that will support the development of REN suppliers' activities.

Support the development of microfinance services in rural areas in order to help rural populations take advantage of the new business opportunities brought by electrification.

9 Conclusion

9.1 Main recommendations:

Rural electrification is still an acute problem in Indonesia: 70 to 90 million inhabitants, most of them living in rural areas, still lack access to electricity in the country. Renewable energy, and solar energy in particular, has been identified as a solution with a high potential for the electrification of remote rural areas, and ambitious targets have been set up by the Government to promote REN technologies.

In the past decades, the GoI has implemented various programs to promote solar energy access. However, these programs were based on financial models that were not adequate enough, and their weaknesses prevented the successful expansion of solar energy technologies in the country.

Throughout the RENDEV project, various studies have been done to review the strengths and weaknesses of Indonesian and Bangladeshi solar energy experiences, to identify the needs and markets for REN technologies, and to assess the potential role of microfinance institutions in both countries.

Building on the findings of all these studies, RENDEV recommends two different financial models that would be adequate for promoting solar energy access in Indonesia:

- SCENARIO 1: Replicate the successful Bangladeshi IDCOL model, adapting it to the Indonesian context. In this model, microfinance institutions have a major role to play in facilitating solar energy access by offering adapted financial products (credit schemes). To do so, they will need strong financial and technical support.
- SCENARIO 2: To reach poorer populations, improve the Indonesian social pay-for-service model. In this model, MFIs will not play a direct role in financing solar energy access, but they can be mobilised to facilitate fee collection and stimulate local development of rural areas in link with electrification.

These models should first be tested at a small-scale (in one selected province for instance), through a pilot program, before scaling up can be planned at the country level.

To design an effective national solar energy program on the basis on these financial models, RENDEV further provides the following recommendations:

- An adequate subsidy policy should be designed in order to bridge the gap between the full cost of the solar technologies and the willingness and capacity to pay of the populations. This subsidy policy should be long term, universal, carefully designed and adjusted to the varying willingness and capacity to pay of target populations according to areas' characteristics and equipment types.
- It is essential to identify relevant Indonesian and international actors and to specify their respective responsibilities within the financial schemes. Indeed, all actors should be aware of and clear about their role and responsibilities. Transparency, coordination and communication will be essential to the success of the program.
- A successful national solar energy program is one that will be stable and operating in the medium and long term in order to effectively reach a significant population. In this aim, the sustainability of the financial model should be ensured at various levels: institutional, financial, technical, social and environmental.
- It is important to keep in mind that the role that adequate financial services can play in link with rural electrification goes beyond financing the mere access to solar energy technologies. Appropriate financial services can also be promoted to support the

development of REN suppliers' activities in Indonesia and to help rural populations take advantage of the new business opportunities created by electrification.

9.2 Action plan:

- Identify with all stakeholders what are the aspects of the current solar energy policies and programmes that should be changed or improved.
- Learn from IDCOL experience in Bangladesh: exchange visits, trainings, etc.
- Review market segmentation for solar energy access and assess with all stakeholders which recommended financial model (SCENARIO 1: IDCOL model; or SCENARIO 2: social pay-for-service model) is most adapted to which population segment. Agree on adequate financial schemes for solar energy access, with a long-term vision.
- Adapt IDCOL financial model to the Indonesian context, by designing a subsidy policy, defining microfinance products and specifying actors' roles according to the particular national context.
- For the poorer population segment, improve the existing social pay-for-service program to overcome its past weaknesses.
- Test the different financial models at a small-scale first, through a pilot program in areas with the most potential for success (one selected province for instance).
- Identify the willingness and capacity to pay of target populations thanks to disaggregated, updated market studies
- In collaboration with all stakeholders, define the optimal subsidy policy on the basis of target populations' willingness and capacity to pay, REN services provision costs and available budget. Define subsidy matrixes to adjust the subsidy level according to areas and types of equipment.
- Under scenario 1, encourage national and local MFIs to identify the financial products and contracts for solar energy access that would best suit the Indonesian context, taking into account the measures necessary to reduce credit risk.
- Under scenario 1, identify the modalities of implementation of a revolving fund for MFIs and the potential opportunities of financing.
- Under scenario 2, assess how existing microfinance providers' networks can be associated for facilitating fee collection.
- Identify the actors involved in the financial schemes, and clearly define with them their respective roles and responsibilities. Identify the needs for financial resources and capacity-building of each stakeholder within the schemes and the solutions to answer these needs.
- Identify the measures to be taken to ensure the institutional, financial, technical, social and environmental sustainability of the national solar energy program. Do not postpone the design and implementation of such measures to a second phase but include them from the early stages of program design and implementation.
- Promote the development of financial services that will support the development of REN suppliers' activities.
- Support the development of microfinance services in rural areas in order to help rural populations take advantage of the new business opportunities brought by electrification.

Appendix[9]

International standards related to solar technologies

PV module

- Photovoltaic modules should meet the specifications of IEC 61215.
- Photovoltaic cells should be in crystalline silicon.
- The number of cells per module should be at least 36 for a rated voltage of 12V.
- The polarity of the terminals of the module should be clearly identified.
- The nominal power of a module should be between 20 and 80 Wp.

Each module must have a plate providing the following information:

- Brand
- Model
- Type
- Serial Number
- Peak power (IEC 61215)
- Voc, Isc, Vpmax, Ipmax
- Identification of terminals + and –
- Security Information
- Indications of compliance with specific standards

Batteries

- Rated voltage of the battery: 12 V
- Nominal capacity for solar batteries (flat plates or tubular) given for two regimes of discharge (C10, or 10h with stopping threshold equal to 1.8 V and C100, or 100h with arrest threshold to 1.85 V / item). [Note: The procedure for the analysis of initial capacity is specified in IEC 61427].
- Resistance to cycling at least 1200 cycles to a depth of discharge of 20% and at least 250 cycles to a depth of discharge of 60%.
- Duration of life of the battery must be superior to 3 years.
- Self Discharge: <5% / month at 25 °C

As for the module, each battery should have a plate with the following information:

- Brand
- Battery model
- Type of battery
- Nominal voltage
- The nominal capacity to C20 or C10 and C100 according to the type of battery,
- Nominal density when battery is fully charged (for opened batteries)
- For opened batteries, the minimum and maximum levels of electrolyte must be stated. The electrolyte level should be visible (translucent trays).
- Indication of the type of alloy grids (Lead - Lead or Antimony - Calcium)
- Identification of terminals + and -

[9] *Activity 13 - Best practices in PV hybrid project design,* IEA PVPS task 11 - PV Hybrids and Mini Grids, Transénergie 2009

- Security information
- Indications of conformity to standards

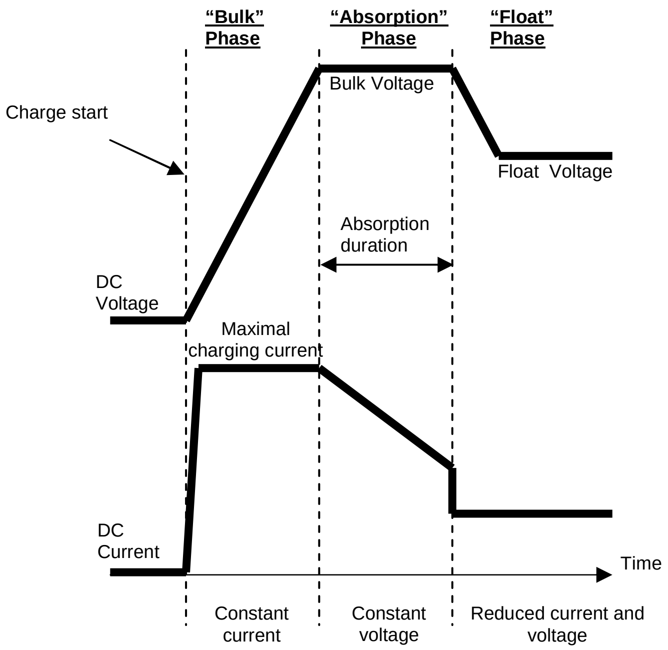
BCR

Electrical parameters

- Rated voltage: 12 V
- Input current and maximum output: 12A
- Parasite consumption of regulator <10 mA at a voltage of 12V nominal
- Maximum voltage drop across the regulator for the maximum current = 0.7 V between the solar panel and battery output (non-return diode included) with no use output and 0.3 V between the battery and the output use when solar panel isn't producing.

Load regulation

- Management of the recharge (see detailed scheme hereafter): bulk phase - absorption phase - floating phase (with or without Pulse Width Modulation) - boost charge phase.



- The type of management of the recharge is not imposed but with the previous algorithm, the service will be provided for three years at least.

Threshold voltage

It is necessary to define absolute minimum and maximum threshold voltages. The thresholds of regulation will be retained within the defined range. The thresholds can be adjusted or variable, but shall in no case exceed the extreme value.

Minimum threshold	maximum threshold

11.4V	15.6V

The threshold given values must be accurate to within 1%. Temperature compensation from -4 to -5 mV / °C element may be applied to the end of charge threshold. A delay of 3 to 30s will be applied to the load shedding threshold voltage after discharge limitation has been reached.

Protection against overvoltage

The regulator should be protected from destruction if a voltage of 1.25 times the nominal open circuit voltage of photovoltaic module is used as input (battery disconnected). It should also have a limitation of the output voltage to 15.6 V when battery is disconnected and photovoltaic module is connected.

The regulator should also be protected against inversion of battery or solar panel's polarity, and against transient overvoltage.

Protection against overloads

The regulator should also be protected against input and output short circuits: electronic protection (no fuse) or circuit breaker than can be reengaged by the user (compatible with IEC 947-2).
NB: A fuse will be placed on the battery / regulator liaison and coordination of protection should be done to ensure that the separation of use is prior to the merger of the battery fuse (fuses and circuit breaker with IEC 62124 and IEC 60364 -7-712).

Building recommendations

There should be a tropicalization of printed circuits (treatment for protection against heat and humidity) according to IEC 61086 recommendations, a degree of protection of the box minimum IP 32, and connectors and cables section suitable for the current.

Electromagnetic Interference

The regulator should not be a source of conducted or radiated electromagnetic interference with radio receivers located in more than a meter away. Typically, for a range of 0.1 kHz to 10 MHz, the field value should be less than 100 µV / m at 1 m from the regulator.

Functional directions

The operation of the system should be visible from the outside to help the user in his management of energy. There should be a user interface with at least signal lights associated with icons, for example:

- Green LED: battery charging
- Green LED: battery fully charged
- Orange LED: low voltage alarm
- Red LED: discharged battery, disconnected use
- Red LED: fault (polarity reverse, overload)

Marking

Each regulator should have provided a mark with the following information:

- Mark
- Model
- Type
- Serial Number
- Nominal voltage
- Maximum admissible current
- Maximum admissible voltage
- Threshold voltage
- Type of load algorithm
- Identification of terminals + and - at the PV entrance, at the battery and at the output
- Security information
- Indications of compliance with appropriate standards

PV module support structure

The modules are assembled on the supporting structures, which must then be set at the most appropriate place. The structures should meet the criteria listed below.

- These assembly structures and module support should be made in corrosion-resistant material, preferably aluminium or stainless steel, with a lifespan greater than or equal to 15 years (see IEC 60815).
- No risk of corrosion by electrolytic couple should exist between the structure and the module.
- All mounting and assembly hardware of the module on the structure on the one hand and of the structure on the building on the other hand should be in stainless material. It should also include device to limit the possible theft of modules (special screws with complex head for example).
- The supporting structures should be able to withstand winds of 120 km / h.
- The angle from the horizontal should be 15 °.
- The structure should be designed to be fixed either on the terrace or in front.

Battery box

The battery box could contain both batteries and electronics devices, and is locked so that the components are not accessible by users. It should meet the following criteria:

- *Volume*: the box should, in addition to electronics, be large enough for a second identical set of batteries to allow the scalability of the system.
- *Material*: the box must be made with material resistant to flame, acid and ultra-violet rays.
- *Ventilation*: the box has two openings, one at the bottom and the other on the top to evacuate the exhaust products at the end of charge (at least 1 cm2 per kWh capacity). The holes should be fitted with grid strainer to prevent the penetration of insects (minimum IP24 protection).
- *Layout*: the box is equipped with a lid fitted with an anti-crime closure or with a closure that can be condemned by the operator. The regulator is placed in a watertight compartment adjacent to the box or included in the box, with inaccessibility of electrical wiring.

Wiring

PV systems should be provided with all the cables adapted and sized for their optimal operation.

Cables

The maximum voltage drop allowed in the cables, which corresponds to the maximum current, should be limited to 3% between the solar panel and the regulator and 1% between the regulator and batteries. Accordingly, here are some standard lengths:

- PV module <-> controller = 10 m,
- Controller <-> battery: <0.5 m.

The connection between solar panel and battery box must be made from flexible cable, resistant to ultraviolet radiation and with a double insulation (type HO7RNF) and complying with IEC 60811.

NB: A fuse protection will be placed on the route battery / regulator.

Connectors

The connectors should have good mechanical strength and low electrical resistance causing a voltage drop of less than 0.5% of the rated voltage for maximum current. They should tolerate at least 150% of the maximum value of current passing through them.

Ministry of Transmigration and Forest Squatter Resettlement

Notes and References

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