Japan International Cooperation Agency

Strategic Review of Photovoltaic Rural Electrification Projects

Summary Report

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1. Lessons learned from JICA's projects

1) JICA's PV-based rural electrification projects

Since the late 1980s, Japan International Cooperation Agency (JICA) has carried out ten PV-based rural electrification studies in developing countries. Pilot projects that employed Solar Home Systems and Battery Charging Stations were undertaken in seven studies. (See Table 1) Those pilot projects aimed to demonstrate the viability of technical, financial and organizational issues that were viewed relevant to the long-term sustainability of PV systems in remote areas. This review is intended to identify good practices of PV delivery models in developing countries, and to propose necessary actions to accelerate the application of PV technology for rural electrification.

Table 1 JICA's PV-based rural electrification studies

Country	Period	Project Title	PV technology employed in pilot project
Indonesia	March 1989 – June 1993	The Study on utilization of Photovoltaic Hybrid Systems in Rural Areas in the Republic of Indonesia	PV/diesel and PV/hydro hybrid with mini-grid
Kiribati	March 1992 – February 1994	Study of Utilization of Photovoltaics for Rural Electrification	SHS
Syria	December 1995 – February 2001	The Study for the Introduction of Integrated Photovoltaic System into the Syrian Arab Republic	SHS, PV-minigrid
Morocco	March 1996 – January 1998	Master Plan Study on Decentralized Rural Electrification on Haouz Region in Kingdom of Morocco	(no pilot project)
Zimbabwe	February 1997 – February 1999	The Study on the Promotion of Photovoltaic Rural Electrification in the Republic of Zimbabwe	SHS
Lao PDR	September 1998 –December 2000	The Study on Rural Electrification Project by Renewable Energy in the Lao People's Democratic Republic	SHS, BCS
Mongolia	October 1998 – August 2000	Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia	PV/wind hybrid
Bolivia	August 1999 – September 2001	Rural Electrification Implementation Plan by Renewable Energy	SHS
Senegal	December 1999 – February 2002	The Study on Photovoltaic Rural Electrification Plan	SHS
Botswana	September 2000 – February 2003	The Study on the Photovoltaic Rural Electrification in the Republic of Botswana	SHS, BCS

2) Good practices

The survery team visited JICA's pilot project sites in the Lao PDR (Laos) and Botswana where a number of Solar Home Systems and Battery Charging Stations were installed. In Laos, a "Sales Model", or "Hire-purchase contract", was employed for delivering SHS. On the other hand, a "Service Model", or "Fee-for-service contract", was employed in Botswana. The team identified the following good practices that may be valuable for future PV-based rural electrification projects.

- Accumulated knowledge on battery use in village

With the background of widely spread automobile battery use for lights and electrical appliances in Laos, rural villagers can quickly learn about the operation and maintenance of Solar Home Systems. The pilot village people can maintain batteries without support from outside, which results in lower operation cost on the side of SHS dealers. In contrast, there were few people in the pilot villages in Botswana who had experience of automobile battery use before the JICA pilot project. Therefore, the service provider needed to maintain SHS components regularly, which pushed up their operation cost. The pilot villagers ended up with relatively high monthly charge and many users canceled the service after a short period.

- Battery replacement by users

In Laos, the SHS users are responsible for battery replacement under the hire-purchase contract. Therefore, they take care of their batteries to use them as long as possible and SHS venders are free from regular maintenance work. If a fee-for-service is employed, the users do not pay attention to the condition of batteries and demand good maintenance of batteries by service providers. As a result, the service providers need to use expensive long-life batteries and conduct regular maintenance, which increase their operation cost.

- Tariff design to test customer's affordability

A down payment that is equal to the price of standard automobile battery is required in the SHS hire-purchase contract in Laos. With this, only those who can pay for new batteries will apply for SHS. Thus the SHS dealers can secure good customers who can keep using SHS for a long time.

- Preparation for grid extension

In the pilot project in Laos, Battery Charging Stations have a modular design. For example, a 3kW BCS has three 1kW units. This allows easy capacity increase by adding a new module and also, easy dismantling and relocation. Actually, one BCS was relocated after the grid reached the BCS pilot village. Thus, measures to prepare for the grid to arrive should be incorporated in the business plan of PV electrification to achieve long-term success.

- Development of local agents

Both in Laos and Botswana, there are designated local agents in the pilot projects who collect monthly charges and provide advice to the users. With frequent contacts with the users by the local agents, the SHS venders can improve their services, and also reduce their operation costs. Capacity development of local agents is a key to success in PV business in remote areas.

- Use of World Bank loan for initial investment

After the JICA pilot project in Laos, the World Bank/GEF and the Government of Laos are undertaking a large-scale PV-based rural electrification project. The World Bank/GEF project is intended to develop regional ESCOs that deliver SHS with a 10-year hire-purchase contract. The Government of Laos pays initial investment using a long-term low-interest loan from the World Bank. The users are requested to pay back the first cost over ten-year period to the Government through ESCO. And ESCOs are free from the risk of default.

- Rule setting by users on utilization of battery charging station

The users of battery charging stations decided the rules of utilizing the stations by themselves. They resolve problems and complaints in the village. Management by villagers has been going well and the service providers are free from operational work.

Other issues identified in the site survey are as follows:

- Use of mobile phones for communication leading to reduction of transportation
- Use of prepaid card system (in Botswana) for reducing fee collection cost
- Battery recycling
- Income generation by extended work hours under lighting

- Revolving fund development (in Laos) by fees from users
- Development of service technicians with assistance from donor

Overall, at the pilot villages both in Laos and Botswana, it was revealed that solar systems were well received by the local people. The next step is to promote the penetration of solar systems into rural areas based on a well-defined strategy.

2) Issues fordissemination of PV-based rural electrification

In Laos, PV systems installed during the JICA pilot project have been in fairly good condition and the number of PV users in the pilot villages is still increasing. It can be said that the sustainability of pilot PV systems has been achieved. However, there are some difficulties to spread PV systems into other remote villages.

- Lack of delivery models for low-income segment

For SHS, users are requested to pay $20 to $50 for down payment and battery replacement. As a result, limited people who can pay that amount are only eligible for SHS. There are no PV delivery models for those who cannot afford the down payment.

- More cost reduction effort required

There is room for cost reduction of PV components, PV modules in particular. The government and dealers are expected to do more such as bulk purchase and tax exemption to cut the cost of PV components.

- Weak financial background of ESCOs

ESCOs that sell SHS with a hire-purchase contract have limited financial capability. Their capital is small and they pursue a short payback period. Securing financial assistance to help ESCOs is very important.

- Shortage of human resources in remote areas

It is important to utilize local human resources as much as possible to reduce operation cost of dealers. However, it is often difficult to find such a person who knows well about PV systems in remote villages. Therefore, capacity development of village leaders and local authorities is essential to facilitate PV-based rural electrification.

- Measures to cope with failure of charge controllers

Except for charge controllers, PV system components are basically durable and require no major maintenance. When a controller fails, there is no quick repair method. It is necessary to develop appropriate low-cost and easy repair method of charge controllers suitable for remote areas.

2. Prerequisites of PV electrification business development

It becomes clear that rural villagers are willing to pay for PV electricity more than we expect because their needs are very strong. PV system cost, however, is still high, $500 for a standard 50Wp SHS, and cash sales are difficult for most villagers. Things are not straightforward. Our goal is to develop a profitable and replicable PV system delivery model targeting low-income rural villagers. Also, we need to secure the sustainability of installed PV systems in remote areas. We need to understand the following aspects before developing business models of PV electrification.

1) Organizational structure

Utilities are not major players in this business. They have no knowledge or experience in PV systems. Their overhead cost is high. It is not recommended for utility companies to get involved in PV electrification. There is no synergy effect between conventional power supply business and PV electrification. Rather, simplicity of PV technology and relatively small capital requirement provide opportunities to small-scale local companies. A fundamental difficulty in doing this business is that profit margin is very small per customer, and therefore, a large customer base is necessary to run the business. It takes long to gain many customers and go break-even. During the long start-up period, the government and donor agencies should help the local companies by undertaking measures such as provision of financial assistance, or conducting campaign and staff training.

2) Customer profile

The potential customers of PV systems live in remote inaccessible villages. Their income is small and knowledge about electricity is limited. However, they pay for kerosene and often use automotive batteries for lights and other appliances. They are eager to improve their life. They have strong demand for electricity and ready to pay some money for electricity supply. It can be said that underlying opportunities for PV are big and the potential PV market can be captured if viable business plans that meet the need of users are employed.

3) Technology and cost

It is always important to consider “easy to finance, easy to build and easy to operate” systems in case of rural electrification. In particular, the priority issue is to make maintenance work simple and easy so that inexperienced rural villagers can operate and maintain PV systems properly.

PV system components are simple; PV modules, charge controllers, batteries, lights and appliances. Among them, the most expensive component is PV module. Its market price ranges from $5/Wp to $6/Wp. The demand for PV modules is increasing worldwide so that the market price of PV module is slightly rising recently. As for batteries, there are two types; automotive batteries and solar (deep-cycle) batteries. Automotive batteries are widely used in rural electrification projects because of lower price and high availability. Solar batteries are selected when reliable electricity supply is pursued.

4) Nature of PV electrification business

PV electrification business is important for developing countries. However, there is no proven success model, which makes the PV business development really challenging. It would be necessary to develop the business in two stages. The first stage is to achieve the sustainability of business. In other words, at the early stage of PV electrification business, PV systems in remote villages must be operated without special assistance from outside both technically and financially. After achieving the “sustainability”, the business model must be applied into many other villages. Regardless of differences in the conditions of villages, the business model should work well. At this second stage, the business becomes “replicable”, which is the ultimate goal of PV electrification business development.

3. Approaches for PV electrification

1) Business model development

（1）Solar Home System

Solar Home System (SHS) is a popular model of PV application in rural electrification. Basically, lamps and TV tend to be used at night with SHS. The standard SHS has a 50Wp PV module with a charge controller and battery, and costs around $500.

The recommended business model for delivering SHS to rural villagers is the “Sales model”, or “Hire-purchase contract”. With the Sales model, PV dealers or ESCOs can save service and maintenance costs by making the users share the maintenance work. And therefore they can reduce the amount of monthly payment. The quality of electronic charge controllers has been improved significantly, enabling easy handling (almost maintenance-free) and reliable operation of solar systems. In this business model, user training is important and must be incorporated into the business plan. On the other hand, with the “Service-model”, or “Fee-for-service contract”, PV dealers are requested to provide good-quality electricity supply services, which require frequent visits to the site for maintenance. They tend to use expensive solar batteries to keep the battery life long. All these factors push up their direct and overhead costs, and the monthly recharge must be raised accordingly. The Service model is appropriate for the customers who are willing to pay some money for good quality electricity.

（2）Battery Charging Station

Battery Charging Station (BCS) has not been highly evaluated, because it is less advanced than Solar Home System. Transporting batteries to BCS is cumbersome. However, investment for BCS per customer is smaller than that for SHS. Hence, BCS may be able to provide battery-charging service with a smaller fee compared with SHS, which will benefit those who cannot afford SHS. The BCS units built in the JICA pilot project in Laos have been operating very well and the users are satisfied. It is strongly recommended to review the advantages of BCS that will benefit the low-income segment. A major risk of BCS is overestimation of demand. If the initial capacity is too big and has a big idle capacity for a long time, the bottom line is in the red and the BCS will stop operation. It is necessary to build small-size plants in steps to meet the growing demand. Therefore, a modular design, 1kW BCS for example, is recommended.

BCS can be relocated easily when a grid extension plan is decided upon.

Also, the idea of BCS can be applied when PV systems are installed at public facilities such as schools or clinics. When PV modules have enough capacity, it is recommended to add battery chargers. The villages will benefit from getting lights and improved life. And the facilities can get income from battery charging that can be used for supplementing the management budget. This is a win-win situation.

2) Recommendations to JICA

- Use the pilot project in Laos as reference

Among the seven PV-based rural electrification projects carried out by JICA, the pilot project implemented in Laos is very successful leading to a subsequent large-scale PV project by the World Bank/GEF. The World Bank/GEF project that is currently underway focuses on the development of private companies (ESCOs), which is also going well. Both projects employed "Hire-purchase contract". These JICA-GEF/WB projects in Laos are considered to be a model that went through the three stages step by step, i.e., "formulation of development model" (JICA), "demonstration of sustainable business model" (JICA) and "demonstration of replicable delivery mechanism by private sector" (WB/GEF). JICA is recommended to fully review the pilot project and share the achievement with other development partners such as the GEF and the World Bank, and also disseminate the lessons of experience in future PV projects in other developing countries.

- Muti-sector project formulation

It is important to recognize that PV-based rural electrification not only provides electricity but also increases the social benefits of people and community in remote areas. This aspect should be properly addressed and taken into consideration to develop multi-sector projects. For example, education, health or water supply will be improved after PV-based electrification. JICA is recommended to take this into account and formulate rural electrification projects with an emphasis on the improvement of community life. Also, it is important to note that adding PV components to social development initiatives will enhance the total value of project. PV can contribute to reducing poverty and improving the human condition by promoting income generating activities and supplying electricity to social/public facilities such as schools, clinics, water pumps, telecommunications and so forth. In order to promote the utilization of PV, it is crucial to coordinate all the parties concerned, i.e., ministries, departments and central-local governments, so that sectoral barriers can be removed and collaborative implementing machinery across sectors can be established.

- Program approach

Along with the building and upgrading of public infrastructures such as roads, bridges, airports and environmental conservation projects, the Japan's grant aid gives priority in particular to projects that meet the basic human needs (BHN) such as education, medical care, public health, domestic water supply, rural and agricultural development, and human resources development. This indicates great possibilities of PV-based rural electrification to be implemented under the grant aid program. For example, under the General Grant Aid program PV application for water pumping and medical care equipment have been implemented. Therefore, adding BCS functions to such PV facilities may be easy. Under the Non-project Grant Assistance program, PV equipment was provided to Mongolia for their rural electrification projects. Also, there are many examples of PV application into community facilities and village electrification under the Small-scale Grant Assistance (Grass-root Grant Assistance). It is always necessary to pay attention to the sustainability of PV systems provided under the grant aid programs. JICA is recommended to review the long-time operation and maintenance of PV systems used in developing countries to provide clear information about operation and maintenance. Also, the coordination between the grant aid program and technical assistance program should be further strengthened by information sharing and combined aid schemes. The technical assistance program may add values to PV project under the grant aid by providing training programs, and dispatching volunteers and experts.

- Collaboration with international organizations

JICA is strengthening partnership with international organizations and other donors in the international aid community. In the field of PV-based rural electrification, international organizations such as the Global Environment Facility (GEF), the World Bank and UNDP and donors such as GTZ, SIDA and DANIA have been active and have a lot of experience. Among those organizations, GEF will be the leading aid agency for PV application. The GEF is willing to strengthen the relationship with Japan, the biggest financial contributor. JICA is recommended to build a collaborative relationship with GEF by jointly reviewing PV projects that both GEF and JICA were involved. The PV-based rural electrification projects in Zimbabwe and in Laos are such examples. It may draw attention from major donor agencies if the two organizations hold a conference on PV-based rural electrification focusing on lessons learned.

- Collaboration with NGOs and volunteers

For the implementation of PV electrification projects, NGOs and volunteers can play a leading role, because the projects are small-scale and community-based. JICA is recommended to pursue the involvement of NGOs and volunteers to accelerate PV electrification projects worldwide. In this case, it is important to give appropriate information and training to them to prevent project failures. Many NGOs and volunteers are willing to learn about PV systems for the sustainable development of local community. Technical workshops and seminars will be necessary to meet their needs.

- South-South Cooperation in Asia

Lessons learned from JICA's PV-based rural electrification projects, the pilot project in Laos in particular, should be shared and disseminated by way of South-South Cooperation. Third-country training, and third-country expert dispatching based in Laos and neighboring Thailand will be effective for assisting other countries in Asia.

- Awareness raising in Africa

For Africa, it is premature to implement PV electrification projects on a large-scale. Many countries in Africa have limited experience and few successful cases. JICA's experience in Africa is also limited. An effective approach may be to raise awareness on PV first to create strong knowledge base for PV application in remote areas. Complete, timely, and accurate information about PV technologies and electrification projects is needed for all the parties concerned including the government, private sector, and potential users. JICA is recommended to develop several regional information centers in Africa and to start this campaign project by utilizing the experience from the past projects.

4. Issues relating to PV electrification

1) Social and economic evaluation

PV electricity demand in non-electrified villages

The explicit and potential demand for PV electricity turned out to be fairly high. PV systems require villagers to pay an initial payment and a monthly fee. Their willingness to make those payments is an indication of demand. The explicit demand can be assessed by the fact that many houses already have batteries in non-electrified areas. This means that people who already have batteries are willing to pay for this mode of electricity despite the higher cost and inconvenience as compared with grid electricity. In addition, the potential demand for PV electrification is high, which can be explained by the high application rate for pilot systems. However, the following points are to be noted for the introduction of PV systems into new villages.

① Cash income levels and ease of obtaining cash income,

② Comparison with alternative energy sources such as battery charging in town and kerosene

③ Scale of benefits by PV electrification as compared with expectations and costs to people

Benefits of PV electrification

People use electricity mainly for lighting, which is useful for a better life, productive work, entertainment and security. According to the questionnaire survey and interviews, the direct benefits are as follows:

Economic benefit: Increase of income due to longer working time at night
: Decrease of energy expenses in some households which relied on battery charging in town before,

Benefits for daily life: Ease of housework with light
: Saving time and labor to charge batteries in remote towns

Cultural benefits: Better social life at night
: Information and entertainment from TV and radio,

: Ease of study at night

It is especially important to note that many cases of income increase were reported. It was also a significant factor in reducing the financial burden of users and led to the expansion of PV electrification. Additionally, the domestic work (cooking at night) of women was made easier because of better lighting, which is an indirect benefit of the system. And we heard that some villagers were getting better at managing money because of the mandatory monthly payment.

Effects on social and economic development

As is found in the JICA projects in Laos and Botswana, PV electricity can help provide modern energy services to households, enterprises, and social facilities such as health, education, water, and telecommunications in remote unelectrified areas.

a. Benefits to improved living standards on a household level

PV lighting helps people gain additional time for studying, reading and working in the evening, and enjoy greater security and comfort. The quality of electric light is better and safer when compared with candles or kerosene and less hazardous. It also provides access to radio, TV/VCD and telecommunication, enhancing information on local and national events and business matters.

b. Benefits to income generating activities

Even small amount of electric power that PV produces can help well-motivated people become economically active mainly by using PV lighting for productive activities such as weaving, food-processing, fishing and shop/bar operations in the evening.

c. Effects on community development and social and economic development

Access to PV electricity by itself is not enough to gain momentum for social and economic development from within the community: however, it can highly improve the ability to use educational facilities, health centers, water supply, communications and battery charging when applied as community infrastructure on a sustainable basis.

Critical factors to increase social and economic effects

a. PV application to social and public facilities

As is mentioned, PV can contribute significantly to reducing poverty and improve the human condition by providing social services in many basic human need（BHN）areas. In addition, PV operations at social/public facilities will have great demonstration effects on people's understanding and appreciation of what PV can do for their life. Therefore, PV electrification projects should take advantage of these issues to maximize local benefits and for the further dissemination of PV.

b. Promotion of productive use

As some ideas and instructions on how to utilize PV electricity could make people conscious of productive and proper use of PV, electrification projects need to have components to promote it as part of their development activities.

c. Working across sectors

The issues of social and economic development by utilizing PV involve many players across sectors such as ministries, departments and local authorities, etc. Therefore, it is a prerequisite to start with setting up the foundation on what those players can work for in a collaborative manner. PV electrification projects should support cross-cutting sustainable energy applications that address local development needs and objectives.

d. Institutional development of micro-financing

As most people in poor rural areas cannot afford the initial investment to benefit from PV services, accessible and affordable financing tools need to be developed as part of PV electrification projects for poverty alleviation.

2) PV Technology

From a technological viewpoint, achieving higher sustainability of PV electrification depends on whether they have domestic ability to produce PV components, whether they can evaluate PV products reliability properly, whether they can install and maintain PV systems reliably.

Domestic production ability

The first possibility of PV components domestic production is on fluorescent lamps, DC drivers and charge controllers. The next possibility is on batteries. Most of the countries in the study are now trying domestic production of lamp drivers and charge controllers. Syria, Zimbabwe and Bolivia are also producing batteries. Trying domestic production is a good way but for achieving the sustainability, production quality control is very important and technology transfer for this is becoming more important now.

Reliability

Reliability of PV components is very important because bad reputation about unreliable products will discourage people's will to utilize PV for electrification. Unreliable components were often seen in the 90's purchased under over-the-counter sales mode. For avoiding such unreliable components, setting up an authority to evaluate reliability and give accreditation to good ones is a good solution. Accreditation can be given in the form of labels. Such system should be carefully introduced to avoid any unfair accreditation.

Technical standard

Many countries are aware of the importance PV components reliability and most of the governments introduce technical standards for their purchase recently. Unfortunately, those standards are not well refined. Some are only the copy from advanced country's and too high level for them. Revising the standards to more practical ones through collaboration between expert of developing countries and advanced countries is recommended.

Installation and maintenance

PV is now popular among developing countries and they learned how to install and maintain in a sustainable way. Technical training for installers and operators were usually done before the PV introduction. User training for better utilization was also done several times along with PV introduction. Technology itself is not so difficult but a problem now is that they don't have enough number of technicians to introduce and maintain PV around the country. Large-scale capacity building through international cooperation is much needed.

Typical PV application systems in developing countries are summarized as follows.

System	Size	Remark
SHS	30-100W	Installed at individual house. Very popular around the world. Typical appliances are lamps and radio/TV. Maintenance and replacement of battery is the most important factor.
BCS	1-10kW	Popular in South East Asian countries. Users bring their batteries to the station and leave them to an operator. Charging needs one day usually.
Lantern	5-10W	A lamp, battery and controller are set in one body. Sometimes a panel is also embedded. Large lanterns have service consents for radio.
Pump	100W-several kW	Cost effective than diesel in remote area and reliable because it doesn't have battery. Small systems operate with DC pump and large systems operate with AC pump. DC pump is more cost effective than AC pump.
Communication	100W-several kW	Very popular among telecommunication companies. Cost effective in remote area. Telecommunication companies take all care of the system.
Street light	50W-200W	High needs because of unstable security in developing countries. Maintenance free system is preferable because it is widely distributed among rural area.
School	200W-several kW	System configuration is same with SHS. Size depends on the school capacity. Typical appliances are lamps, video, IT facility.
Clinic	200W-several kW	System configuration is same with SHS. Size depends on the clinic capacity. Typical appliances are lamps, a fridge and communication facility.
Community	200W-1kW	System configuration is almost same with SHS. Effective for PV awareness raising because community area is where many people gather and can see what PV is.
Mini-grid	More than several kW	It is not cost effective under current cost situation. Only when there is incentive for environment protection and enough demand in daytime, this can be applicable.
Grid connected	More than several kW	For the time being, this is urban application but this technology should be monitored because the technology standard for this will be likely to be applied to mini-grid system.

Technology frontier

・Solar panel

Crystal solar cell technology is now prevailing and maturing. A possible breakthrough is improvement of material utilization by reducing the thickness of Si-substrate. Since it is considered to take time, the current technology and cost of solar module will not change so much for the time being.

・BCS technology

-Integrated charger

Smart charger that can charge several types of batteries at once with tuning suitable current for each battery is developed. This is very suitable for BCS.

・White LED

White LEDs are becoming popular now although they are still expensive. In the near future their cost will become reasonable. The brightness of white LED is not so high but the most promising feature for PV application is their long life. Their life is about 50,000 hours, almost forever. Also, their energy consumption is small compared with fluorescent lights.

3) Environmental issues

Used battery treatment

Pollution by used lead acid battery is very common concern for utilization of SHS in developing countries. Fortunately any serious environmental problem caused by used lead acid battery was found through our site surveys in both Laos and Botswana. In both countries, used batteries are bought by traders that collect used battery for recycling of lead. Generally used batteries of SHS are collected together with used car batteries for recycling in most countries. Therefore SHS project operators do not need to establish their own used battery collection and recycling systems, if used car batteries recycling systems are effectively working in the countries. In the case of small island countries where battery recycling system is not yet established, project operators need to develop used battery collecting and recycling mechanism such as mandatory deposit for new battery sales, used battery collections by SHS project operators etc.

Clean Development Mechanism

SHS is a zero emission technology and contributes to GHG emission reductions. Therefore SHS rural electrification projects are applicable for CDM under the Kyoto Protocol.

- Potentials of GHG emission reductions

Annual GHG emission reductions by 50Wp SHS is estimated 40-50 kg-CO2 compared with diesel generator and 200-300 kg-CO2 compared with kerosene lighting. Without SHS, people commonly continue to use kerosene lamps. Therefore reasonable estimation of GHG emission reductions by 50Wp SHS is considered as 200-300 kg-CO2.

- Baseline and monitoring methodology

The approved baseline and monitoring methodology which is applicable SHS rural electrification projects is the indicative simplified baseline and monitoring methodology 1.A Electricity generation by the user. This methodology uses diesel generators as baseline emissions. Therefore a modification of the methodology which allows SHS project to use kerosene replacement as baseline scenario needs to be proposed to the CDM Executive Board.

- Benefit of CDM

IRR of SHS rural electrification projects is expected to increase more than 2% with CER (GHG emission reduction credit from CDM), assuming that CER price is $10 and crediting period is 21 years without consideration of CDM transaction costs. But most SHS projects cannot gain financial benefits of CDM, because of the high transaction costs such as validation, registration, verification costs. Therefore reduction of transaction cost is the key issue for SHS projects to apply CDM.

- Solution to reduce transaction costs
  - ✓ Increase project size (number of household)

  According to the World Bank CDCF report, the transaction cost of small scale CDM is estimated to be more than $160,000 over 21 years. Assuming that CER price is $10, more than 4000 SHS (50Wp) is necessary to recover the transaction cost. Therefore it is recommended to increase project size to make financial benefits of CDM bigger.

  - ✓ Apply a national PV electrification program as a CDM project

  As one of the ideas to increase project size, it would be recommended to apply a national PV electrification program as one CDM project. Once a national PV electrification program is registered as a CDM project, each individual SHS electrification project under the program will be automatically a part of the CDM project without any CDM procedures. Also CER revenue may be used as a financial resource of national rural electrification fund.

- ✓ Use ODA funding for CDM project design

ODA funding may be used to cover a part of CDM transaction cost, although diversion of ODA project to CDM is prohibited. For example, JICA study on PV rural electrification can include feasibility study of CDM project and development of CDM-Project Design Document (PDD).