ASEM Inclusive Eco-Innovation Programme

ASEIC-GGGI Cambodia Project in 2012

GREENING LOCAL COMMUNITIES THROUGH APPROPRIATE TECHNOLOGY

SPECIAL FOCUS: ECO-INNOVATION IN ACTION - FINDING UNTAPPED ENTREPRENEURIAL OPPORTUNITIES WITH SOLAR HOME SYSTEMS AND SOLAR COOKERS

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ASEM SMEs Eco Innovation Center (ASEIC)

The ASEM SMEs Eco-Innovation Center (ASEIC) aims to promote eco-innovation for small and medium-sized enterprises (SMEs) in Asia and Europe. Its establishment was endorsed by the leaders of ASEM member countries at the 8th ASEM Summit in Brussels, Belgium. ASEIC seeks to serve as an international platform where growing environmental regulations and eco-innovation practices are shared and new opportunities are created. ASEIC is currently funded by the Small and Medium Business Administration (SMBA) of the Republic of Korea and its office is located in Seoul.

ASEM
SMEs
Eco-Innovation
Center

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TERMS

ASEM	Asia–Europe Meeting
ASEAN	Association of Southeast Asian Nations
ASEIC	ASEM SMEs Eco-Innovation Center
GDP	Gross Domestic Product
GGGI	Global Green Growth Institute
GNI	Gross National Income
EAC	Electricity Authority of Cambodia
EdC	Electricité du Cambodge
ESMAP	Energy Sector Management Assistance Program
HFO	Heavy Fuel Oil
ISAC	Institute of Sustainable Agriculture and Community Development
kWh	Kilo-Watt hour
LPG	Liquid Propane Gas
MFI	Micro-financing Institution
MOI	Ministry of Interior
NBC	National Bank of Cambodia
NCAT	National Center for Appropriate Technology, USA
NGGMP	National Green Growth Master Plan
NGO	Non-governmental Organisation
NPIC	National Polytechnic Institute of Cambodia
PRT	Provincial Reconstruction Team
PV	Photovoltaic
RE	Renewable Energy
REF	Rural Electrification Fund
RGC	Royal Government of Cambodia
SBC	Small and Medium Business Corporation
SBCS	Solar Battery Charging Station

SEC	Solar Energy Cambodia
SHS	Solar Home System(s)
SMBA	Small and Medium Business Administration, Republic of Korea
SME	Small and Medium Enterprise
TATC	Takeo Appropriate Technology Center
VE	Village Entrepreneur

EXECUTIVE SUMMARY

Only six percent of Cambodia's rural population has access to electricity. Most of this electricity is from village grids often powered by inefficient diesel generators (World Bank, 2009). People at the bottom of the economic pyramid rely heavily on firewood for cooking and kerosene for lighting, which poses serious environmental and health-related threats. In addition, most of the agricultural produce of Cambodia (mainly rice) is cheaply exported to Thailand and Vietnam without being properly dried. Some regions have started to use expensive imported electrical produce dryers but this has largely proved to be unprofitable due to the high price of electricity.

This project seeks to address these problems through the adoption and demonstration of so-called "appropriate technologies", which are non-high tech solutions, specifically tailored to the actual needs of local people in Cambodia. With these guidelines in mind, during 2011 and 2012, one hundred and twenty solar cookers were locally manufactured, sixty solar home systems (SHS) were constructed, and grain drying facilities were demonstrated in select provinces. All of these initiatives were specially designed to suit the local conditions of the rural community in Cambodia. The project aims to create untapped local business opportunities by commercialising the technologies while reducing health and environmental risks for local residents.

The ASEM SMEs Eco-Innovation Center (ASEIC), which aims to promote eco-innovation for small and medium-sized enterprises (SMEs) in Asia and Europe, is the implementing agency of the project. The funds for the project are appropriated by the Small and Medium Business Administration (SMBA) of the Republic of Korea via the state-run Small and Medium Business Corporation (SBC). The project is linked to the Green Growth Planning in Cambodia by the Global Green Growth Institute (GGGI), whose fundamental objective is to help Cambodia meet its goals of developing the national economy, spurring job creation and identifying new opportunities for economic growth.

The target customers for SHS and solar cookers are rural low income families, which constitute 79% (Cambodia Socio Economic Survey, 2004) of Cambodian households. Since the process of encouraging households to adopt new technology into daily life requires enormous effort, the project puts an emphasis on the bottom-up approach by utilizing the locally based Institute of Sustainable Agriculture and Community Development (ISAC) to build a strong bond with the local community. This strategy underscores the importance of gaining a deeper understanding of the culture and the local environment in order to build mutual trust, which is crucial for the success of the project. To foster sustainability and ongoing capacity building for ISAC local staff, ASEIC and its partners developed the Takeo Appropriate Technology Center (TATC). The main objective of the center is to encourage young entrepreneurs to set up locally based micro or small social enterprises that contribute to the well-being of people in the region. This report discusses the best ways to distribute the project's locally manufactured solar products while keeping in mind that technology must be affordable and accessible to poorer households as well as the general public. Some key findings and suggestions are as follows:

- Most of Cambodia's rural areas are unelectrified as the national electricity grid is slowly extended. Solar has many advantages for families using car batteries or kerosene lighting in their homes and there has been consistent growth in market demand for SHS. ISAC has a long and established presence in Takeo, which is a strong foundation for understanding the best marketing strategy for the area. ISAC is therefore encouraged test the market in Takeo with 60 sets of locally produced SHS, while focusing first on direct cash-sales without financing in order to get an honest and realistic picture of the current market.
- Solar cookers have many uses ranging from cooking to sterilization but have proved to be difficult to distribute around the world on a purely commercial basis. Careful testing of the market should be executed before deciding to pursue profitable solar cooker sales, especially in a market like Cambodia where the rural population is scattered and poses serious logistical challenges. Solar cookers are a completely new technology in Cambodian markets and ISAC has great potential for marketing their

"made in Cambodia" solar cookers to end user households as well as local NGOs and government.

This project attempts to integrate a bottom-up approach into a top-down method, since it not only deals with capacity building programs but also encourages local untapped business opportunities. If successful, the project can be replicated in other nations to have an even greater impact.

INTRODUCTION

A Country Profile

The Kingdom of Cambodia is a constitutional monarchy, which shares its borders with Laos, Vietnam, and Thailand. It has a total landmass of 181,035 km^2 and a population of 15 million. Its capital city is Phnom Penh and three other major cities are Siem Reap, Battambang and Sihanoukville. Cambodia's GNI per capita in 2010 was $760[1], ranking only 185th among 215 countries (World Bank, 2011). However, its GDP growth rate remains relatively high, reaching 7% in 2011, following a drastic drop in 2009 and 2010. In 2009, Cambodia had 29,000 small and medium enterprises (SMEs), with less than 50 employees each. Eighty percent of these enterprises belong to the food, beverage, and cigarette manufacturing industries.

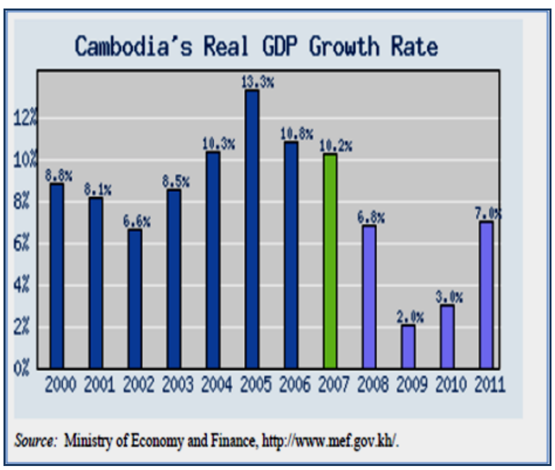

Figure 1: GDP Growth of Cambodia

Enterprise type	1998	1999	2000	2001	2002	2003	2004	2005
Food, beverage and tobacco	18,590	19,147	20,152	21,871	21,568	20,869	22,712	23,343
Textile wearing apparel leather	310	396	366	2382	1,417	1,406	1,672	1,662
Wood products including furniture	895	814	869	141	13	13	16	-
Paper products printing publishing	26	23	24	23	15	21	25	31
Chemicals petroleum coal plastics	55	67	297	277	275	96	120	153
Non-metallic mineral products	811	777	666	721	757	681	680	718
Fabricated metal products	1,375	1,647	1,824	1,454	1,899	1,850	2,239	2,222
Other manufacturing	2,035	1,356	1,208	1,286	976	1,049	667	618
Total	24,097	24,227	25,406	28,155	26,920	25,985	28,131	28,747

Notes: SMEs in this data set are defined as employing up to 50 people. There are very few enterprises that employ between 50 and 100 people in Cambodia, so not including this group still provides a reasonable estimation of enterprises with fewer than 100 employees.

Source: Cambodian Ministry of Industry Mines and Energy, *Cambodian National Institute of Statistics Yearbook 2006*

Figure 2: Number of SMEs in Cambodia

Cambodian residents primarily use firewood for cooking, thus resulting in severe health-related and environmental problems. Burning firewood gives off air pollutants that pose health risks, and the widespread cutting of trees to obtain wood leads to rapid deforestation.

[1] Note that all prices in the document are in US dollars.

Cambodian residents use 24% electricity, 38% battery, 36% kerosene and 2% other methods (like candles) to light their homes at night (Figure 3). Phnom Penh is responsible for most of Cambodia's electricity demand (99% of homes), followed by a 62% electricity, 14% battery, and 24% kerosene usage in other major cities. Aside from urban centers, provincial villages use 11% electricity, 45% battery and 42% kerosene, which is a major increase in battery and kerosene use compared to usage in the cities. The cost of electricity in Phnom Penh is an average of $0.16/kWh but can be as much as $0.90 in rural areas (Frankfurt School, 2011).

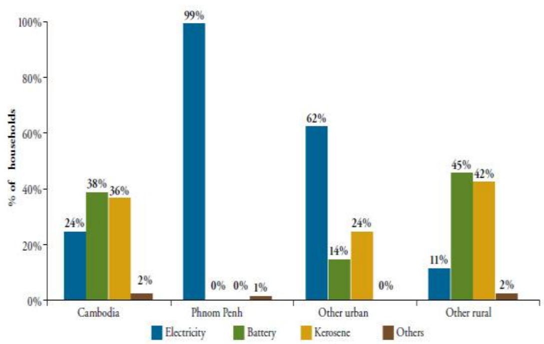

Figure 3: Lighting Methods in Cambodia

Source: IFC, 2012

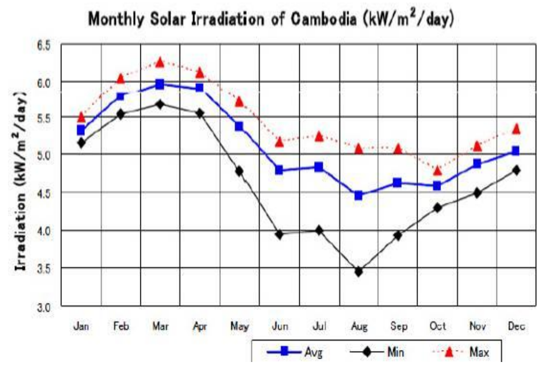

Figure 4: Cambodia Monthly Solar Irradiation

Source: Picosol, 2012

The price of diesel is also increasing every year such that a litre of diesel which was approximately $0.40 in 2000 is now at least 2.5 times more expensive ($1 or more). Consequently, the cost to recharge car batteries using diesel generators is also continuously increasing.

The daily average sunshine in Cambodia is greatest in March (the dry season), at 6kW/m^2 and lowest between August and October (rainy or monsoon season) at 4.5kW/ m^2. In August, the average daily sunshine falls to a minimum of 3.5kW/ m^2. The variation per month is rather large (see Figure 4). The irradiation levels in March are the highest around the coastal regions and the north while relatively low in the South; however, the difference is an insignificant 0.3 kW/m^2. It is therefore concluded that technologies utilizing solar energy are appropriate in all regions of Cambodia.

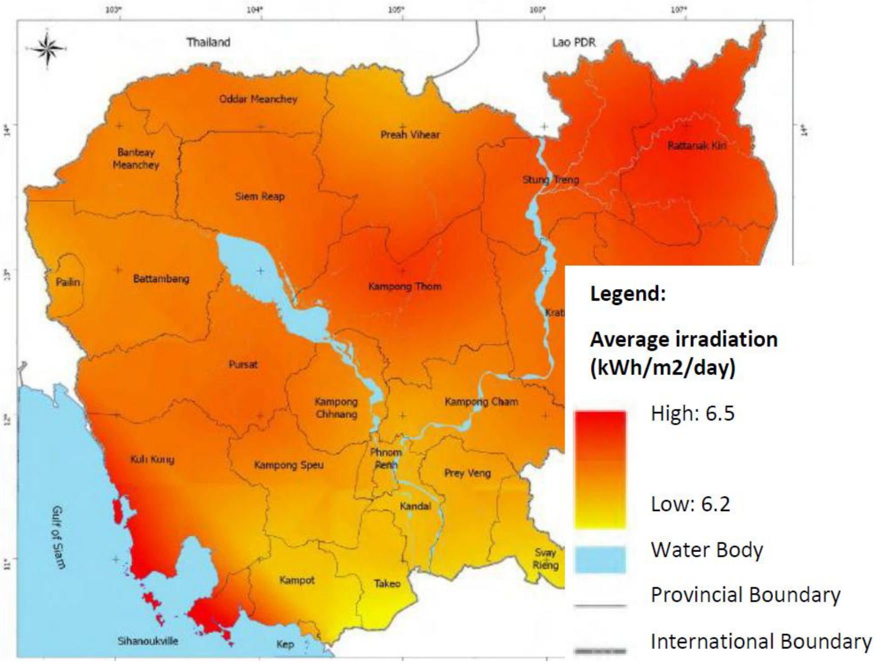

Figure 5: Solar Irradiation Map of Cambodia

Source: CRCD, 2005

Figure 6: Detailed Cambodia Map

Source: National Online Project

B Takeo Province Profile

The primary local project partner, ISAC, has its operations in Takeo and will target this region specifically for its initial commercial ventures. The province of Takeo occupies an area of 3,563 km^2 which shares its border with Kandal in the northeast, Kampong Speu and Kampot in the west, and Vietnam in the south. The province is a mostly flat, containing many rice paddies and agricultural farms and is bound on the east by the Bassac River. With a tropical climate, Takeo is hot and humid with lots of rain during the monsoon season, allowing for cultivation of various agricultural produce. The annual average temperature is around 27°C and the lowest is around 16°C. December and January are the coldest months and April is the hottest. Generally, November to March is considered the cold season with temperatures ranging between 22-28°C, March to May the hot season at 28-36°C, and May to October the monsoon at 24-32°C. The humidity during the monsoon season is high, rising up to 90%. The annual rainfall in Takeo was 1,038mm in 2009 and 1,094mm in 2010 which was lower than the national average of 1,733.95mm and 1,493.43mm in respective years.

Takeo's population is 877,839 which makes up approximately 6.4% of the total population of Cambodia and is gradually declining. The population density is 255 people per square kilometer and the economy centers around rice farming, fishing and fruit harvesting.

The area for rice cultivation in 2010 was 183,804ha in the monsoon season and 80,904ha in the dry season, which totals 264,708ha (9.5% of the nation's total area for rice cultivation). The quantity of production in 2010 was 596,439 tons in the monsoon season and 371,107 tons in the dry season, resulting in a total of 967,546 tons. Takeo has the largest area for dry season rice cultivation in the whole country. Fruit cultivation is found in Takeo including bananas (1,150ha), cashew nuts (966ha), coconuts (970ha), mangos (798ha), custard apples (335ha), oranges (25ha), guavas (175ha), and palm trees (215,878ha).

C Background of "Appropriate Technology"

To address the myriad socioeconomic and technological problems confronting Third World countries in the mid-1960s, economist E.F. Schumacher introduced the concept of "intermediate technology" in his groundbreaking book, *Small is Beautiful* (1973). Utilizing intermediate technology involves the efficient use of local resources, and it also seeks to cater to the needs of the local people. Moreover, it ensures simplicity in product design and affordability in price. Intermediate technology has also been branded as "appropriate technology" or "alternative technology." "Appropriate technology" has been the most widely used term because the word "appropriate" takes into account the unique needs of local people.

In his thesis, *The Gandhian Approach to Swadeshi* and *Appropriate Technology: A Conceptualization in Terms of Basic Needs and Equity*, Hans Bakker claims that appropriate technology encompasses all types of technology that cater to the basic needs of people at the bottom of the economic pyramid (Bakker, 1990). Meanwhile, the National Center for Appropriate Technology in America (NCAT) defines the term as "devices or strategies that are appropriate for the applied environment in cost and size." Amid these definitions, appropriate technology is generally characterized by the following features:

1) The price must be affordable to the users.
2) It should utilize local resources.
3) It should generate jobs, tapping local labour and technology.
4) It is small in scale and simple in design.
5) Its use must be simple enough to be understood even by people who are not well-educated.
6) It should foster social collaboration and local development.
7) It should tap renewable energy sources.
8) It should easily adapt to changes in local environment.
9) It does not entail intellectual property rights, loyalties, custom taxes, etc.

Given these characteristics, appropriate technology corresponds to the harmonious relationship between nature and technology. In addition, the specialized application of appropriate technology makes it well-suited for one local area and inappropriate in another. Abudakar N. Abdullalli noted that its overarching aim is to help promote the welfare of the local people. Similarly, Peter Dunn stressed that appropriate technology must go smoothly with local culture and should thus preserve societal traditions.

The definitions above renders appropriate technology different from conventional types of technology. It is not just technology alone but also a way of thinking or a philosophy that integrates economic growth and sustainability. It also fosters a responsible attitude on the use of technology. According to Dunn, appropriate technology is “self-revolving, active and a perfect systematic approach to development. It is an approach to community development that is composed of knowledge, technology and the founding philosophy.” Furthermore, appropriate technology is people-centered; it is a philosophy that prioritizes human progress rather than technological advancement alone. It incorporates an array of goals, processes, and actions that address basic human needs.

Project Development

A Project Description

This is the second year of the GGGI-ASEIC Cambodia project under the ASEM Inclusive Eco-Innovation Programme, initiated in 2011. For the greening of Cambodia, the project objectives include setting up the TATC with a 5kW solar generation facility, fabrication of 120 solar cookers, assembly of 60 sets of SHS to be installed at homes of local families and the setting up of drying facilities using incinerators and floor heating systems in Phnom Penh, Battambang, and Mondulkiri. The project is carried out by ASEIC in collaboration with the Center for Appropriate Technology of Hanbat National University and other important stakeholders who actually implemented the project on site in Cambodia, namely the Energy Farm Inc., the NPIC, and the ISAC School.

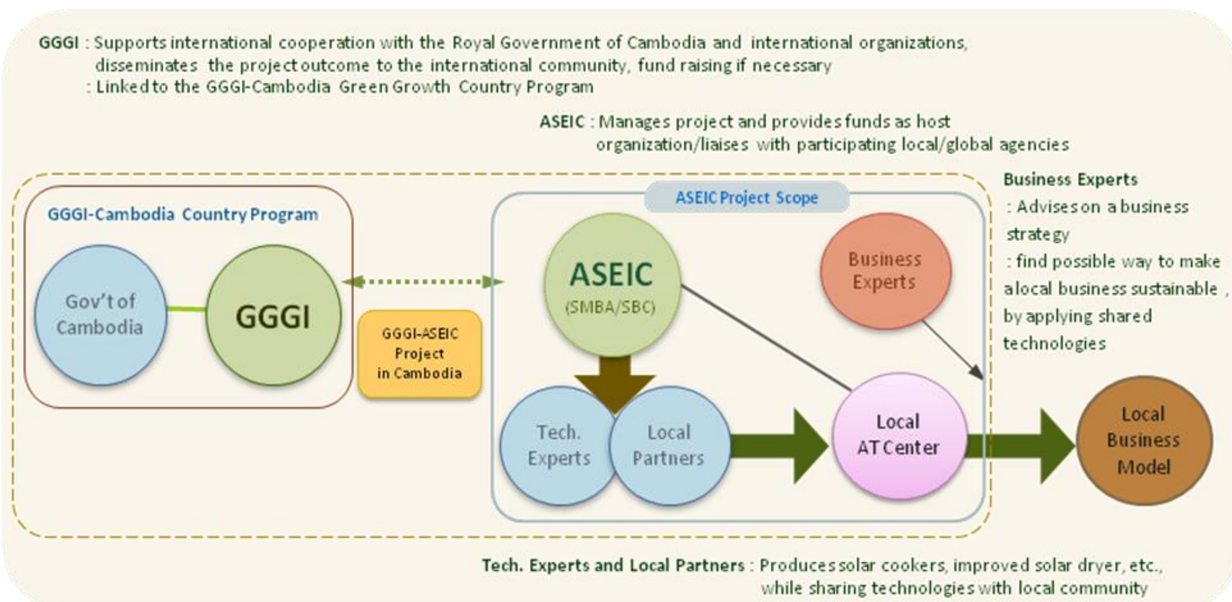

Figure 7: Stakeholder Dynamics

The progress of the second year project is summarized as follows:

- February 2012: Prior field study (ASEIC/GGGI)
- March 2012: ASEIC and Hanbat Industry-Academic Cooperation Foundation signed an MOU for undertaking the project (March 26, 2012)

- June 2012: Conducted first progress check (ASEIC)
- August 2012: Conducted second progress check (Hanbat University)
- October 2012: Final field inspection and project finalization

This project is linked to the GGGI's Cambodia Green Growth Program, which is intended to develop the National Green Growth Master Plan (NGGMP) to assist Cambodia in achieving continued rapid economic development while preserving environmental integrity. GGGI's objective is to help Cambodia meet its goals of developing national economy, spurring job creation, and identifying new opportunities for economic growth. In doing so, GGGI's country program for Cambodia includes both the top-down and bottom-up approach, which includes establishing a green growth legal framework; tailoring specific policies; and scoping, analyzing, and implementing plans in forestry, small- and medium-sized business promotion, green job creation, and waste management (GGGI, 2011).

B Project Components

1 Takeo Appropriate Technology Center

The TATC was set up as part of the project to support the manufacture of solar cookers and SHS at ISAC in Takeo with the help of the 20-30 students. The center was constructed by extending the roof from the building built in the first year to ISAC's existing building, thus adding 3 new rooms (Figure 8). The rooms will function as the office for the TATC, solar battery storage (Figure 9) and storeroom for SHS materials (Figure 10).

Figure 8: Takeo Appropriate Technology Center

Figure 9: Storeroom for Solar Batteries

Figure 10: SHS Materials Storeroom

In addition, a 5kW photovoltaic generation facility was set up (Figure 11 to Figure 14) on the roof at the ISAC so it could supply part of the electricity needed for the center.

Figure 11: Frame Production

Figure 12: Panel Electrical Connection

Figure 13: Battery Electrical Connection

Figure 14: Setting up Panel Array

The 5kW photovoltaic generating facility was set up using 50 modules of 100Wp photovoltaic modules, which were connected vertically and horizontally in strings of 5 modules each. The modules are divided in two parts for generation. Two TS-60 MPPT controllers from the manufacturer Morning Star were used to manage the battery charging cycles. The two controllers are connected individually to the respective ports in order to charge the batteries uniformly. In the case where one of the controllers malfunctions, the counterpart can function normally to charge the battery bank to a minimum of 50%. The battery bank is composed of 8 strings of 8 Trojan T-105s.

2 Solar Home Systems

ISAC is currently in the process of assembling 60 SHS sized 50Wp, 80Wp and 100Wp to install at homes of local families. The following figures show the first test installations.

Figure 15: Panorama of SHS Installation

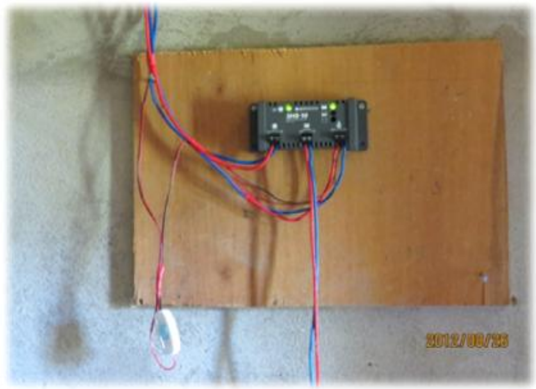

Figure 16: Charge Controller

Figure 17: Battery Connection

Figure 18: Connection to the Light

According to the monthly solar irradiation in Cambodia (Figure 5), the minimum irradiation in August is 3.5 kW/m^2 (the quantity of solar energy shining on a 1m x 1m area per day). Theoretically, it is possible to store 140Wh of electricity per day per 0.41 m^2 of 50W module given that the efficiency of the solar module is 15.38%, the module generation efficiency is 80%, the battery charging efficiency is 80%, and the case where an inverter is used, the DC-AC conversion efficiency is 80%. The graph below shows the quantity of electricity generated by a 50Wp model, calculated based on the data measured by ISAC in September.

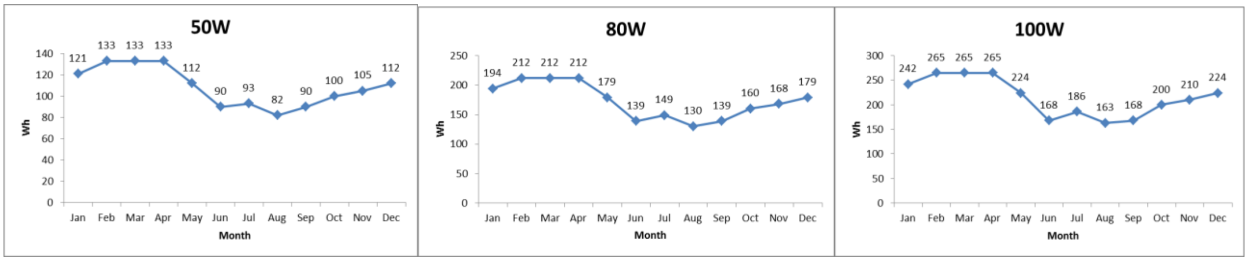

Figure 19: Quantity of Electricity Generated by a 50W/80W/100W Module (Wh/month)

The actual generation of the 50W module in August was 83Wh which is about 60% of the calculated value. However, the two weeks in September during which the experiment was conducted was in the middle of the monsoon with many cloudy days. Hence, it can be concluded that this is the minimum value, typical under the worst monsoon conditions.

Typical power consumptions of DC electrical appliances are shown in Table 1. Using a 50Wp module during September (monsoon season), a 10W bulb can be used for nine hours or a 14”color TV watched for an hour along with a 10W bulb for 2 hours.

Table 1: General Power Consumptions of DC Appliances

Device	Type	Power Consumption
Colour Television	**14”, vol : 50**	65W
Colour Television	**14”, standby power**	12W
Lamp	**20W, CFL**	15W
Lamp	**10W, fluorescent tube**	11W
Lamp	**20W, Osram, solar**	7W

One major purpose of this project is to create a foothold for ISAC staff to become self-reliant through capacity building. Accordingly, technology about the photovoltaic facility was transferred to the students studying at ISAC just as was done for the solar cookers in the first year. To accomplish this, they were provided with basic electricity theory and SHS assembly classes, carried out over several sessions.

On October 9, 2012, officials from ASEIC, SBC, and GGGI, together with local partners, demonstrated the use and efficiency of the SHS to local residents and students in the Takeo region. *The Korea Times* published a feature article about the project on October 15, 2012 (available at http://www.koreatimes.co.kr/www/news/biz/2012/10/335_122199.html and in Appendix A).

The various methods of distributing SHS will be examined in the special focus section.

3 Grain Drying Facilities

Facilities to dry cereal crops were adapted from the incineration facilities developed in the first year by using the heat generated from incineration to heat up the floor. The drying facilities are divided into two types depending on use. An open-type green house is used for drying large quantities and a closed-type with a solar collector (brick) used for cereals that can dry without sunshine.

The following figures show the set up process for a drying facility:

1

A. Dimensions 4 x 6 m

B. Weld squared pipes with side dimension of 8 x 8 cm and set up the foundation using concrete.

(1 part cement to 2 parts sand to 1 part gravel)

Figure 20: Laying the Foundation (closed-type)

2

A. Dimensions 4 x 6 m

B. Use cement to lay the foundation and set up 4 layers of bricks of size 18 x 8 x 8 cm

C. After laying the bricks, fill the space with sand or mud till the top of the bricks and flatten it.

Figure 21: Laying the Foundation (open-type)

3

A. Weld the cylindrical pipes (diameter 4 cm) according to the dimensions (truss height 80 cm, column height 180 cm) as shown in the picture to the left.

B. Make the frame of the drying facility and the floor heating system according to the standard dimensions.

Figure 22: Welding, Drying Frame, Floor Heating System

4

A. Place a 3 cm thick cement layer on top of the filled mud.

B. Mortar (use coarse sand) mix ratio (cement 1: sand 3)

Figure 23: Concrete Work for the Floor

5

A. Adjust the heating floor system according to the size of the drying facility

B. Lay plastic sheets on the floor so that it will be easy to separate

C. Remove the mold within15 minutes so it will be easy to separate.

Figure 24: Making the Heating Floor Sections

6

A. Block the middle part so that the smoke from the incinerator can be released equally at both ends.

B. The spacing between the areas just below the heating floor should be one column in the middle and two on either side towards the middle of the two parts. Each column should be of two layers of bricks.

Figure 25: Make the Heat Transfer System

7

A. Lay the heated floor parts on top of the columns set up in the previous stage.

B. To center it right in the center, the truss should be placed before laying the heated floor parts.

Figure 26: Lay the Heated Floor Parts

8

A. Set up the incinerator once the floor heating system is set up.

B. Plaster the heating floor once all the parts have been laid down.

Figure 27: Install the Incinerator and Plaster the Heating Floor

9

A. Plaster with mortar to prevent release of smoke from the incinerator

B. Set up 2 more layers of bricks above the heating floor

C. Place the plastic sheet from the top to bottom while making sure the plastic sheet covers at least 20 cm of the bricks.

Figure 28: Plastering and Setting up the Plastic Sheets

10

A. Install aluminum cylinders (diameter 100 mm) at 5 cm intervals within the solar collector (dimension of 2 x 3m is appropriate)

B. Paint the interior of the solar collector and the aluminum cylinders with black enamel (more than 2 layers).

C. Finish by covering the collector with transparent glass of thickness greater than 5mm

Figure 29: Set up the Solar Collector

11

A. Install the roof on top of the masonry (height of front wall 2.8 m, height of rear wall 3.5 m), set up the solar collector in the middle and cover the surrounding with galvanized iron sheets

B. Take caution to prevent rain leakage

C. Paint over twice

Figure 30: Closed-type Drying Facility

12

A. Make facility to remove the ashes from the bottom of the chimney but opening should be fully sealed otherwise.

B. The height of the chimney should be at least 2.5 m higher than the heating floor.

C. Make crossing devices to secure the position of the plastic sheets.

Figure 31: Open-type Drying Facility

Table 2: Comparison of Different Types of Drying Facilities

Classification	Closed-type Drying facility	Open-type Drying facility
Summary	▪ Install solar collector (120w) ▪ Incinerator (function as a furnace) ▪ Install heating floor (make heating floor parts) ▪ Dimensions 4x6m	▪ Electrical facilities not needed ▪ Quantity to dehydrate for each cycle: Approx. 4 tons ▪ Incinerator (function as a furnace) ▪ Install heating floor (make heating floor parts) ▪ Dimensions 5x7m
Use	▪ Medical material (Moringa, Goya) ▪ Mango	▪ Chili, Pepper, Cassava, Beans ▪ Fermented Feed
Exterior	▪ Bricks, Plastic Sheets	▪ Plastic Sheets on Top of Truss
Incinerator fuel	▪ Daytime: None (solar collector) ▪ Night: Corncob, Chaff	▪ Daytime: None (natural light) ▪ Night: Corncob, Chaff

On October 10, 2012, officials from ASEIC, SBC, and GGGI, together with local partners, demonstrated the use and efficiency of the grain drying facilities to local residents and students near Battambang. Once local response is positive for this pilot project, it can be applied to other regions by building local capacity.

4 Solar Cookers

100 new solar cookers were manufactured by ISAC for the project in 2012. The production cost for a single solar cooker is estimated at $160 and has proved to be still unaffordable for local residents in Cambodia given their income level, according to initial ISAC surveys. The various methods of distributing solar cookers will be examined in the special focus section. On October 9, 2012, officials from ASEIC, SBC, and GGGI, together with local partners, demonstrated the use and efficiency of the solar cookers to local residents and students in the Takeo region. In 2011, *The Korea Times* published a feature article about the solar cooker development in Takeo (available at http://www.koreatimes.co.kr/www/news/biz/2011/11/335_99623.html and in Appendix A).


Figure 32: Solar Cookers at ISAC

SPECIAL FOCUS | ECO-INNOVATION IN ACTION - FINDING UNTAPPED ENTREPRENEURIAL OPPORTUNITIES WITH SOLAR HOME SYSTEMS AND SOLAR COOKERS

This remainder of the report discusses future options for two of the project components, solar cookers and SHS. Until now the project has focused on capacity building and technical training in order to teach ISAC to manufacture solar cookers and assemble SHS while also having the technical knowledge to troubleshoot and repair systems after installation.

The goal is that ISAC will now be able to commercialize their activities involving these new products and the remaining sections consider the probability of success in these efforts as well as recommendations for how ISAC can weigh the various options available as they now begin to sell the first stock of both products.

A Solar Home Systems

1 Market Analysis

Cambodia has an excellent sun resource (Figure 5), which is good news for solar energy and SHS. Solar energy is still very new to Cambodia and the reputation is mixed depending on the location. In a Frankfurt School (2011) survey for Vision Fund across 17 provinces, only 36.2% of those interviewed had ever heard of solar energy and 18.0% knew somebody who was using it. As discussed earlier, transportation and logistics in Cambodia are extremely difficult and this makes installation and maintenance of solar systems difficult as well. The reputation of solar has much to do with the long term functioning of systems and some stories from the field can help paint a picture of the challenges with introducing this new technology.

A solar village entrepreneur in Kampong Chhnang lost many customers after lightning struck the house of one of her customers. The house burned down and it was a dreadful event for the village. Although the solar panel was not the highest point in the vicinity and contains mostly non-conductive material (plastic and glass), all agreed that the newly installed solar system must have caused the accident **(Zwetsloot, 2012).**

Diesel battery charging stations generally charge at a very high current and operators often check the status of charging from the temperature of the battery case. Customers are also used to picking up their battery hot from the station before evening. An entrepreneur in Kien Svay who participated in a test with a solar battery charging station (SBCS) had disappointed customers because their solar-charged batteries were cool to the touch. Although their batteries were actually fuller and cared for much better compared to a conventional diesel charging station, they were dissatisfied the solar charged batteries. Common belief is that fully charged battery should be hot. In the end the pilot was ended preliminary **(Vanderlaan, 2012).**

1.1 Cambodian Context

Very few households in Cambodia have access to grid quality electricity. In 2010, only 12.3% (MIME, 2011) of households were electrified in rural areas (29% of households when including urban areas). There are several players involved in rural electrification, the Cambodian government being the largest. Aside from the national grid, there are hundreds of independent suppliers of electricity at the village or commune level. The renewable energy sector is also growing, led by government programs, NGOs and the private sector.

1.1.1 Government Rural Electrification Plans

The government of Cambodia has ambitious plans for rural electrification. The most recent goals from the major partners (MIME, EAC, REF, EdC) state:

- all villages in the Kingdom of Cambodia should have access to electricity of any type by the year 2020
- at least 70% of all households in the Kingdom of Cambodia should have access to grid quality electricity by the year 2030.

The mix of electricity sources for this plan is summarized in Table 3. Specific plans for stand-alone systems are in Table 4. It can be seen that the government has insignificant plans for solar and SHS distribution.

Table 3: Plans for Government Rural Electrification Development 2011-2030

	Coverage for rural areas	2010	2015	2020	2030
Connected households	National grid	6.9%	29.1%	47.4%	66.2%
	Hydro mini-grid	0.0%	0.6%	0.3%	0.1%
	Biomass mini-grid	0.0%	0.4%	0.3%	0.0%
	Existing diesel mini-grid	4.4%	1.9%	1.4%	0.6%
	New diesel mini-grid	0.0%	1.9%	1.2%	0.1%
	Solar Home Systems	0.0%	0.7%	1.4%	0.2%
	Total percentage of rural households	**11%**	**34%**	**52%**	**67%**
Connected villages	National grid	10.9%	46.1%	78.3%	94.8%
	Hydro mini-grid	0.0%	1.5%	0.6%	0.2%
	Biomass mini-grid	0.0%	1.2%	07%	0.1%
	Existing diesel mini-grid	11.9%	5.4%	2.7%	0.9%
	New diesel mini-grid	0.0%	5.1%	1.9%	0.1%
	Existing battery charging stations	34.7%	14.3%	6.8%	1.3%
	Solar Battery charging stations	0.0%	4.5%	9.0%	2.6%
	Total percentage of rural Villages	**57%**	**78%**	**100%**	**100%**

Source: MIME, EAC, REF, EDC 2011

Table 4: Stand Alone System Government Plans

Stand alone system plans	Unit	2011 - 2015	2016 - 2020
Plan for providing SHS household wise	SHS	16.744	20.679
Plan for providing Solar systems community wise	Village	997	997
Plan for establishment of BCS	Village	569	455

Source: MIME, EAC, REF, EDC 2011

Prices for electricity in Cambodia are already some of the highest in the world and especially in the region. The average tariff in urban areas is $0.16 per kWh but can be as much as $0.90 (Frankfurt School, 2011) in rural areas. Currently 89.2% (EAC, 2011) of the electricity flowing through the national grid is generated from imported diesel and heavy fuel oil (HFO). Such a high dependence on imported fossil fuel is no security that electricity from the national grid will be affordable in the future.

Even if the government plans stay on target, it will be nearly 20 years before electricity reaches most rural households. There is an immediate demand for electricity and many families will look to other short term solutions instead. This is good news for the private sector as there are numerous opportunities to introduce solar energy directly to unelectrified villages in the form of solar lanterns, SHS, and solar village grids.

The government also encourages participation from the private sector. During the September 12, 2012 ASEAN meeting on power connectivity, prime minister Hun Sen mentioned that:

> ***"Green energy and connectivity must be developed and the transfer of renewable energy technology from technologically advanced and economically developed nations needs to be transferred to ASEAN's poorer countries" and "renewable energy sources including hydro, wind and solar powers must be effectively developed."***

The Rural Electrification Fund (REF) branch of government has supported SHS integration in the past few years, first offering rebates for SHS through solar companies and most recently distributing nearly 12,000 SHS to rural villages. There is no government regulation or policy regarding solar energy for the private sector including market regulation, quality standards, or end user support. There was a reduction in import rates for select solar components (35% down to 7%) in 2011. This was a huge victory for the solar energy sector in Cambodia.

Conclusions and recommendations

- **Most of Cambodia's rural areas are unelectrified and this will be the case for at least 20 years or more as the national electricity grid is slowly extended.**
- **The government has few programs for SHS distribution and leaves an opportunity for the private sector to take the lead.**
- **Electricity rates in Cambodia are expensive, making solar a viable option compared to other countries.**

1.1.2 Non-Government Electricity and Solar Energy Situation

Despite the low electrification rates in rural Cambodia, households are not in the dark waiting for the government to stretch new power lines. Hundreds of rural electricity enterprises (REEs) service anywhere from 50 to 5000 customers on independent grids supplied from diesel generators. These entrepreneurs are extremely important at the village level but are largely unsupported, unlicensed and unregulated at a national level. The tariffs of REEs are extremely expensive, ranging from $0.30/kWh to $0.90/kWh (Frankfurt School, 2011).

IFC (2012) estimates that 45% of rural households get their electricity from car batteries. Batteries are charged at a diesel generator stations at the village level and many communities have an organized daily pickup and delivery system. This high rate of car battery use is quite unique to Cambodia. According to World Bank (2012) almost $52 million is spent yearly on battery charging. This is a costly energy source at $2-3.5/kWh (Frankfurt School, 2011) but can be used intermittently according to household cash flow and has the advantage of established country-wide distribution.

This has huge implications for solar as SHS or solar battery charging stations (SBCS) have the potential to replace car batteries and diesel generator charging. 42% of rural households (IFC, 2012) also use kerosene lanterns either as a primary source of lighting or occasionally when used together with other forms of electrical lighting. Solar has clear safety and health advantages over kerosene lighting.

Despite the challenges for integrating solar into rural areas, there is still a general optimism for the future of solar in Cambodia's development (IFC, 2012). It estimates that 10,000-20,000 SHSs have been installed to date in Cambodia and along with solar lantern distribution, the penetration rate of solar products in Cambodia is still very low at a mere 1-1.5%. This leaves a huge market that has not been targeted and enough room for many more players without significant competition.

In a recent study, SNV (2011) ranked solar lanterns in third place and SHS in fifth place out of 19 for the most promising renewable energy technologies ready for scaling up in Cambodia (but solar cookers did not make the list). In 2011, the only completely solar focused NGO, Picosol Cambodia, introduced a "Solar Roadmap for Cambodia" which presents a strategy to create energy access through solar for 200,000 rural families by 2020.

Conclusions and recommendations

- **The reputation of solar in rural Cambodia is mixed depending on location and history of projects.**
- **Logistics and transportation in rural areas make it difficult to install and maintain systems.**
- **Solar has many advantages for families using car batteries or kerosene lighting in their homes**
- **The market penetration of solar products is very low and there is general consensus that there is a large market for SHS and solar lanterns.**
- **Relevant organizations have implementation solar strategies which ISAC can be a part of.**

1.2 Target market

1.2.1 Demographics

There is a range of households in rural Cambodia but they usually fall into one of the categories of Figure 33.

1. Very Poor	2. Rural Poor	3. Rural Middle Class	4. Rural Rich
			
Thatch siding with thatch or iron roof **Income: $1.5/day**	Wood siding with iron or asbestos roof **Income: $1.5-3/day**	Wood siding with tile roof **Income: $3-10/day**	Brick or half wood half brick **Income: $10/day**

Figure 33: Typical Cambodian Rural Family Homes

Source: Kamworks, 2010

The very poor struggle to cover basic needs and cannot afford a full priced SHS at this time, with or without financing. They would, however, be an appropriate customer for a solar lantern as many households like this still use kerosene lighting. The rural poor have a similar situation, although perhaps with favourable financing terms, a small SHS for lighting could be afforded. The rural rich earning more than $10/day will likely be able to afford a generator or other form of energy which can satisfy their high energy demands. The rural rich would likely find the amount of energy produced by a SHS much less than they think is acceptable given the price. The rural middle class is the ideal customer for a 50-100W SHS similar to what ISAC hopes to sell. This market segment has an annual income of $1100 (IFC, 2012). Interested customers in the rural middle class can save up to pay cash for a system or buy immediately in the case of favourable financing options.

Conclusions and recommendations
▪ **The size of SHS that ISAC intends to sell should be focused towards the rural middle class household.**

1.2.2 Geographical Considerations

ISAC only has one office and they have only just begun to sell SHS. Therefore it is logical that ISAC start in Takeo province regardless of the ideal geographical target market in Cambodia. Fortunately, Takeo is a geographically ideal market region with significant off-grid and remote areas which are ideal for SHS sales. Within 20-40km of the ISAC office, there are plenty of unelectrified villages that are suitable for testing the market and building SHS distribution for several years.

The price for solar energy is still relatively high at $1/kWh (Picosol, 2011) and SHS prices cannot compete with energy from the national grid or even isolated diesel generator mini-grids. The best geographic regions for SHS are those that are off-grid with no near plans for grid extension to the region. Therefore, it is beneficial to look at the national grid extension and renewable energy plans. As seen in Figure 34 and Figure 35, there has been little grid penetration into Takeo province so far, especially in the east. Even if the government reaches grid extension targets by 2030, there are many communities desiring immediate energy solutions. Solar energy prices have been falling drastically in the last 10 years and as the prices get closer to "grid parity" the hope will be that solar can compete with grid-electricity long before 2030.

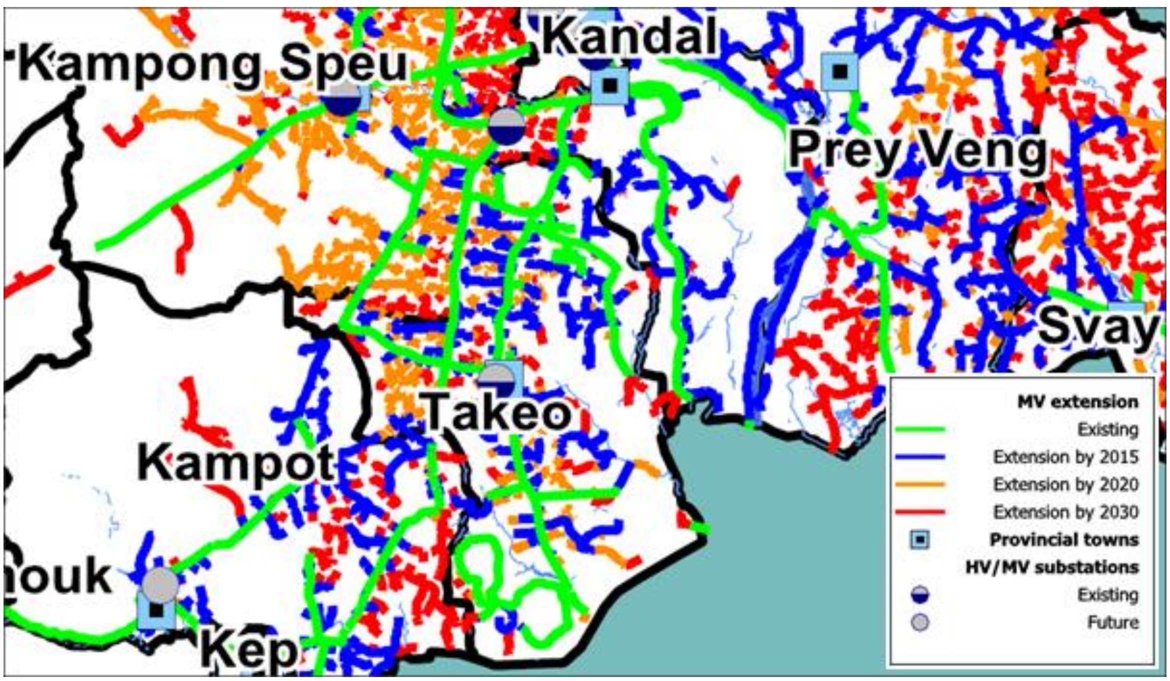

Figure 34: Grid Extension Plans to 2030 (green is existing, blue by 2015, orange by 2020, red by 2030)

Source: IED, 2011

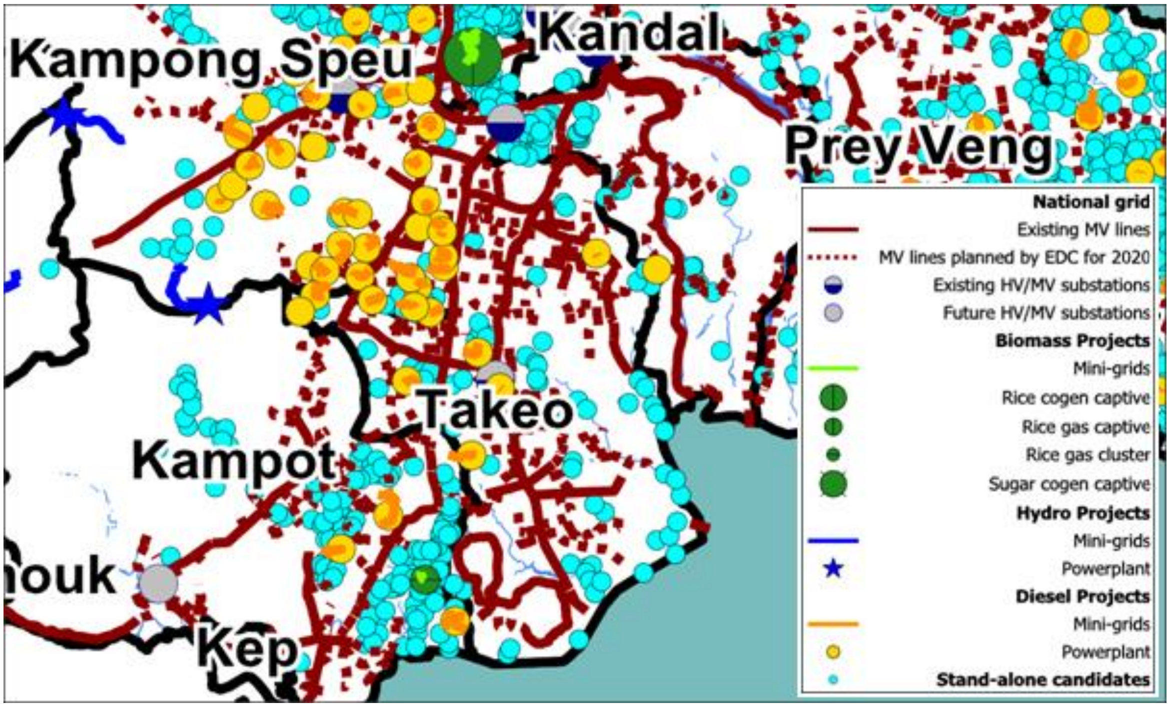

Figure 35: Grid Extension by Mini-grid and Standalone Systems (grid extension by 2020 in red, stand-alone villages by 2020 in blue, power plants in yellow)

Source: IED, 2011

Conclusions and recommendations

- **Grid penetration into Takeo is minimal and will remain so even up to 2030, leaving most of the province as a suitable market for SHS.**
- **ISAC's history in the province and central location is an advantage over other SHS distributors in the market.**

1.3 Market Players

Unlike the case with solar cookers, SHS distribution is already an established and growing market in Cambodia. As ISAC strives to locate its place in this market, it is useful to take a brief glimpse at the other market players.

1.3.1 Solar Product Manufacturers

There is little manufacturing in Cambodia in general and most products are imported and resold. The reason for this is the relatively small population and lack of manufacturer support and incentive. Kamworks is the only solar company that has attempted to manufacture locally. Their first product, the MoonLight solar lantern was designed and assembled in Cambodia. Despite being locally made, the components for this solar lantern were all imported from other countries in the region or further.

1.3.2 Solar Home System Resellers

Most of the local Cambodian companies including Khmer Solar, KC Solar, NRG Solutions, Kamworks, and Solar Energy Cambodia are just assemblers and resellers of imported SHS components. These companies simply import solar panels, batteries, charge controllers and inverters, to assemble the SHS package for sale. These companies have their own sales teams as well as technicians for installation and maintenance. Since prices are mostly related to international component prices and importing, it is best if the company can order components in large quantities.

1.3.3 International Players

There are few international parties interested in Cambodian SHS projects since there have been so few of notable size. Only the World Bank REF project in 2011 to distribute 12,000 SHS to 7 provinces got the attention of international players, several of whom bid on the project both to import the components and install the systems.

1.3.4 Government

Aside from previously discussed government support of SHS, from time to time government ministries tender projects to the private sector. The Ministry of Interior (MOI), for example, funds SHS projects occasionally.

1.3.5 NGOs

The NGO sector is often involved with SHS integration, usually incorporated as part of their regular programs and usually outside the market, in areas which are too poor for companies to target. There are no known NGOs that focus only on SHS distribution. NGOs typically do not import or install their own SHSs but instead tender to the private sector companies.

Picosol Cambodia is the only known NGO to focus entirely on solar energy. They have professional training courses for SHS installers, maintainers and sellers. Picosol has worked with many of the established solar energy companies including Khmer Solar, Kamworks, and NRG Solutions. Picosol recently produced the “Solar Roadmap for Cambodia” (Figure 36), which shows various players and their activities related to solar energy and SHS. Activities necessary in order to reach larger solar dissemination are divided between stakeholders over time. The yellow arrow suggests a possible market location for ISAC.

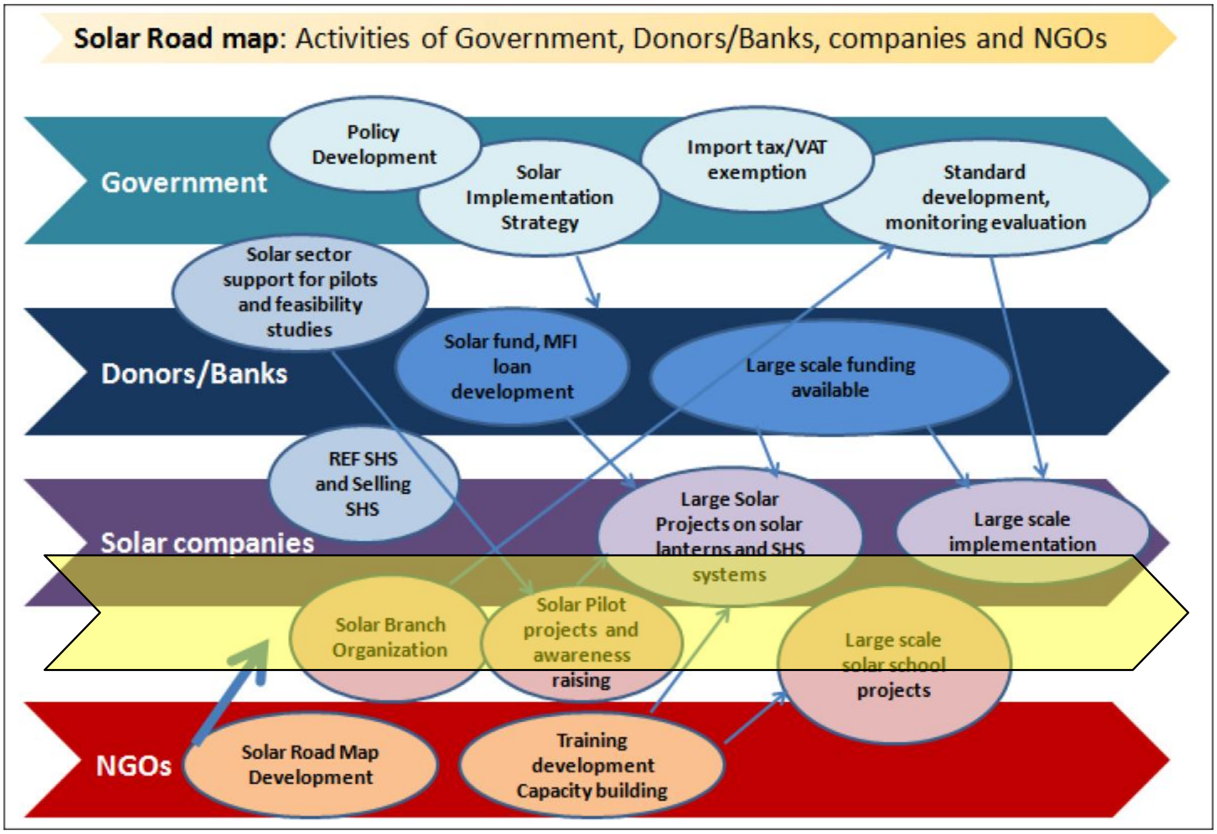

Figure 36: Flowchart of Stakeholder Involvement (suggested ISAC positioning in yellow)

Source: Picosol 2011

Table 5: SHS SWOT Analysis

Strengths	**Weaknesses**
▪ SHS component understanding ▪ SHS assembly and installation training ▪ Long presence in Takeo ▪ Components available locally ▪ Educated and enthusiastic staff ▪ Developed ISAC facilities	▪ Long history of non-commercial activities ▪ Lack of sales and marketing experience
Opportunities	**Threats**
▪ Excellent sun resource in Cambodia ▪ Minimal SHS penetration into the market ▪ Lack of rural electrification ▪ SHS prices continually falling ▪ Location in Takeo province ▪ Donated initial batch of stock ▪ Cheap Energy Farm charge controller	▪ Reputation of solar projects in Cambodia ▪ Competition from established companies ▪ Lack of distribution options ▪ Cheap low quality products ▪ Low rural solar awareness

Conclusions and recommendations

- **The future role for ISAC in the SHS market is unclear. On the one hand, they cannot continue to receive funding to sell systems and disturb the market and on the other hand they cannot jump into direct competition with other solar companies, lacking sales and distribution experience and skills to select and import SHS components.**
- **Thus, they need to take a strategic approach while setting the clear goal and vision.**

2 Sales and Distribution

ISAC is currently in the process of selling their first 60 SHS as a practical way to test the market. During this process, they are also considering how they may function in the future with a more commercial approach.

2.1 Marketing, Awareness, and Demonstration

As mentioned earlier, only a third of Cambodians have ever heard of solar energy and only a tenth have heard about someone who has a system. A lot of effort still needs to be put into awareness and marketing so that households not only understand the potential of solar, but desire and demand begins to grow organically. Lack of modern communication requires any marketing effort to be tailored to the needs, aspirations, and expectations of the potential customers (SNV, 2011). All the basic aspects of marketing (product, place, price, promotion) need to be addressed in this market that is so young.

In 2010, IDE achieved a marketing breakthrough in an industry traditionally only held by NGOs. They introduced a best practice for toilet manufacturing along with a marketing campaign which cleverly pointed out the health risks associated with open defecation. Their toilets instantly became an appealing product and over 10,000 were sold in the first year.

Even in poor rural areas, there is no shortage of motorbikes, TVs, and mobile phones. SHSs have the potential to impact families as strongly as these products but there has never been the widespread desire as seen in other countries of a similar development.

2.1.1 SHS Product

A new technology needs to offer something better to customers than what is already commonly used. Solar products have several qualities which may not be obvious right now to the general public. In a rural community familiar with car battery and kerosene use, solar offers no fire hazard and a stationary power supply. Villagers do not realise the amount of time and cost that accumulates transporting batteries to a central diesel charging station.

2.1.2 SHS Place

Marketing activity should be focused on the target area and this means travelling into the most remote areas of Cambodia. Rural families typically live their lives very close to home and rarely ever travel to major urban areas. Therefore, solar demonstration needs to be brought to them where they can have time to experience its value. SEC is a leader in this regard as they spend the majority of their time in rural villages spreading the message of solar by word of mouth.

2.1.3 SHS Price

IDE managed to manufacture their toilet for less than a quarter of what had been spent previously. This made the product within reach of a much larger audience. There is a market price for every product and in Cambodia this does not mean as cheap as possible. As in the case of mobile phones and motorbikes, more expensive products can be popular as they become symbols of status. Kamworks has taken this approach with their SHS, deciding not to compete on price but rather creating a recognized quality brand.

2.1.4 SHS Promotion

The Cambodian countryside is not a place that responds well to modern marketing methods. Ideas are shared and reputations built largely through experience and word of mouth. Clients like to see what they are getting. “It is easy to do it, once the neighbour has done it!” (Frankfurt School, 2011). Solar is a new concept which has not yet gained market trust. The opinions of relatives and village leaders are also very important before adoption of a new product. A good example of joint promotion came from the partnership of Picosol, CMK and Kamworks. In a specific district of Kandal province in 2010, Picosol led demonstration and awareness events and funded 20 showcase systems for health clinics, police stations, and commune halls. Kamworks provided solar products and CMK provided financing options for customers. Demonstration events and solar road shows were received well as they combined entertainment and lucky draws for solar products.

Conclusions and recommendations

- **Creative and clever marketing is still needed in the solar industry to spark demand and desire for solar products.**
- **ISAC has a long and established presence in Takeo which is a strong foundation for understanding the best marketing strategy for the area. Strong connections built over the years can help with word of mouth advertising and special access to villages.**
- **Private-public partnerships are important as companies cannot afford to take on the entire burden of solar awareness and demonstration.**

2.2 Financing SHS

Financing is the most important aspect of SHS distribution, both for this project and other organisations working to do the same. There is question about financing for the supplier (ISAC in this case) as well as financing for the customer (end user of the SHS). ISAC currently has the advantage of donated stock and does not have real market pressure to make sales and receive payments as fast as possible. Therefore, the case of ISAC’s market testing with 60 SHS will be addressed along with a second future case where ISAC will need to pay for new stock from their revenues. As with the financing discussion with solar cookers earlier, the following sections will focus on financing options for customers and not ISAC itself as a SHS supplier.

2.2.1 Government Financing Programs

There is currently no government support for SHS financing, both for the supplier as well as the end user. In the past few years there were attempts through the World Bank financed REF government program to offer subsidies per installed SHS but this program was not successful and has since ended.

2.2.2 Microfinance Partner

A microfinance partner could relieve the brunt of customer financing, giving ISAC a second choice to offer customers rather than only up-front cash payment. In an ideal relationship, ISAC would find a customer interested in a loan and then forward the request to an MFI partner to evaluate the customer's credit worthiness. If accepted, the full cost of the system could be paid upfront to ISAC and the MFI would take care of collecting payments for several months. The sale would be exactly like a cash sale from ISAC's point of view and there would be no problem in using revenues to buy more stock to continue selling SHS. Unfortunately, establishing this relationship with an MFI is more difficult than it sounds and several attempts have been tried in the solar industry to get such a program going.

There is currently a "general reluctance to disburse RE designated loans" in the MFI sector, the main reason being a "general lack of awareness and lack of knowledge of the advantages of alternative energy forms for rural households" (Frankfurt School, 2011). There are few MFIs who are willing to talk about loans for SHS and fewer still who have done real testing or developed SHS specific loans. AMRET and PRASAC have been involved with financing in a bio-digester program, Vision Fund has been conducting surveys and studies in 2011-2012 regarding SHS financing, and CMK is currently piloting a small project for SHS financing with the solar energy company, Kamworks. ACLEDA Bank has recently entered into a partnership with the NGO, LOCAB. Although the relationship is just beginning, LOCAB would provide technical expertise and maintenance of sold systems while ACLEDA would provide the financing (IFC, 2012). All of these mentioned MFIs have local presence in Takeo province but will only approach the subject of SHS loan financing on a case to case basis.

Some of the obvious reasons why MFIs are reluctant to develop SHS loan programs include questions about what to do if there are technical problems with a SHS after sale, what to do if a customer wants the system removed, and the primary use of a SHS not being an income generating activity which makes it more difficult to know if a customer will be able to afford payments or not. Finally, loans are typically larger than MFIs are comfortable giving. The types of systems demanded most by the market are in the range of \$400-\$1000 and therefore require a 2-3 year payback time in most cases.

There is also the end user customer perspective to consider. As mentioned previously, the 29.82% per year interest rate is a huge deterrent for a customer as this can add a 30% increase to the total price of the system. When customers take the time to calculate this, many lose interest in the option of a MFI loan.

Despite the challenges with micro-finance it is advisable to pursue this partnership option. It may take several meetings and some negotiation, but if an agreement can be made, it is advantageous to at least have this financing method available in order that it can be offered to customers as an alternative to direct cash payment.

2.2.3 Self-financing Sales

Self-financing refers to ISAC selling a SHS and collecting incremental payments over several months or years after the sale and installation. This will no doubt be the most tempting option for ISAC as they begin market testing since they are not bound by time to recover their investment for initial stock. Also, it will be much easier to sell systems if customers are given other options than paying the full price upfront. However, going down the path of self-financing is a slippery slope since word can spread fast about attractive payment terms and soon all customers will expect the same in the future.

In the future when ISAC must buy new stock from their revenues, they will not have the luxury to wait months or years to recover their investment. Therefore, it is most advisable to focus on direct sales wherever possible. If self-financing is used, it should be limited to a certain amount of units per month or used only to break into poorer communities.

2.2.4 Direct cash-sales

A direct sale of a SHS to an end user customer is the preferred option as money can be collected immediately and therefore used immediately to buy new stock for additional customers. Selling for upfront cash will shrink the market as most households cannot afford to buy a SHS in one payment, however, there are companies who only sell through cash sales and have been very successful. SEC, which was started in 2008, deals only in cash sales, and has already sold and installed more than 2000 units (SEC, 2012). There are also certain times of the year where there is more cash on hand. For example, after harvest could be an opportune time to sell as families have more than usual cash on hand.

Awareness and marketing are also an important factor. Cambodians save and gather cash for certain items that they find most useful. This can be seen in the poorer countryside where many families own motorbikes, TVs, and several mobile phones.

Conclusions and recommendations

- **ISAC should focus on direct cash-sales at first without any financing for customers. This is the only way to get an honest picture of the market during this testing phase.**
- **ISAC should avoid self-financing payment programs for customers so as not to set a precedent they cannot follow in the future.**
- **MFI partnership is not an easy solution to customer financing and a fast enough solution to consider in the initial testing phase. However, in planning for the future, it would be wise to begin building relationships with local MFIs in the Takeo capital (Vision Fund, AMRET, PRASAC, AMK, CMK, Acleda) to see what is possible regarding SHS financing in the future.**

2.3 Distribution Options

Solar products are most popular in remote areas that are difficult to access. Therefore, distribution of systems to customers is inherently difficult for everyone involved. It is expensive to have systems sitting in storage, especially in numerous remote locations but without rural storage locations, the distance to customers for installation and maintenance is expensive.

The ISAC SHS product, like the solar cooker is not appropriate for distribution alongside other products in third party channels. The product requires qualified installers and ISAC needs to be in direct contact with customers in order to offer maintenance and after-sales service.

In the history of SHS business in Cambodia, companies have not been able to support many storage locations or offices aside from their main location. SEC has retail offices in six (SEC, 2012) major Cambodian cities which is insignificant when considering the distance to remote regions. The SHS distributor, Grameen Shakti in Bangladesh (see case study at end), supports 1485 offices in order to reach the necessary rural areas and Bangladesh is 20% smaller in size than Cambodia. This is an unfair comparison but it hints at the challenges involved with distributing SHS in Cambodia to the communities that need them most.

As discussed with solar cookers, ISAC has little choice at the moment regarding distribution. It is important to keep operations close to their office in this testing period so they can easily interact with customers, perform maintenance, and provide after-sales service. ISAC is centrally located in Takeo province and it is feasible to service most of the province by keeping a central stock and distributing directly to customers after each sale or group of sales.

Figure 37: Difficult Distribution on the Roads and Rivers of Cambodia

Source: Kamworks (2011) left, NRG Solutions (2012) right

Conclusions and recommendations

- **It is too early in ISAC's solar program to discuss distribution in much detail. For the testing period with the first 60 systems, there is no choice but to distribute from their main office to each customer or group of customers directly.**
- **Future distribution outside of Takeo would bring great challenges to ISAC and it is too early to strategize, since there is no decision on what future role ISAC may have in the SHS market.**

2.4 Installation, Maintenance, and Service Considerations

The future of SHS success in Cambodia has everything to do with installation, maintenance, and service. Many companies are able to import and assemble SHS packages but only the best ones have figured out what to do when systems of their customers fail in difficult to reach locations.

Using quality components is a good start in avoiding after-sale hassles but even the best systems still have occasional problems. Often it is not the main components that fail but rather a corroded connector or a rat-chewed wire that cripples the system.

Customers appreciate SHS warranty but it is a lot easier to offer than honour. It is risky for a company to offer longer warranties than offered by the component manufactures to the company. For example, customers want warranties for the system longer than 1 year but it is rare to find a battery manufacturer in China offering warranties greater than 1 year.

The case of financed systems brings after-sales challenges because any fault in the system can cause customers to delay or withhold payments. In these cases, a company has no choice but to offer good service until the system is paid for, irrelevant of system warranty conditions.

The most successful SHS installers in Cambodia are able to arrange maintenance with the least amount of travel and effort, either by having a network of skilled technicians in the customer's region or the ability to solve problems over the phone.

Conclusions and recommendations

- **Every visit to a customer after installation is costly for a company so make sure systems are installed professionally and customers are able to perform their own simple maintenance (wiping dust from panel, checking for broken cables and corrosion on connectors).**
- **Travel to and from a customer along with system maintenance during the warranty period can eat up all a company's profits. Take care with offering warranties and make sure the customer is clear on the details of the warranty.**

3 Product Analysis

3.1 Product

ISAC has three sizes of SHS for their market testing phase. This includes 20 units each of 50Wp, 80Wp and 100Wp systems. IFC (2012) suggests that "40 Wp and 80 Wp SHS are the most popular SHSs available targeting the rural affluent and rural rich". In a recent WB-REF project, 12000 SHS sized 30Wp and 50Wp were procured for subsidized sales in 7 provinces (REF, 2012). After the project, all 50Wp systems were sold but there was trouble selling the 30Wp systems. There was also an overwhelming demand for systems larger than 50Wp. The reason for this is the customer's desire to power color TV. A 30Wp system could not power a typical TV (14") for more than ½ hour, and a 50Wp around 1 hour per day. Normally at least an 80Wp system is needed to power a TV for 2-3 hours per evening since those available usually consume at least 60W per hour.

SHS companies in Cambodia have different views on what should be included in the SHS package. At the higher end, Kamworks offers only quality components, complete with a solar battery and battery box, panel roof support, and high quality wiring. Other companies like SEC sell systems without batteries so customers can continue to use their car battery.

Conclusions and recommendations

- **ISAC's choice in offering 50Wp-100Wp sized systems is a good choice given the history of successful sales in Cambodia.**
- **In the testing period with the initial 60 systems, ISAC should consider offering different types of packages in order to gauge market response. For example, systems could be offered with or without battery.**

3.2 Price

Solar companies have been working long enough in Cambodia to establish a known price range for small SHS (<100Wp) packages. The package usually contains a solar panel, charge controller, battery, wiring and an inverter for the larger sized systems. The retail price of these SHS ranges between $7-9/Wp (IFC, 2011). This means that an 80Wp SHS would retail anywhere from $560 to $720.

This price range is based mostly on the cost of imported SHS components and the cost of installation and service. Companies who import in large quantities or sell SHS with cheaper quality components can offer lower prices. Some companies offer more features, longer warranties, and good after sale service which places them at the top of the price range.

One of the most difficult challenges with SHS pricing is the cost of installation and maintenance. This has everything to do with road conditions and the distances to remote villages. Some companies change the price based on the distance to the customer and others will not even install if there is only one system in a distant village.

To achieve the $7-9/Wp price range, installation and maintenance is usually carried out completely by motorbike with occasional use of a larger vehicle if there are multiple systems.

ISAC has already spent considerable time deciding on a pricing strategy for their systems, however, it is difficult to set firm prices until more experience is gained through sales and installation. ISAC prices are currently lower than the market average which at first glance could be a possible market advantage. However, there are many unforeseen expenses during travel and differences between each rural household. Price calculations can easily miss small components like circuit breakers, cables, lamps, sockets and junction boxes which quickly add up.

ISAC has no plans to import SHS components in the future but rather, buy from other solar companies. Importing SHS components is one of the major activities of established solar energy companies and they would include a significant profit margin before selling components to ISAC. ISAC should consider their future price in relation to the market average when this is taken into consideration.

Conclusions and recommendations

- **ISAC's current price list for systems is lower than the market rate. This cannot be the final retail price since they have not had experience with sales and installation yet. There are many hidden costs that must be accounted for in the price if ISAC is to operate on a commercial basis. Hidden costs usually come in the form of small components (wires, connectors, circuit breakers) unique to each installation and unforeseen delays and challenges on the back roads of rural areas, especially in rainy season. ISAC should also keep in mind their future as a commercial entity buying SHS components at market rate. It is no advantage to have cheaper pricing for the first 60 systems if the prices must be raised afterwards.**
- **ISAC should keep their prices flexible, at least until after the initial testing phase with 60 systems. To be safe, an extra margin could be added in order to account for unknown hidden costs.**

3.3 SHS Components

The SHS package is only as good as the quality of its components. Most often the package includes a solar panel, charge controller, battery, and wiring. The best quality components come from America, Japan and Europe but over the last few years, much of the manufacturing has shifted to Asia and now China and other countries like India, Korea, and Vietnam are popular locations to buy components. Solar panel and battery manufacturing in specific have almost entirely moved to China and more and more manufacturers are offering components according to international quality standards.

In the history of Cambodian SHS distribution, there have been a variety of components installed in rural homes ranging from cheap charge controllers and inverters from Vietnam to solar panels from Vietnam and charge controllers from Germany. As mentioned earlier, the penetration rate of SHS so far has been quite low and the reputation of solar and solar companies is still questionable. This would suggest that the choice of components is very important in solar awareness and reputation. There is also the question of SHS maintenance. SHS have the potential to be nearly maintenance free if quality components are used. This is extremely important as multiple visits for maintenance and troubleshooting can waste the entire profit from the sale of a system.

Conclusions and recommendations

- **Using higher quality components means higher SHS prices but less maintenance and repairs.**
- **ISAC has been testing the low-cost Energy Farm charge controller manufactured in Korea. Using this component may prove to be a market advantage as it is cheaper than the alternatives.**

B Solar Cooker

1 Market Analysis

1.1 Global Context

Solar cookers are not a new technology and have been distributed in many forms to many countries throughout the world. There are hundreds of organisations in many countries that are manufacturing parabolic-style cookers similar to that of ISAC. Nearly all projects are in developing countries with similar end users to those in Cambodia. Some important conclusions can be made when comparing a few of these organisations. Firstly, distributors of solar cookers are a mix of not-for-profit NGOs and companies.

In developing countries which are poorer and have smaller and more dispersed populations, generally NGOs are the primary solar cooker distributors. In these cases, the cookers are usually subsidised, since the product is too expensive for end users. In many cases, these subsidies do not interfere with market forces because the NGO projects are in the poorest communities where end users have no purchasing power.

Companies who have been successful with commercial sales of solar cookers are found in countries where there are highly concentrated markets such as India, China, and Bangladesh. In these markets, local mass production (thousands of units) and shorter distribution channels help to lower the price. Cambodia does not fit into this category since access to infrastructure is relatively poor compared to its neighbours and countries of similar income levels. Cambodia's low income, low population density, and history of conflict are reflected in the poor coverage, quality, and efficiency of much of its infrastructure (WB, 2006).

Conclusions and recommendations

- **Solar cookers can be found across the world and have been distributed by various means and incorporated into many different projects.**
- **There has been commercial success for solar cooker distributors, mainly in concentrated markets. Solar cookers are also being distributed to countries with more dispersed and poorer populations but generally by means of subsidized NGO or government programs.**
- **There is a wealth of information available about solar cooker projects in other countries. Careful research of successful and unsuccessful projects in other countries will help prepare for future activities in Cambodia.**

Table 6: Parabolic Distributor Comparison

Organisation	Organisation Type	Country	Market	End User Price	Parabolic Type	Subsidy
Sol Suffit	NGO	Senegal, Tanzania	NGOs, resale through entrepreneurs	$110	Eco3	NGO Subsidy
PRINCE	Company	India	End user households	$120	SK-14	15% Government Subsidy
PRINCE	Company	India	End user households	$120	Pressed-metal sheets	15% Government Subsidy
Starlight Afghan Free Energy	Company	Afghanistan	NGOs, PRT, end user households	$80	Pressed-metal sheets	No
Barli	NGO	India	End user households	$20	SK-14	90% cost covered by NGO
SEC	Company	Cambodia	End user households	$180		No
Soleil Burkina	NGO	Burkina Faso	End user households	$150	Papillon	Yes
ISAC	To be confirmed	Cambodia	To be confirmed	$160	SK-14	N/A
Solar Serve	Company	Vietnam	End user households	$100	SK-14	No but cheaper Chinese reflectors used

Figure 38: SolarCooker Eco3
Source: Solar Cooker NV (2012)

Figure 39: PRINCE (Indian Manufacturer) pressed galvanized steel solar cooker

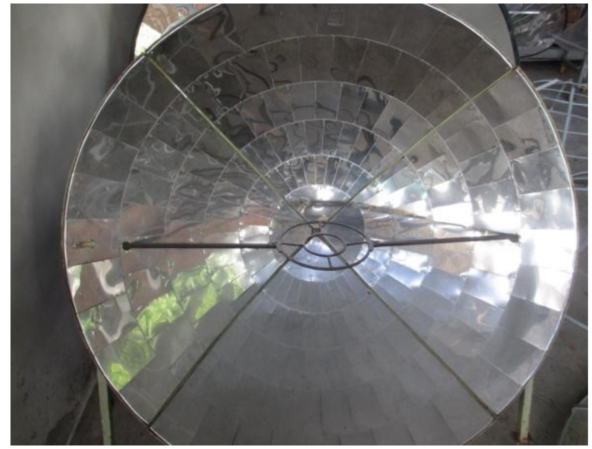

Figure 40: SK-14 Solar Cooker using cheaper Chinese-made reflectors

Figure 41: SK-14 Solar Cooker using expensive German-made reflectors
Source: ASEIC (2011)

Figure 42: Papillon Solar Cooker
Source: SCI (2004)

Figure 43: Starlight (Afghan Manufacturer) pressed steel parabolic solar cooker
Source: Afghan Starlight (2012)

1.2 Cambodian Context

Energy prices in Cambodia are some of the highest in the world and therefore traditional biomass accounts for 90% of cooking fuel, resulting in one of the world's highest deforestation rates of 0.8% per year (Frankfurt School, 2011). Solar cooking is an attractive alternative, emitting no smoke and requiring no biomass. Unfortunately, there are limitations to solar cooking as sun energy cannot be controlled. Cambodia is generally a sunny country but there are many times of the day and year when it is not possible to cook with solar energy.

The Cambodian dry season offers consistent and favourable conditions for solar cooker use but the rainy season can be quite unpredictable. Initial testing by ISAC in Takeo has already shown that it is challenging to rely on the solar cooker during the rainy season, which typically lasts from May to October.

Agriculture and specifically rice farming, accounts for the majority of rural Cambodian work. In Takeo province for example, 94% (NCDD, 2009) of families have their main occupation as rice farmers. In rural areas, the typical family wakes up early to eat breakfast so they can get an early start before the heat of the day. Most families return to eat lunch at 10:00 or 10:30 and are too hungry to wait until noon when sun conditions for solar cooking are the most favourable. The evening meal is often eaten after dark since the sun goes down around 6PM. After an in-depth study into solar cooker distribution across the world, GTZ (2007) concluded that solar cooker acceptance remains the greatest challenge. This is surely the case for Cambodia as well since serous lifestyle changes are required for solar cooker users in order that they can capture the full potential of the technology. This could mean eating at different times in the day or moving to a more flexible eating schedule which can account for cooking delays due to changing sun conditions.

A typical stilted Cambodian home will have the cooking area underneath the house or behind in an attached covered shelter. Families are not used to cooking in the open where sun conditions are the best and ISAC has found through initial testing that privacy is also a concern. Creative options to integrate solar cookers into the lifestyles of such families are necessary.

The current price of the ISAC solar cooker is estimated at $160 and this is already expected to be a significant barrier to sales and distribution. Initial survey results indicated that families in target regions of Takeo province use wood for approximately 75% of their cooking fuel. This is promising news for solar cooker introduction but the most ideal users of solar cookers should find it difficult to gather wood for free, in order that they desire an alternative to the high cost of wood.

Solar cooking is a new concept in Cambodia and ISAC has only demonstrated the technology a few times. Therefore, it is too early in the project to make any conclusions about the solar cooker reception in the Cambodian context.

Conclusions and recommendations

- **Cambodia is an ideal market for solar cooker introduction as wood burning is the primary means of cooking for the overwhelming majority of rural families.**
- **Solar cooking conditions are favourable in the Cambodian dry season but challenges exist in the rainy season where the weather is more unpredictable.**
- **A lifestyle change is required for users to take full advantage of solar cooking.**
- **ISAC has only just started to introduce their solar cooker so no conclusions can be made at this time regarding the general reception of the product in the Cambodian market.**

1.3 Geographic considerations

ISAC currently has very limited geographical access to the Cambodian market. Their only office is located in the far south of Cambodia and there are no plans in the near future to expand to multiple locations. Since it is only the beginning of product distribution, it is important to keep in contact with customers for feedback and after-sales service. This can only be possible if the distribution is contained to a small region so that the project can be closely monitored and evaluated. Therefore, the majority of solar cooker distribution should be contained to Takeo province.

If sales conditions prove favourable, expansion of distribution channels to Kampot or Kandal provinces might be possible. Urban areas are not suitable for solar cookers since the cookers take up a significant amount of space and should not be shadowed by neighbouring buildings at any angle of the sun during the day.

Since 94% (NIS, 2007) of rural Cambodians cook with firewood (4% charcoal), the best market for a solar cooker would be in non-forested areas and especially those regions that have been recently deforested as distribution lines for wood fuel from other areas are not established. In these regions, it is more difficult to gather wood for free and therefore, there are more potential customers who might seek alternatives to wood-burning stoves.

The ISAC office is located in Takeo, which is a largely non-forested region (see Figure 44). Thus, Takeo province, Kandal province and the east side of Kampot province are ideal market locations for solar cookers geographically. Angkor Borei is one district in Takeo province which has been recently deforested (Figure 45). This could be a district to target sales efforts within Takeo province.

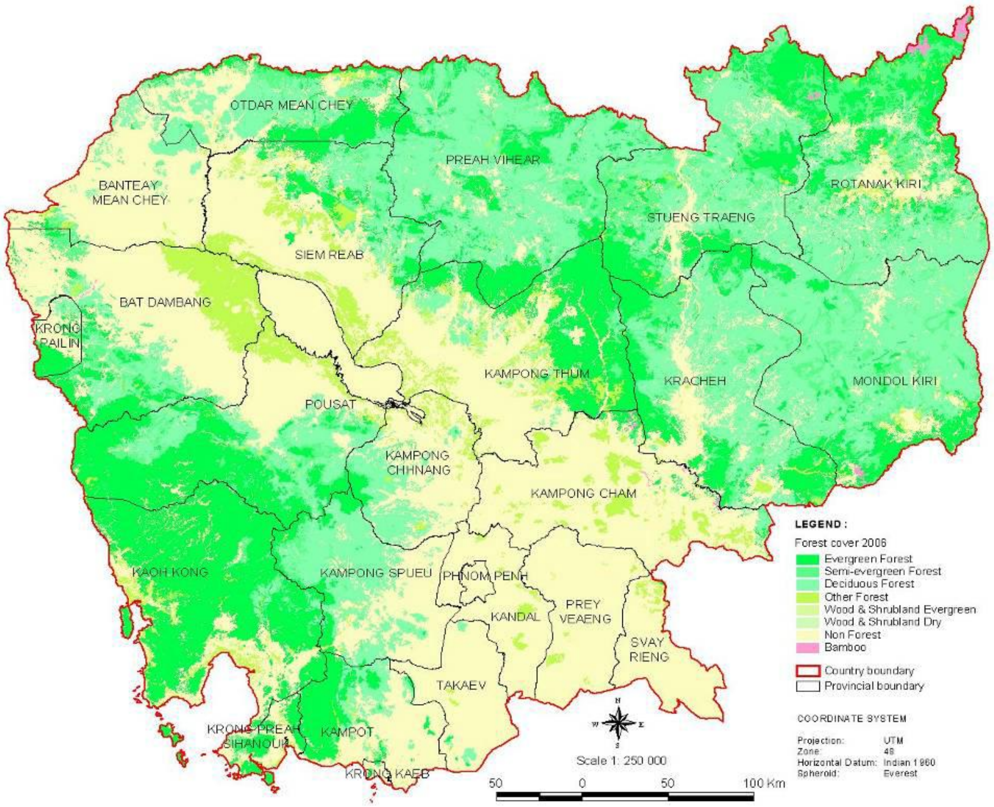

Figure 44: Forest Coverage Map 2006

Source: FA, 2010

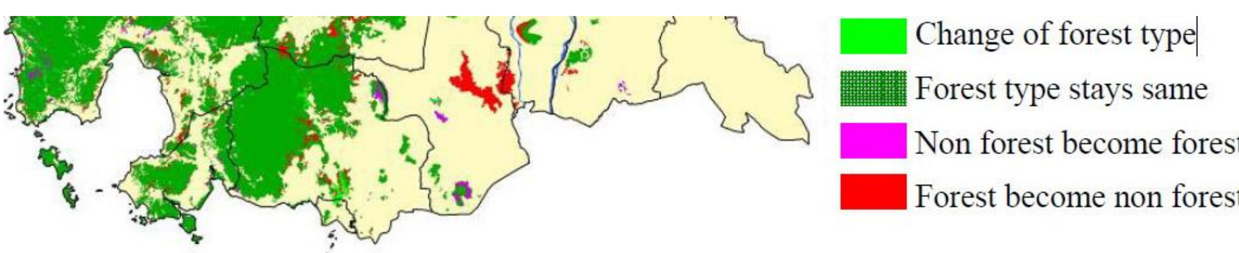

Figure 45: Forest Cover Map Change 2006 (Southern Cambodia)

Source: FA, 2010

Conclusions and recommendations
▪ **The ISAC office is conveniently located in the middle a favorable geographic market (Takeo Province) so this is the most logical area to start selling/distributing solar cookers.**

1.4 *Solar Cooker End User*

The 1.4 diameter solar cooker is designed specifically for single (extended) family use. The ideal customer would be one that has traditionally cooked with a woodstove but finds it increasingly more difficult or expensive to find wood. Many villages exist in this situation where the nearby wood resource is exhausted or gathered only seasonally and the only alternative is to buy wood. The ideal customer would be a rural family living far from the nearest town market, where supplies for daily living are difficult to acquire and transport.

Petroleum-based fuels for cooking, specifically Liquid Propane Gas (LPG), are preferred in higher income urban areas because these fuels are convenient and easy to use, even though they are more expensive than biomass fuels (IBRD, 2011). This is the case in Cambodia and likely all would cook with LPG if they could afford it. The ideal solar cooker customer therefore, would not be able to afford this luxury or the ongoing cost of gas fuel or would be outside of gas container distribution channels.

1.5 *Target Customer*

The target end user of the SK-14 is a rural family but this is not necessarily the only possible customer for ISAC.

1.5.1 End User

Selling to the end user is the most favourable option but it is too early in the project to know if this is possible. The typical end user (rural family) will surely struggle to pay for a solar cooker up front. The most ideal end user (poorest rural families struggling to find wood for stove cooking) may not be able to afford the solar cooker even with financing options. ISAC is still in the beginning phase of real sales testing to end users so it is too early to confirm these concerns.

1.5.2 NGO

Cambodia has over 200 international and 800 local NGOs who are actively engaged in promoting local development (WB, 2006). Many of these NGOs are involved in rural development, agriculture, food security, natural resources and the environment and could have interest in solar cookers to compliment their programs.

Many NGOs are involved in the poorest regions of the country where a solar cooker would be the most useful but the family would never be able to afford the product, even with financing. As environmental concerns start to play a heavier role in development and aid, more NGOs are looking for projects that address these issues.

The NGO as a direct customer is a possible option for ISAC who has been concerned so far mostly with capacity building and manufacturing. Taking the role as the product supplier with direct sales to NGOs avoids the long process of ISAC building up its own sales force, demonstration and distribution network.

1.5.3 Existing Companies

There are more than 20 (YP, 2012) companies selling solar products in Cambodia. Several of them have product lines which aim to offer a wide variety of solar options. A solar cooker may prove to be a complimentary addition to an existing company's product line, especially one that can be marketed as "made in Cambodia". An existing Cambodian solar energy company could be a possible customer and reseller of ISAC solar cookers. At present, Solar Energy Cambodia (SEC) offers solar cookers but in practice they do not stock them in Cambodia and instead import from China upon request.

1.5.4 Solar Cooker Rental

A solar cooker rental program has potential on a limited basis as customers would have the advantage of using the product only when it is most convenient for them. While this option would surely mean a longer pay back time for ISAC, it avoids the upfront cost to the customer. Testing a rental program should be considered but only after analysis of the full cost of administration and management. Since each solar cooker is difficult to transport long distances, the costs associated with transferring the product between customers should be fully considered. There is also the risk of added administration cost if a customer rental schedule needs constant attention.

1.5.5 Mobile Food Vendor

It is very common in urban Cambodia to see food sold from street-side carts. Carts are normally pushed by hand or attached to the side of a motorcycle. Some vendors cook food from scratch, and others have pre-prepared food that is heated upon request. There is potential for solar cooker sales or rental to such a food vendor but only after a practical test is conducted. Customers of street-food carts generally do not want to wait long and only actual testing can show whether or not the solar cooker could meet customer demand in such a fast-paced urban context.

Conclusions and recommendations

- **The target user of the solar cooker is obvious but the ISAC customer is not. Selling to the end user is the most favorable option, but this may not be possible given the financial constraints of the ideal end user. If the end user can not be the customer, then the customer could be an intermediary such as an NGO or a company.**
- **Research the NGOs working in Takeo and those with their head offices in Phnom Penh to see which may have missions to address environmental concerns that could be mitigated by the use of solar cookers.**
- **Meet with select NGOs to see if they would be interested in partnering in the future to purchase ISAC solar cookers and integrate them into their projects. NGOs are now beginning to draft budgets for the upcoming 2013 project cycle. The next couple of months are critical regarding sales of solar cookers for their projects.**

Table 7: Solar Cooker SWOT Analysis

Strengths	Weaknesses
▪ Manufacturing knowledge ▪ Local production ▪ Office location ▪ Contacts in Takeo province	▪ High price ▪ Technology not easily integrated into Cambodian culture and climate ▪ Lack of sales + business training
Opportunities	**Threats**
▪ Free firewood is more difficult to find ▪ Donor funding available ▪ Large target group ▪ Donated initial stock of product	▪ Cambodian road conditions ▪ Clouds and rain for half the year ▪ Dispersed population ▪ No commercial SK-14 market

The analysis of ISAC's potential solar cooker market is summarised in the Table 7 SWOT Analysis.

2 Sales and Distribution

2.1 Marketing and Awareness

2.1.1 Marketing

Solar cooking is a brand new idea in Cambodia. The parabolic solar cooker is unknown to the majority of Cambodian families and cooking food by sunlight alone is surely nothing short of magic to a population accustomed to wood-fired stoves. Demonstration is therefore the most powerful marketing method available. This kind of product would be difficult to describe and sell by any other marketing methods (print, radio, TV).

2.1.2 Awareness

Environmental and health related awareness can make solar cooking more attractive to rural households. Families endure wood burning stoves because of their economic situation but are not happy with the smoke and smell. The smokeless solar cooking option is therefore an attractive alternative, especially as families become more aware of the risks of regular smoke inhalation.

2.1.3 Demonstration

Solar cooker demonstration is certainly the most essential marketing tool available. To a population that is accustomed to seeing materials burn in order to cook food, solar concentrated heating needs to be witnessed first-hand. Print, radio and discussion could add details to the purchasing options but on-location demonstration remains the only reasonable form of marketing until solar cookers are more common and understood.

Unfortunately, demonstration is an expensive and time consuming activity, compared to print flyer advertising, for example. There are limitations to how many people can be invited to ISAC for demonstration and eventually there will be the need for a travelling demonstration show. The solar cooker is a large product to carry around the countryside and distances between rural villages are significant, considering the poor quality of roads.

The high costs of solar cooker demonstration can likely not be paid for through product sales, especially at the beginning. Therefore, whether or not the project is commercially viable, it is possible to have funding support to cover demonstration and awareness events.

Leaving a test solar cooker in a target village for a length of time could be an alternative to a demonstration show. Since the cooker is easily portable for short distances, it is possible to wheel the equipment between households in order that every family can test the unit for a couple of days.

Rural Cambodia has plenty of gathering places suitable for solar cooker demonstration, including market areas, commune and district halls, pagodas, and schools. These areas would be great locations for demonstration events, assuming there is advance notice given. There may also be options to partner for events with those demonstrating other products like filters and toilets for example.

Conclusions and recommendations

- **Demonstration is the primary marketing tool.**
- **Funding to cover awareness and demonstration events is necessary whether or not solar cookers become a commercial product.**
- **There were only four official ISAC demonstrations in the first year of the project. ISAC needs to consider a more serious and systematic approach for solar cooker demonstration, covering a certain amount of area per month.**

2.2 Financing Options

Financing is a concern for ISAC to buy materials to construct and stock solar cookers as well as for customers to pay the full price to ISAC. ISAC has the starting advantage of donated materials to construct 120 initial units so they do not have financing concerns for their testing period. Concerns with financing still remain for the customers of ISAC solar cookers. Initial ISAC experience has shown that up-front payment is a struggle. To date, only one solar cooker has been sold directly and this was not at full price. The other units are currently being paid for in instalments to ISAC, a certain amount per month until the full amount is collected.

The following sections will focus on financing options available for the product end user as a customer and will not discuss financing of ISAC itself at this time. Having said this, keep in mind there are serious concerns for ISAC ordering new materials on a commercial basis as significant capital is required to import reflector sections in large quantities. The following sections also assume that the solar cooker program will attempt to achieve commercial sustainability where product will be sold at full production cost plus profit.

It should also be noted that it is too early in the project to go into great detail about solar cooker financing options for customers. At the moment there has been little sales attempt by ISAC and there is no guarantee that solar cookers will sell even if favourable financing conditions are available.

2.2.1 Self-financing

Self-financing by ISAC itself on a small scale is a viable option for initiating the first several sales and can operate in parallel to other financing methods. For example, ISAC could offer that a customer pay $15 per month for a year which would result in an overall higher price in order to take some interest into account.

The problem with offering this type of sale to any customers is that it sets a bad precedent for the future. At the moment it is easy for ISAC to give favourable sales conditions to customers since they did not invest in the initial stock of product themselves. When new stock is needed, ISAC cannot afford to wait months or years to get paid from customers. Furthermore, if some customers are given several months to pay for a solar cooker, word will travel and others will want the same conditions. Therefore, if self-financing is used at all, it would be wise to select an appropriate sales cap per month in order to make it clear that this is not a widespread solution.

2.2.2 Micro-financing

There are currently 18 licensed Cambodian MFIs and 26 rural credit NGOs registered with the NBC (IFC, 2009). The benefits of micro-finance include upfront full payment for the product from the MFI to the seller, joint marketing between the seller and the MFI, and after-sale money collection responsibility taken by the MFI. However, there are several challenges to overcome before this relationship can be established. MFIs are generally hesitant to offer loans for new products, especially those that are not inherently income-generating. Secondly, the interest rates in Cambodia are quite high with an average interest rate of 2.54% per month (IFC, 2009). This translates to a significant increase in overall cost to the customer.

2.2.3 Direct Sales

Direct sales is by far the most favourable and simple method of payment. This method of sales should be the highest priority. In the case of direct sales to NGO customers, a full cash payment would not common practice. Also, there are certain times of year, for example directly following crop harvest, when families have more than usual cash on hand. This can be an opportune time to incentivise customers to buy solar cookers at full price.

Conclusions and recommendations

- **ISAC has favourable starting conditions since they have not had to invest in their initial stock of 120 solar cookers. This advantage can be used to test the market without a time constraint to recover the capital investment.**
- **It is recommended that attempts be made at first to only sell the product directly. If this is not possible then ISAC should self-finance the sales on a limited basis by offering that customers pay several payments over the next several months or years.**
- **It is too early in the project to consider micro-financing for solar cookers. ISAC has the ability to self-finance at the moment and an MFI could possibly take this place in the future.**
- **It is too early in the project to make conclusions about what options are needed for financing. More sale attempts are needed in order to get more customer feedback. It is still not proven that solar cookers are even desired by the market so there is no need to waste time exploring complex financing options at this time.**

2.3 Distribution and Sales

There are challenges regarding the distribution of a parabolic solar cooker. The materials used to construct the cooker are relatively small, easy to pack and transportable, however, the cooker cannot be sold in sections, and rather, must be assembled beforehand due to the technical expertise and precision required (jig to position pieces, welding to connect sections). This results in a large awkward product that is difficult to transport and store. Aside from transportation concerns, each product is relatively expensive and it is not feasible to have stock at many locations.

Due to the amount of demonstration required and education involved before selling the product, it is not easy to pass the cooker onto a third party distribution channel to be sold along-side other products (water filters or cook stoves for example). ISAC is therefore constrained to being the only storage location at least in the short term and during their upcoming sales testing period, with all sales resulting in transportation from ISAC to the customer. This is not a big problem if distribution is initially limited to Takeo province because ISAC is already conveniently located at the centre.

2.3.1 ISAC sales agent

ISAC has its own staff that are familiar with constructing solar cookers and have already had experience with market surveys and initial sales in surrounding villages. Since sales activities are just beginning, ISAC using its own staff as sales agents is the most cost-effective and logical solution at this time.

2.3.2 External sales agent

Hiring the services of a local sales agent or village entrepreneur (VE) to sell directly to end users could be an option for distribution but there are many upfront challenges. Firstly, it would be very difficult to hire a sales agent to work on a commission basis only. This is primarily due to the nature of the product. Solar cookers are difficult to sell and without the assurance of relatively easy sales, a sales agent would request a high base salary in addition to commission. Since there have been limited sales of solar cookers to date, this is not an advisable option at this time.

An external sales agent with a focus of selling to an intermediate customer (NGO, government, third party company) could be a possible option at this time. Since the ISAC staff do not have much experience in sales and NGO relations, this agent could be a local person living in Phnom Penh with connections to NGOs or perhaps a foreigner who can more easily approach international NGOs. It could be possible in this case for the sales agent to work on a commission basis.

2.3.3 Existing Distribution Channels

Solar cookers are quite new to Cambodia and ISAC is most likely the only local manufacturer of SK-14 style parabolic solar cookers. At the moment, the main strength of ISAC is in manufacturing and capacity building. With a production line set up to manufacture solar cookers and a substantial stock of product ready for distribution, it is logical that ISAC would use existing distribution channels while they test and develop their own sales activities.

There are some up-front limitations with using existing distribution channels at this time. Most resellers like to have a certain stock of products ready for distribution down the channel. In the case of the solar cooker, the product is too large and expensive to keep significant stock at various locations in the distribution channel. Therefore, at this time it is most reasonable to keep the majority of stock at ISAC and possibly have a few units at key locations for demonstration. Any sale in the distribution channel would trigger a delivery from the main ISAC location.

There are several solar companies in Cambodia with a range of solar products. At the moment, none of them have stock of solar cookers although at least one (SEC) claims to be able to sell the product. With the exception of Kamworks, all the solar companies in Cambodia are not involved in manufacturing solar products and are essentially local importers and resellers of foreign solar products. SEC is also the only known solar company to have presence in Takeo. They have a small distribution hub in Ang Ta Saom (Takeo) near the main market.

It is possible that one or more companies would agree to have the ISAC solar cooker as a part of their solar product lines. It would be preferable for ISAC to arrange that the solar company takes care of the sales but ISAC takes control of installation, training, and maintenance. At the start, it would also to be wise to narrow the geographic market. At the moment, it is not feasible for ISAC to be involved in regions too far from the main office. The first step should be distribution in Takeo province only, with the possibly of Kandal or Kampot provinces if the location is not too far away (for example, within 50km of ISAC office). This can also ensure that after-sales service is handled professionally, especially at the beginning of sales operations.

Conclusions and recommendations

- **It is too early to discuss specific distribution strategies in detail since there have been so few attempts so far at selling product.**
- **ISAC should begin by distributing directly from their main office to nearby customers or directly to NGOs, companies, and government.**

2.3.4 Installation, service, and maintenance considerations

The SK-14 solar cooker is a robust product that requires little if any service and maintenance. The developer of the SK-14 says that the product can have a lifespan of 10-20 years when used under care and kept clean (EG Solar, 2009). At the moment ISAC builds all solar cookers at their main office so there is no real installation for a customer, just transportation. At this point in ISAC's sales program, installation, service, and maintenance are not serious issues worth discussion.

3 Product Analysis

3.1 Product Details

Parabolic cookers are the most efficient (fastest cooking) type of solar cookers since they concentrate sunlight into a focal point. Cookers with small focal points have a greater concentration of solar energy; however, they need to be rotated more frequently to follow the movement of the sun.

The solar cooker used in the project is the SK-14 parabolic solar cooker invented by Hans Michlbauer in Germany. It is one of the most widely distributed, highest quality and most efficient solar cookers available. In 1994 the SK-14 was compared with 25 other cookers and won awards for the highest cooking temperature and second highest efficiency. In 1997 the SK-14 gained world-wide acceptance when the first large-scale accepted solar cooker test by GTZ in South Africa awarded the SK-14 as the favourite cooker of large families (EG-Solar, 2012). Take note that all these tests, awards and projects were in the context of subsidised NGO programs rather than business ventures.

The SK-14 is durable, light, relatively straight-forward to construct and easy to use. Temperatures at the focal point can reach 250°C with a short heat-up time. During a clear sunny day, 3 litres of water will cook in 30 minutes and can satisfy 20 people assuming a 12 litre pot is used. The cooker must only be rotated every 15-25 minutes to face the new position of the sun. The heated area is located within the dish, therefore burning and blinding are easy to avoid. When it is time to stir the food, the reflector dish is simply rotated over the pot, so that the user and pot can be shaded (EG- Solar, 2009).

There has been some negative feedback for parabolic solar cookers as well. These cookers are more difficult to build than solar box ovens, and even if they are produced locally it is often necessary to import certain parts. This makes them notably more expensive than box ovens. They also have to be adjusted to track the position of the sun about every 25 to 30 minutes and they are much more sensitive to wind, which makes everyday use more difficult. A further limitation arises from the fact that the users of these cookers are easily dazzled by the sun reflecting in the parabolic dish. On most models of parabolic cookers there is also the risk of the reflector becoming dirty when food boils over, thus reducing efficiency. If the reflector is dented or scratched in the course of cleaning, the effectiveness of the cooker is considerably diminished (GTZ, 2007).

3.2 Product Selection

3.2.1 Parabolic alternatives to SK-14

There is no question that the SK-14 is a suitable choice for quality and efficiency. The main concern with using the SK-14 when it is to be marketed as a commercial product is the high production cost. Most of the materials can be found locally, however, the high quality reflector sheets (80% of material cost) cannot be found locally or even in the region (Asia). For this reason, these cookers are found mostly in NGO projects where subsidies can be used.

There has been a struggle to distribute solar cookers even in countries that have a better sun resource than in Cambodia (Afghanistan, most African nations) where the solar cooker can be used more hours during the day and during more months of the year. This is another up-front disadvantage for any type of solar cooker distribution in Cambodia.

It should be kept in mind that solar cookers or stoves in any form around the world have not proven to be an easy product to commercialize. Most programs struggle to distribute, even when subsidies are involved. After an in-depth study into solar cooker distribution across the world GTZ (2007) concluded that all solar cooker dissemination strategies have had little success and wide-spread solar cooker acceptance is still a problem. GTZ goes on to propose the most successful dissemination strategies, all which involve some sort of subsidy.

Companies that do not want to rely on subsidized products have found alternatives to the SK-14 while still maintaining high product quality. PRINCE from India and Starlight from Afghanistan (see Table 6) for example, press their own metal sheets and stick reflective tape to the surface. The overall advantage from a business point of view is that this allows for manufacturing of parabolic cookers at a significantly reduced price. This is of course also primarily suited for concentrated markets that can support mass production and distribution.

Solar Serve in Vietnam has had success in selling the SK-14 type solar cooker but by using cheaper reflectors purchased in China. There is a drop in efficiency for the cooker but a 40% cheaper end user price.

In summary, the choice of a high quality SK-14 to be used as a commercial product poses some difficult challenges. There are also challenges to solar cooker distribution no matter what type of cooker is chosen. This being said, this solar cooker is the first product of its kind to be sold in Cambodia and ISAC has not had sufficient time to test the Cambodian market. Final conclusions can only be made following their upcoming sales testing period starting November 1, 2012.

3.2.2 Manufacturing cost savings

The primary distributor of the SK-14 solar cooker is a German NGO called EG-Solar. This NGO was set up by the inventor of the SK-14. They specialize in supplying the parts to construct SK-14 cookers around the world along with technical support.

Table 8: Calculations for the Local Production of the SK-14

Item	Cost
Reflector plates	\$52
Other parts	\$32
Labour	\$45
Manufacturing Cost	\$129

Source: Adapted from EG-Solar (2012)

Table 8 shows the target costs required to construct the SK-14 in developing countries. The cost for ISAC to manufacture a solar cooker is quite comparable to those calculated in Table 8, suggesting that ISAC has already done all that is possible to reach target production cost. Therefore, it can be concluded that \$160 is a suitable price in order to account for all manufacturing costs, profit and sales margin. As discussed earlier, the only options for significantly lowering the price would involve using a lower grade of reflector material or switching to a completely different style of solar cooker.

4 Future testing and ideas

4.1 Blackened Cookware

Black colour cookware substantially increases the efficiency of the solar cooker. Although it is possible to use black paint or blacken cookware in the fire, in some cases there is also a market for better quality cookware constructed with black material. Distributors of solar cookers and stoves in other countries have had success with selling blackened cookware (pots, tea kettles, pans, pressure cookers) as separate accessories. This is also an option for ISAC should there be a demand.

4.2 Stirling Engine

Anywhere from 45% (Intellicap, 2012) to 72% (Solar Roadmap, 2011) of rural Cambodians use car batteries in their homes, which they charge at village diesel generator stations. Solar cookers are often standing idle between meals while there is a still a good solar resource. If there was the option to use the solar cooker for another purpose during the idle times, it could increase the attractiveness of the product. A Stirling type engine has been used along with solar cookers to generate electricity. Some versions of cookers have the engine built in while others have the ability to attach or detach the engine when the solar cooker is needed for cooking.

There is not widespread use of solar cookers combined with sterling engines but such a device has great potential for Cambodia. This technology would need further research but could prove to be an interesting pilot project for the future.

4.3 Custom Size Solar Cookers

The SK-14 solar cooker used in the project is not the only size of solar cooker that can be produced. Different applications of solar cookers require different sizes and configurations. Altering the size and shape (narrow the focal point) of solar cookers can increase the temperature or speed up cooking times. For example, ISAC has already been in contact with palm sugar manufacturers who may be interested in solar cookers but a much larger pot would be required, thus requiring a larger solar cooker.

It would be valuable in the future to study the possibility of custom sized solar cookers made-to-order. These would not be on stock but developed and manufactured according to each customer's order. Before different sized cookers could be offered to customers, an in-depth analysis would need to be performed to see how much extra cost would be involved with modified designs and manufacturing procedures.

4.4 Insulating Baskets

According to EG-Solar, the organization of the inventor of the SK-14, insulated baskets should always be used alongside solar cooking to ensure that hot food can be consumed when it is most needed, rather than having to be consumed just after it has been cooked. With the aid of an insulated basket, people can also enjoy a hot meal after sunset in the countries which this is traditional (EG-Solar, 2012).

Insulated baskets are not readily available in Cambodia and could be a useful accessory to the solar cooker. These along with thermoses could be sold by ISAC as well in the future if there is demand. IF not accessory products, insulating baskets and blackened cookware could still be part of ISAC's demonstration and awareness events.

Conclusions and recommendations

- **The SK-14 solar cooker is a quality product but most often used in subsidized NGO projects rather than commercial ventures.**
- **ISAC has met the target pricing for SK-14 manufacturing and have calculated a sales price which reflects all costs of manufacturing, distribution and sales.**
- **There are a few ideas for accessories that could be sold alongside the ISAC solar cooker as well as ideas for future pilot projects involving solar cookers.**

C Project Stakeholder Analysis

1 Involvement History

1.1 Stakeholders Supporting ISAC

There have been several parties involved before and after the project start in late 2011. ASEIC provides the overall management for the project with funding from the SMBA/SBC arm of the Government of Korea. SBC deals with all the contractual issues on behalf of ASEIC. The project is implemented through the Hanbat National University of Korea and the local partner and recipient of project funds is ISAC, based in Takeo province in Cambodia. The project is part of the GGGI-Cambodia Country Program which has relationship with the Cambodian Government. The Korean based social enterprise, Energy Farm, is the official equipment vendor and provides solar expertise for the project.

The project was kick-started in 2011 with ASEIC providing ISAC with materials to construct 20 solar cookers. Energy farm provided the technical expertise and taught ISAC how to professionally construct SK-14 style cookers. The official launch of the solar cooker project was on November 23, 2011 with an exciting demonstration of the solar cookers to more than 100 nearby residents.

The first phase of the project also included the installation of 20 improved waste incinerators for schools on the outskirts of Phnom Penh with support from NPIC.

In 2012, solar dryer and solar home system initiatives were added to the project as well as an expansion in the solar cooker project with 100 new units. Components for 60 SHS were prepared by mid-2012 and in late September the first 3 test systems were installed in households near ISAC in Takeo province for initial testing. General solar understanding, SHS installation procedure and basic business training was provided in mid-2012 by the local NGO, Picosol Cambodia.

1.2 ISAC's current status

ISAC's solar activities are the main focus of the project and the future form of ISAC's activities are uncertain. They have a history of not-for-profit NGO activities, involving mainly education and agriculture. In the past couple years they have been testing various commercial ideas, again mostly in agriculture. Most recently through this project, ISAC staff has been trained to manufacture solar cookers and assemble SHSs and have been given an initial stock of each product after the completion of the project. The goal is that ISAC will find some way to commercialize these products but focus so far has been on staff training and manufacturing with some demonstration. Commercialization may force ISAC to spin off a commercial branch or require ISAC to partner with external commercial entities.

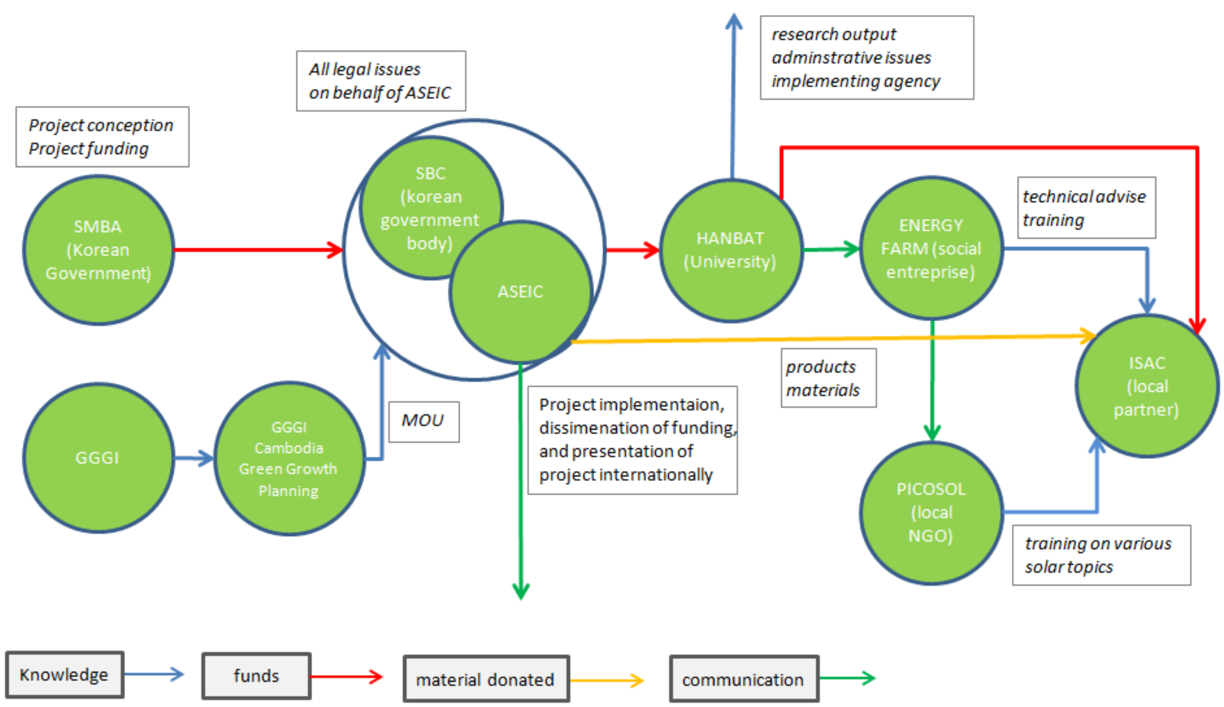

Figure 46: Project Current Stakeholders

2 Future Contribution

2.1 Continuing Stakeholders

The general stakeholders of the project can consider some options to support ISAC. The primary concern moving forward into 2013 is the most effective way to support ISAC financially.

There are several ways to support ISAC in ways that will not upset the market that they hope to join. These include:

- Business training for ISAC, ongoing business consulting for ISAC
- Support of solar and SHS awareness events

- Solar cooker demonstration events
- Subsidy for solar cookers*
- Ongoing technical training for ISAC staff
- New solar pilot and research projects

*in the case where there is no commercial market for solar cookers and the subsidy could be used to help make the product more affordable in poorer regions.

And, funding for further products itself is not desirable if ISAC is to become an honest commercial entity.

2.2 Possible New Stakeholders

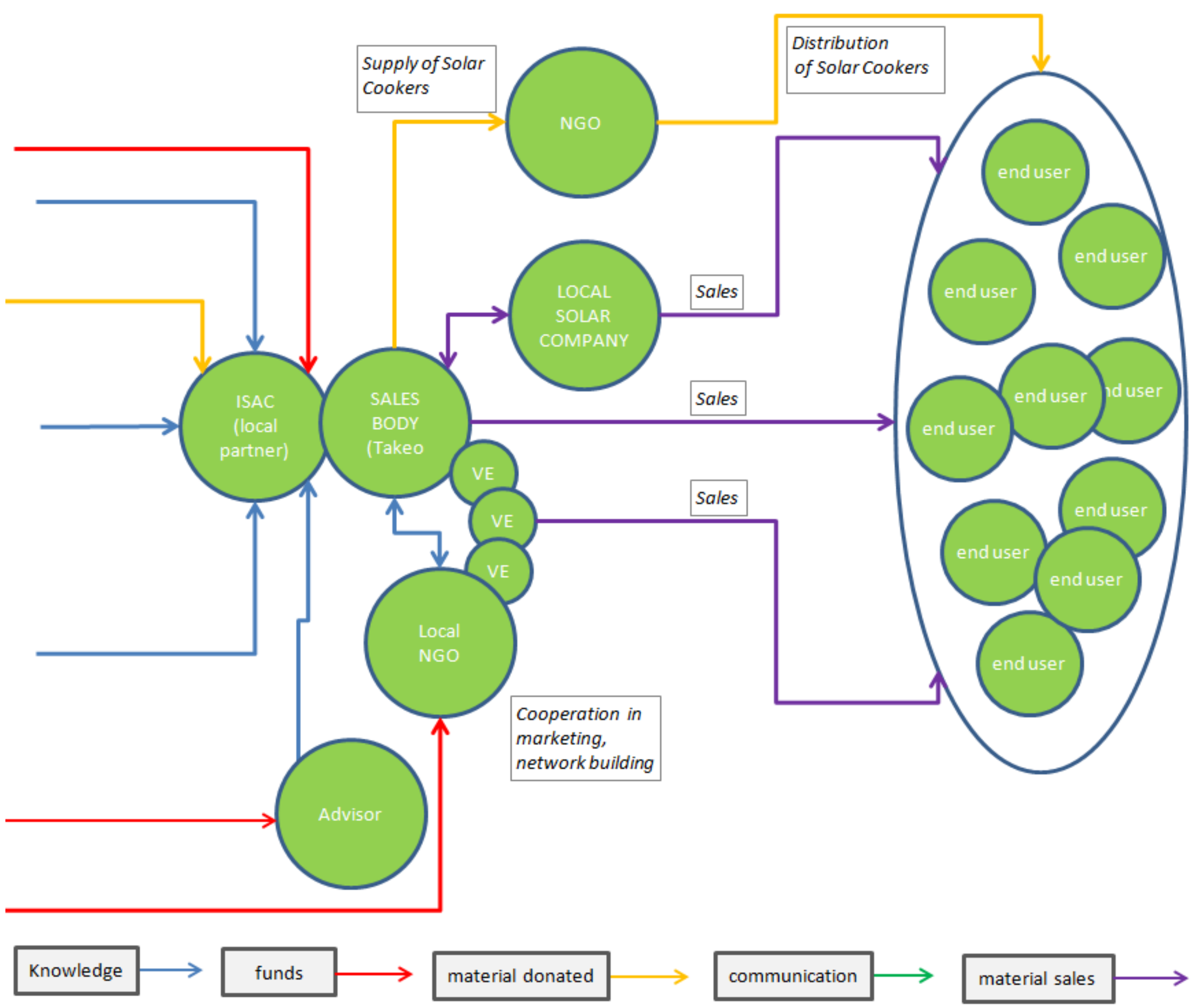

Figure 47: Possible New Project Stakeholders and Partners

It is unclear at this point if ISAC can commercialize either of its solar products and if they will be able to do it alone. ISAC has a history of being a not-for-profit NGO and clearly needs more support by those with commercial training and experience. Possible new partners and stakeholders in the project could include business consultants or mentors and sales and marketing experts.

If ISAC decides to only manufacture solar cookers then there will be need of partners who can sell the product for them. This could include external sales agents, local government, NGO partners or existing solar energy companies.

There are NGOs involved with solar awareness and integration and possible partners exist here as well. Picosol is one local NGO which ISAC has already begun a relationship and there is potential to expand this partnership in the future.

2.3 Future of ISAC's solar programs

It is still unclear what role ISAC can play in the commercial solar product market. ISAC's history as an NGO gives it a difficult starting position in this venture. Commercially successful companies commence business after successful research shows a clear market for a product. This has not been the starting point for this project.

Ideally both SHS and solar cookers can be sold and the revenue used to buy new stock and further expand the project. The products would generate enough income so that a commercial entity could spin off from ISAC and become sustainable.

2.3.1 ISAC's Future in the Solar Cooker Market

The successful demonstration event on November 23, 2011 is an indication that people are interested in the technology but no clear indication that many people will buy or afford the product. Initial surveying actually shows that people will have difficulty affording the product and find it difficult to integrate into their lifestyle. Despite this fact, ISAC is currently busy manufacturing the remaining 100 solar cookers without considering sufficient market research and product demonstration. If ISAC was operating commercially, units would be instead manufactured according to sales forecasts.

It is now time for ISAC to focus on testing solar cookers in the market and they have an advantage of 120 units available in stock. Until now there has not been real effort to sell solar cookers and also there is a lack of pressure to recover the capital investment for their initial stock of product. ISAC needs to focus more energy into systematic product demonstration and sales trips both to end user customers and intermediary customers like NGOs and solar companies. Only after significant time in these activities can ISAC determine their future position in the market.

2.3.2 ISAC's Future in the SHS Market.

ISAC has a similar story regarding its start with SHS. There is now a stock of 60 systems and it is time to test the market by putting more effort into sales. Only then will it become clearer if ISAC should branch out to compete with other solar companies or take a smaller role by partnering with activities already in progress.

As SHS is a more developed market in Cambodia and there are important questions that ISAC needs to answer during the next market testing period.

- Can ISAC successfully sell the first 60 SHS?
- Can the systems be sold for cash or will ISAC need to wait several months before collecting all payments.
- Can ISAC afford new components using revenue from sales?
- Does ISAC want to compete with the established solar energy companies?
- Does ISAC want to import SHS components in the future?
- Does ISAC want to build up a sales team or subcontract sales activities?
- Can ISAC buy components from other solar energy companies and still price their own SHS competitively?
- Is there a role in the market if ISAC only wants to install and maintain SHS?

D Distribution Success Stories

1 Solar Home Systems

1.1 Grameen Shakti

Grameen Shakti in Bangladesh is the most successful SHS sales and installation company in the world. By September 2012, they had installed 954,227 systems (GS, 2012) (see Figure 48). Every day, Grameen Shakti installs 500 systems (Climate Progress, 2012).

SHS companies have been working in Cambodia for almost as long in Bangladesh so it is interesting to investigate why Bangladesh has been so successful and why Cambodia faces many more challenges for distributing SHS.

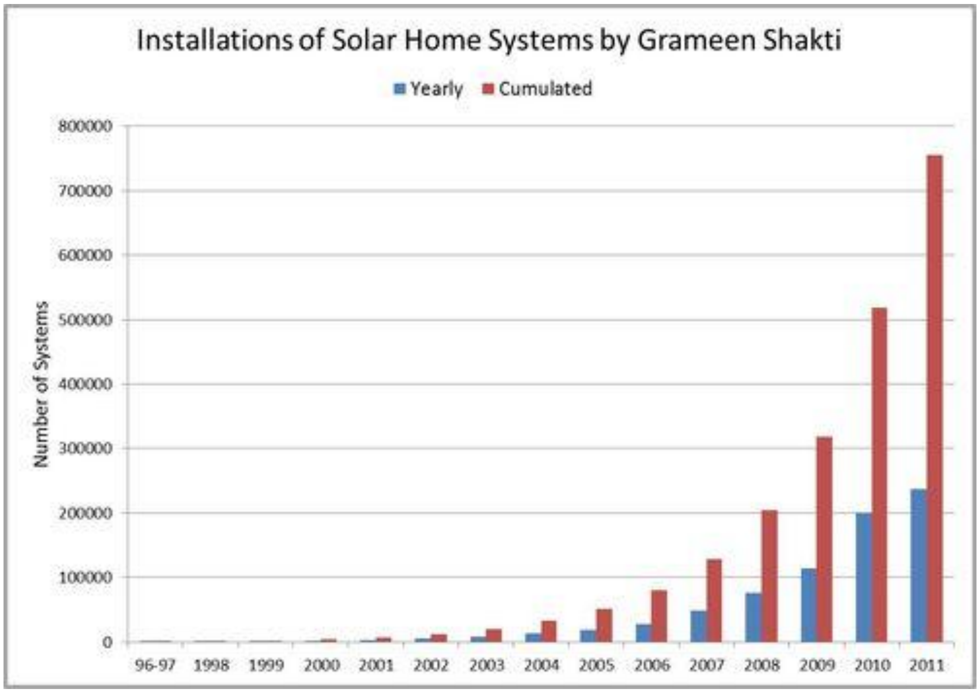

Figure 48: Grameen Shakti Historical SHS Installations

Source: Climate Progress, 2012

1.1.1 National Program, Government Support and Financing

Infrastructure Development Company Limited (IDCOL) was established in May 1997 by the Government of Bangladesh (IDCOL, 2012). IDCOL is the national Bangladeshi program which regulates SHS quality and supports organisations with financing. Grameen Shakti works within the IDCOL program and is its most successful SHS implementer. Grameen Shakti offers a simple and attractive financing package to any of its SHS customers (see Table 9), made possible because of IDCOL's support. IDCOL requires that SHS customers pay at least 10% upfront but then takes responsibility for 80% of the outstanding loan while SHS implementers like Grameen Shakti cover the remaining 20% (CIERP, 2011). IDCOL offers "soft loans of 10-year maturity with two-year grace period at 6% per annum interest to its partner organizations" (IDCOL, 2012) and receives its own financing from large global organisations including the World Bank.

Table 9: Grameen Shakti Financing Mechanism

Option	Down payment	Instalments	Service Charge (flat rate)
Option 1	15%	36 months	6%
Option 2	25%	24 months	4%
Option 3	100% cash payment with 4% discount	N/A	N/A

Source: GS, 2008

This type of national support both organisationally, technically, and financially is certainly part of the Bangladesh SHS success story. In contrast, there is no national support in Cambodia, no SHS soft-loans available for SHS customers and no coordination for technical standards. This isolates Cambodian solar companies and results in slow SHS integration.

1.1.2 Demographics

Aside from national support, the demographic situation in Bangladesh is very favourable with regards to distribution and logistics. Bangladesh has a population density of 1015 persons per square kilometre (BBS, 2012) compared to a mere 75/km2 in Cambodia (NIS, 2007). The concentrated population in Bangladesh allows Grameen Shakti to open a rural office with instant access to thousands of customers within 30km. Grameen Shakti currently supports 1485 offices in all 64 districts and 50,000 villages. In Cambodia, local solar companies struggle to support any offices outside the major cities (Phnom Penh, Siem Reap, Battambang). The distance between customers along bumpy roads in Cambodia, adds extra transportation and maintenance costs to each system sold and leaves a legacy of neglected customers and malfunctioning systems.

Conclusions and recommendations

- **Cambodia has much greater challenges with SHS sales and distribution compared to Bangladesh. All new companies entering the market should be aware of the challenges and lack of support.**

1.2 WB REF project 2011

The Rural Electrification Fund (REF) was founded in 2004 under the Energy Sector Management Assistance Program (ESMAP) of the World Bank. The first program involved offering a $100 subsidy for any SHS installation greater than 40Wp. After the first two years of the program there were only 95 applications for the subsidy due to the complexity and misunderstandings of the application procedures as well as the lack of attention to financing for the customers. The program was stopped and the plan was changed to the REF procuring 12,000 SHS (30Wp and 50Wp sized) of their own to implement in a new project.

Details of the project were very favourable to the customer. Systems were still subsidised by $100 and customers were given the option to pay instalments over five years (without interest). The program finished in early 2012 and it is too early to gauge the longer term market effects. A third party company was contracted to collect money over for the five year payback period and there have been no serious problems regarding customer payments so far. The main concerns from customers are the long wait times for repairs and as well as complaints about low performance from the systems they thought would generate more power.

Conclusions and recommendations

- **There is huge demand for SHS that have favourable financing conditions. The market can accepts a huge amount of systems in a short time as all the 12000 systems were installed in four months.**
- **Customers have unrealistic expectations about the amount of power their SHS can generate. Only a system of 80Wp or higher is large enough to support satisfactory operation of a colour TV found in Cambodian markets**
- **50Wp systems were much more popular than 30Wp in the program. In the end, there were 30Wp systems left over without customers.**

1.3 Solar Energy Cambodia

Solar Energy Cambodia (SEC) is a Cambodian Solar Company founded in 2008. They take pride in their ability to reach to the furthest and most remote locations. This is made possible through their various office locations in Phnom Penh, Battambang, Takeo (Ang Ta Saom), Svay Rieng and Prey Veng. With over 2000 systems installed up to date, they have been the most successful Cambodian company spreading SHS into rural areas. Remarkably, SEC only sells systems for up-front cash.

Their success comes for a number of reasons. They tend to target the rural middle class who can afford to pay for systems up-front. The systems are also tailored to the needs of the customer. If a customer already has a car battery then they are offered a system without a solar battery. When the car battery is exhausted, a solar battery could be purchased.

Systems are not sold by their Wp rating which is confusing to a non-technical audience but rather, they are sold according to what they can power. For example, a certain system will be sold specifically for powering a colour television. There is high demand for cheaper components (poorer quality) and SEC provides this option.

SEC staff spend their days on the back of motorbikes on rural roads and not in Phnom Penh offices. Their colourful posters can be seen on trees and fences all over the country. They have been quite systematic in their approach and even distant villages will have some marketing material.

SEC provides fast service for customers and is able to install systems quickly after they are ordered. They operate very informally and relate well to rural villagers.

If SEC fails at any point it is the same problem as everyone else in the field – repair service. It is not uncommon to hear customer complaints about poor quality components or slow repair service. SEC is still a young company and only time will tell whether or not their strategy keeps them successful for the long term.

Conclusions and recommendations

- **Sales of SHS on commercial basis without subsidy is possible**
- **The market wants the product and price to be tailored according to their needs**

2 Solar Cooker

2.1 Starlight Afghan Free Energy

Starlight has only been in operation since 2011 but took ample time for market research before launching their solar cooker business. A final decision was made that Starlight would manufacture their own style of solar cooker which contains pressed metal and reflective tape for the parabolic dish. Their cooker has a high efficiency and they are able to set a market price of $80. At this price, they are able to sell directly to Afghan families without subsidy and outside help. Afghanistan has an advantage of 300+ sunny days per year, allowing customers to save 70% on their cooking energy needs.

There is an option for ISAC to take a similar path in the future but it would mean changing to a completely different type of solar cooker. ISAC has invested a lot of time and effort into the SK-14 style cooker but it is of no use if this style of cooker is too expensive to sell on a commercial basis.

Conclusions and recommendations

- **Starlight has an attractive price for their parabolic cooker which has performance similar to that of the SK-14. Starlight and other solar cooker companies around the world tend to manufacture different types of solar cookers and not the SK-14 so they can drive down the price.**
- **ISAC should consider how other solar cooker distribution companies have been successful. They tend not to use the SK-14 style cooker because it is too expensive to sell directly to the ideal end user customer.**

2.2 Barli Institute

It is clear to see that a solar cooker has most benefit for the rural poorest who would never be able to afford the technology. Barli Institute was established in India in 1985 and has distributed over 50 SK-14 style solar cookers every year for the last 12 years. Barli was interested in using a high quality cooker but made no intention to sell the cookers on a commercial basis since their target distribution is for women in very poor families.

Barli focuses on long lasting development programs and therefore trains 60-75 women each year for a 6 month period. The training also includes literacy, health care, tailoring, organic agriculture and environmental conversation. Regarding the solar cookers specifically, there is a 3 day training focused on use and maintenance and then the solar cookers are sold to participants with a subsidy covering 90% of the cost.

This program has the disadvantage of relying on funding for ongoing support of the project but is able to integrate the solar cookers into the lives of families who need them most. The SK-14 has been quite popular in NGO projects around the world but only sold with subsidies involved.

Conclusions and recommendations

- **Barli Institute in India uses the same SK-14 parabolic solar cooker as ISAC. Barli's target market of rural poor women forces them to heavily subsidise the cookers for distribution. This is the same story with many distributors of SK-14 solar cookers.**
- **ISAC should consider the story of Barli and other NGOs working around the world to distribute SK-14 solar cookers. The SK-14 is generally found in subsidised NGO projects and not as a commercially successful product.**

E Summary of Conclusions

ASEIC has two new solar initiatives involving solar cookers and SHS in partnership with GGGI, Hanbat University, and ISAC. For the last year, their focus has been to learn how to professionally manufacture solar cookers and assemble SHS by supporting the establishment of the TATC. The question is whether ISAC, the key partner in Cambodia, can commercialize their activities in order that their activities may progress sustainably without donor supported programs.

There is a promising story with ASEIC's initiative on SHS, as the market for this product is quite established and there are many players already involved. Unlike the solar cooker, assembly of the SHS is quite straight forward and distribution success is found in the quality of promotion, sales, installation, and after-sales service, all of which are new activities for ISAC.

The ISAC SHS is quite similar to those offered by several other established solar energy companies and commercialization of ISAC's activities could put them in direct competition with others who have been selling for years. At the moment, ISAC is not skilled in marketing and sales which is at the core of SHS distribution success. Therefore, ISAC will need to decide whether they want to develop these skills or find some other place in the SHS market. There is also a great need for more not-for-profit NGO activity in solar energy including technical training, solar awareness, industry quality standards, and establishment of solar energy associations.

The ISAC solar cooker is based on a popular German design called the SK-14. This type of parabolic cooker is popular throughout the world because of its high quality and performance and the ease with which it can be manufactured locally. The unfortunate problem is the high price for the reflector sections used in the dish portion of the cooker. These reflectors need to be imported from Germany and are expensive even in large quantities. There are cheaper quality versions available in the region but this has a significant negative effect on the efficiency of the cooker.

ISAC plans to commercially sell the SK-14 solar cooker despite the fact that this has not been so successful in other countries, especially without subsidies. The SK-14 is most popular in NGO projects which are donor supported. Companies who have been successful selling solar cookers use different manufacturing methods in order to offer more attractive pricing. These companies are also found in more concentrated markets like China and India where mass production and sales help to drive down the unit price.

Despite these potential difficulties, the parabolic solar cooker is a new product for Cambodia and ISAC has not yet spent much time demonstrating and selling the product. Therefore, before any firm conclusions can be made, ISAC will need to put effort into sales to learn more about the specific Cambodian market response to the SK-14 solar cooker. There are also other options aside from sales to end user customers. For example, NGOs and solar companies are potential markets for solar cookers, in which case ISAC could take the role of manufacturer and distributor.

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APPENDIX

Appendix A: The Korea Times Articles Highlighting Cambodia Project

MONDAY, OCTOBER 15, 2012 — BUSINESS FOCUS — Foreign Aid A3

What it takes

to make solar power shine

This **solar panel** can change lives of **Cambodians** — both users and manufacturers — and shows how **foreign aid** should be implemented.

Reportage

Every project has to have an exit strategy. A team of Korean technicians can come here and easily install 100 solar power systems in a month. But who will maintain and repair them after they have left?

How they learned to **build and sell** photovoltaic systems **on their own**

A man is frying noodles on a pan heated by concentrated sunlight at the Institute of Sustainable Agriculture and Community Development (ISAC) in Takeo, Cambodia, on Nov. 23. Staff of the ISAC tested in front of some 100 local residents the solar cooker that they eventually want to produce and sell.

Korea Times photo by Kim Da-ye

Appropriate tech more than foreign aid tool

Solar cooker project in Cambodia shows it doesn't take cutting edge technology to change the lives of the poor

The trash is burnt in the open air on the outskirts of Phnom Penh.

Analysis

By Kim Da-ye

PHNOM PENH, Cambodia — Time seems to have frozen for several decades in Cambodia.

Once a powerful empire in Southeast Asia between the ninth and 15th centuries during which Angkor Wat was built, Cambodia is now one of the world's poorest countries. Its GDP per capita with purchasing power considered was estimated at $2,100 in 2010, 186th among 227 countries, by the U.S. Central Intelligence Agency.

Although the country reported double-digit growth between 2004 and 2007 and 6 percent growth in 2010 after the global financial crisis, a foray into the rural area where over 90 percent of the poor live finds no electricity and a lack of clean water and sanitation facilities at many individuals' homes. The damage done by the communist Khmer Rouge regime that is estimated to have killed 1.7 million people in the late 1970s is evident with the trials against the former leaders still ongoing.

Among the foreigners who enter Cambodia to reach out to the poor are a group of Koreans who say that it takes no cutting-edge technology to help change lives there.

The catalyst is actually something basic but fitting precisely into the locals' need called "appropriate technology." While appropriate technology does not carry any patent and non-technicians can easily learn to use it, the Koreans say that people can even make money out of it with a distinctive business model.

Are they too ambitious? A field trip to rural Cambodia shows it could be very much a realistic goal that beats the outcome of one-way, top-down foreign aid.

Appropriate technology

Some 80 kilometers south of the capital Phnom Penh is Takeo, the third-poorest province in Cambodia where Kim Gi-dae, director of the Institute of Sustainable Agriculture and Community Development (ISAC), set up a school there in 2003.

On Nov. 23, more than 100 residents of Takeo gathered at the ISAC to welcome Korean visitors. A festive spirit loomed large with a temporary pavilion adorned with colorful fabric and a row of intensely gleaming, mirrored objects on the left.

Kim Man-gab, right, a professor at National Polytechnic Institute of Cambodia, shows Lee Tae-sang, left, the general manager of Small & Medium Business Corporation (SBC), how the low-cost incinerator works.

Korea Times photo by Kim Da-ye

In the center of the anodized-aluminum overturned domes, the residents fried and grilled bananas, sauteed noodles, boiled rice and even heated up old irons. Solar cookers concentrate the heat powerfully enough to boil water and bake bread, replacing the wood stoves that the locals use.

The 20 solar cookers had been manufactured by the Cambodian staff and students of the ISAC under the guidance of Kim Dae-gyu, the CEO of Energy Farm, a small-size Korean social enterprise focusing on renewable energy.

It's no secret how a solar cooker is built. Similar appliances have already been distributed in other developing countries. But Kim believes it is among the tools best suited for Takeo residents, to be "transferred" the technology to them for free of charge.

Products developed under appropriate technology, first defined by economist Ernst Schumacher in his book "Small is Beautiful," tend to suit the locals' needs, not what the developed world think they would want, and use locally available raw materials. They are also environmentally-friendly and easy to repair.

In the case of the solar cooker, a survey of 97 Takeo households carried out earlier this year found that 81.4 percent of them need to boil water and 72.2 percent rely on firewood for cooking. Not only does the use of firewood result in much pollution, it causes deforestation.

In addition, Cambodia's biggest renewable energy asset may be the sunlight available most days, even during the rainy season running from May to October.

The solar cooker was chosen among various appropriate technologies in this particular project led by the ASEM SMEs Eco-Innovation Center (ASEIC).

ASEIC is a state-funded organization that aims to work as a bridge between Asia and Europe in encouraging green innovations by small- and medium-sized enterprises (SMEs). ASEIC initially consulted Hong Seong-uk, the director of the Center for Appropriate Technology at Hanbat National University, who connected the organization to Energy Farm and the ISAC.

This project with a "bottom-up" approach couldn't work without ISAC having built a strong bond with the local community for nearly a decade. And that bond only exists because the director's dedication. Kim Gi-dae would even give up the education of his own children to run the school with donations from acquaintances.

> *"If I am given an opportunity, I want to run a small company selling the cooker," Narom Doung, a 22-year-old Cambodian, said.*

A total of 80 million won, Korean taxpayers' money allocated by the Small and Medium Business Administration via the Small and Medium Business Corporation, went into this project.

It also involves the Global Green Growth Institute (GGGI), a Korean-led initiative to promote a new model of sustainable economic growth called "green growth." The GGGI will assist ASEIC in developing an international network as well as raising funds.

The project sponsored another appropriate program in Cambodia, building basic incinerators designed for the local climate.

It was invented by Kim Man-gab, a professor at the National Polytechnic Institute of Cambodia, who is already well-known for the G-Saver, a 20-liter heat retainer developed in Mongolia where people have been known to freeze to death.

The incinerator is built with bricks so as to be water-proof in the tropical climate with three small openings — a chimney, a hole for ventilation and another on the bottom for clearing.

It doesn't filter every toxic chemical emitted from incineration but it's not the advanced technology the locals need.

Outside the wealthy neighborhood around the Royal Palace in Phnom Penh, many of the streets are heavily littered. Once the trash mounts up, the residents simply burn it leading to fumes and ashes freely floating in the air.

Kim says that what the locals need now is a simple technology that gets them into the habit of disposing of waste properly, even during the rainy season and not burning it in the open.

He is building the incinerators next to schools, so that they handle waste efficiently as well as teaching their students how to do it.

Business model

So far the appropriate technology sounds very much like a tool for foreign aid in the impoverished countries. Many of the ideas incorporated are against development-oriented capitalism.

But the goal of ASEIC and other stakeholders is commercialization of the appropriate technology. The Koreans want the Cambodian ISAC staff to set up their own SME, create a market for the solar cooker and eventually achieve financial independence.

Narom Doung, a 22-year-old staff member of ISAC, was grilling bananas on a solar cooker on Nov. 23 when the Koreans visited Takeo. He comes from a family that still cooks with firewood.

He participated in making the solar cookers and said $140 would be the right price for the cooker. "If I am given an opportunity, I want to run a small company selling the cookers," Doung said.

Kim of Energy Farm is mulling three different means of distribution: non-governmental organizations (NGOs) buy them from the Cambodian SME and give them out free, local residents buy them at a full price, or locals get them cheaply with subsidies from NGOs.

Those who have worked in social services long enough know that the first option is the worst because freebies are likely to be left idle while people tend to actively use paid-for products.

With the second and third options, buyers may pay the money back in many installments in the form of microfinance.

This way, the product may efficiently reach the "bottom of the pyramid" that targets the poorest yet largest socio-economic group, Kim Ju-hern, the team leader of ASEIC.

Jeong Ok-ju, a senior program manager at the GGGI and its envoy to Takeo, said that the solution for distribution may involve all three options.

"Solar cookers have been used in various parts of the world," Jeong said.

"This project is important because once a successful distribution model has been established, it could be applied elsewhere."

The solar cooker, however, has many hurdles to overcome in the process of commercialization.

It is likely to be priced at $160 including an operating profit of $20. That's expensive for Cambodians whose average income, officially available as the gross national income per capita, was $760 last year.

Kim has tried to cut down the raw material cost but found that compromising on good-quality anodized aluminum that reflects 94 percent of the sunlight would leave the cooker impractical.

But Kim said that the making of the solar cooker was one significant step for the Cambodian workers, some of whom did not even know how to use a ruler.

Cutting a metal sheet with precision and welding the pieces have taught the staff the basic skills necessary for manufacturing more advanced products, said Kim, who wants to eventually transfer more advanced technology like the solar photovoltaic system seen in the work by Grameen Shakti of Bangladesh.

Grameen Shakti, chaired by Nobel Laureate Muhammad Yunus, incorporated expertise in microfinance in distributing green solutions including the solar home system to rural villagers.

"One of the ISAC staff members was a gang member addicted to drugs. He couldn't concentrate on one thing for more than three minutes," Kim said.

"But he became totally devoted to the solar cooker project. It was a life-changing experience for him."

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