Energy at the Margins: Assessing the Initial Impact, Opportunities and Challenges of a Solar Lantern Project in Kalimantan, Indonesia

Paul Gubbins, Kevin Hong, Neha Kumar, Karina Nagin, Alicia Ng, Erisha Suwal

Contents

Executive Summary

The Government of Indonesia is facing significant challenges to provide electricity to its population due to geographic and financial constraints. Off-grid solutions provide the potential for electrification in remote and sparsely populated areas. Solar lanterns are one example of an alternative lighting device for domestic consumption in remote communities.

This report was created as part of Columbia University's School of International and Public Affairs (SIPA) Workshop in Development Practice. The project was undertaken by the request of the client, Kopernik, who is currently implementing a solar lantern project in 3 villages in Central Kalimantan, Indonesia. The project is being executed in partnership with the local NGO, Friends of the National Parks Foundation (FNPF). The objective of the report is to identify the need and initial impact of solar lanterns in 3 remote river communities.

During field visits the SIPA team collected data to better understand the energy portfolios of the communities and the general village context into which solar lanterns were being introduced. In total, the team interviewed 62 respondents. Some of the key findings help to provide understanding of the local context and need for solar lanterns:

- On average, 29% of household expenditure goes towards energy costs (primarily on fuels for lighting, cooking, transportation and entertainment)
- Overall, 33% of households ranked electricity or fuel as their greatest challenge
- 40% of households interviewed had direct access to electricity either form generators or solar panels
- Approximately 1/4 of households have no direct or indirect access to electricity - these households rely primarily on kerosene

Through interviews and focus groups it was apparent that households rely on a diverse mix of energy sources including: benzene and diesel generators, solar home systems, biomass, battery powered flashlights, and kerosene. These energy sources can be used for a variety of productive activities including cooking, transportation, lighting and entertainment. Given this complex energy portfolio, the team found that solar lanterns have a complementary role to play and can be economically and environmentally more suitable for domestic lighting than diesel generators, kerosene and solar panels.

The SIPA team evaluated the initial impact of the Firefly solar lanterns, which were distributed during the pilot project approximately 6-8 months prior to the initial field visit. Out of 24 lanterns distributed to two communities, Tanjung Harapan and Sungai Cabang, the team conducted individual interviews and focus group discussions with 7 community members who received the solar lanterns. Overall, the respondents recognized many advantages of solar lanterns over kerosene lamps including: health, safety, portability, communication and quality of light impacts. However one of the biggest impacts noted was the cost savings.

- Households with solar lanterns reported reducing kerosene consumption by 6.13 liters, on average
- On average, households with solar lanterns decreased monthly household expenditure on kerosene by 40.2% or USD 3.74 per month

One of the main challenges to impact the team identified was the issue of durability and maintenance. It became apparent that no training material or information about maintenance was distributed with the lanterns during the pilot. Given that some of the impact in health and environment requires years to realize, the issue of durability can significantly limit the long-term impact of the solar lantern project. Therefore addressing the issue of sustainability was a key component for the team's recommendations.

Giving deep consideration to Kopernik's structure and available resources the report identifies three primary short-term recommendations to help Kopernik meet its organizational objectives. The recommendations cover issues of financing, distribution and maintenance. It is our hope that the short-term recommendations along with the long term strategic recommendations offered in this report present a platform for implementing changes on the ground and within Kopernik's model. We believe the actions recommended will strengthen Kopernik and its future projects and help to ensure increased impact and sustainability.

1 Introduction

From 2010 – 2011, a team of six students from Columbia University's School of International and Public Affairs embarked on a six-month-long research project into the role of solar lanterns in rural indigenous villages of Central Kalimantan, Indonesia. The project, which included two separate trips in January and March 2011 to three different villages in Indonesia, was part of their graduate school coursework in development practice.

Over the course of the past six months, the team has worked closely with their client Kopernik, a non-profit organization that links providers of innovative technology with technology users in the developing world and donors worldwide via an online marketplace. Kopernik's Solar Lantern Project in Central Kalimantan is being implemented in partnership with the Friends of the National Parks Foundation (FNPF) a local Indonesia NGO

FNPF's Collaboration with Kopernik

FNPF is largely focused on environmental conservation efforts and FNPF's work has focused closely on reforestation, wildlife conservation and conservation education for youth. The Founder and CEO of FNPF, Pak Bayu, was interested in collaborating with Kopernik in order to realize FNPF's aim of expanding its project outreach to new rural communities. Pak Bayu and his team were interested in a project that would deliver both direct and indirect benefits to targeted communities in an effort to gain additional support from the villagers living there. As a result, Kopernik and FNPF collaborated to bring solar lanterns, specifically the Firefly 12 Mobile solar lantern, to rural villages of Central Kalimantan.

Objectives of Intervention

Introducing solar lanterns into these villages appears to be an innovative solution for multiple reasons. Firstly, it offered a much-needed alternative energy option because the Indonesian government has yet to provide sustainable and reliable electricity sources to these isolated communities. Secondly, solar energy offered savings opportunities to the villagers, who spend an average of USD 7.41 a month on kerosene for lighting purposes. The renewable energy aspect of the solar lanterns also fit perfectly with FNPF's strong emphasis on environmental conservation. For more information on the Firefly 12 Mobile (See Annex 1).

Pilot Solar Lantern Project

In 2010, a pilot project was initiated, where 24 solar lanterns were distributed free of charge to two villages. Plans for a large-scale distribution of 316 solar lanterns are underway in 2011. There are no secondary plans to bring in more solar lanterns once the full-scale project has been executed. To address the potential problems of malfunctioning solar lanterns, it is also crucial to implement simple preventive (ex-ante) and corrective (ex-post) measures. Villagers would be better informed on how to care and use their solar lanterns by introducing a training program or even distributing instruction manuals to consumers at the point of purchase. The presence of a simple maintenance program can also prolong the operational life of these lanterns and yield higher returns on purchase. Villagers will therefore be able to send their solar lanterns for repair or exercise their warranty should their solar lanterns malfunction without the need to retire them before their estimated expiration date.

Breakdown of the Report

Section 1 provides an overview and lays out the objectives of this project. *Section 2* describes our approach to the project and the research methodologies that the team relied on during their fieldwork. *Section 3* discusses Indonesia's economic and energy context, including the energy context within Central

Kalimantan. This section also presents the baseline results for energy use and expenditures at village levels, and the socio-economic characteristics of the household samples. *Section 4* provides an analysis of the solar lantern technology and the impacts of the Firefly 12 Mobile in the villages. This analysis is based on the results from the pilot project conducted in 2010, and from extensive focus group interviews and surveys conducted during the team's fieldwork. *Section 5* examines the project design and implementation used for the pilot, specifically the financing model, partnerships and distribution model, and identifies strengths and weaknesses that may inform the forthcoming solar lantern project. Finally, Section 6 discusses strategic short and long-term recommendations for Kopernik to consider for reinforcing and expanding on its operational model.

1.1 Objectives of the Report

The objectives of the report are to:

(1) Identify the potential impacts of solar lantern technology across different dimensions of individual and community welfare.

(2) Understand and quantify - where possible - the initial impact of Kopernik's pilot distribution of solar lanterns in Central Kalimantan.

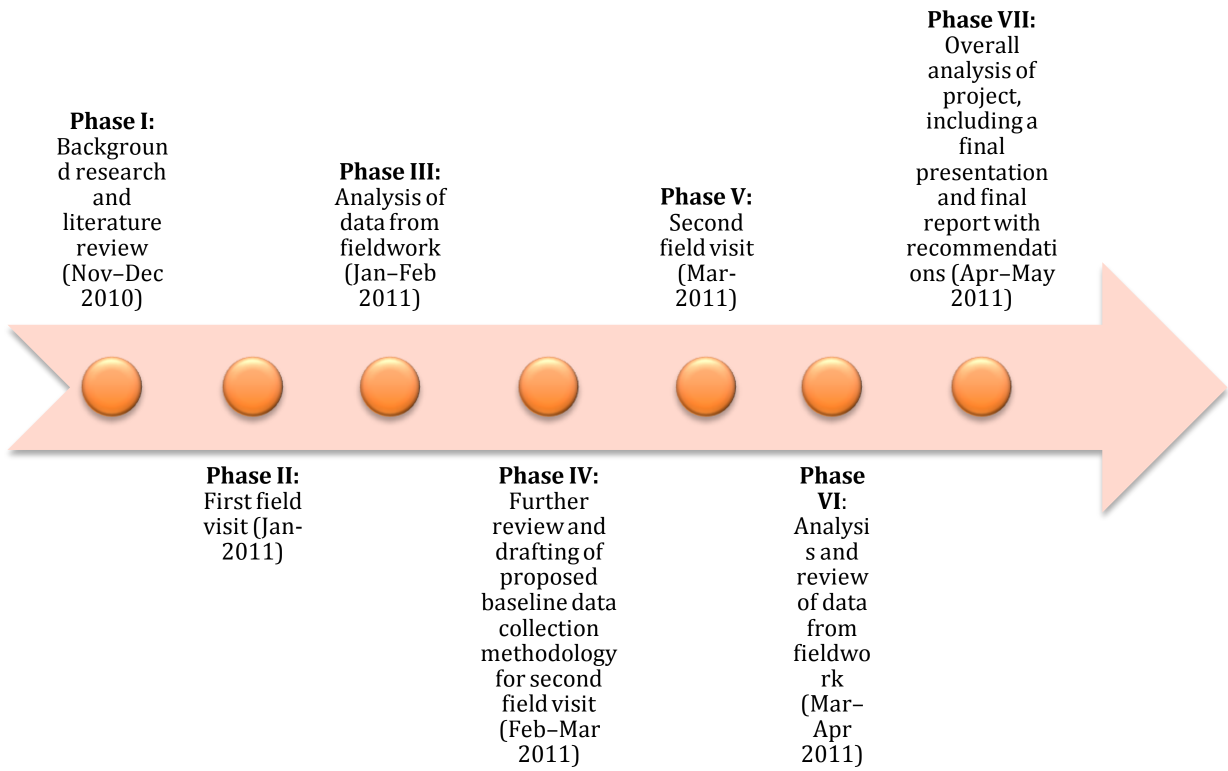
(3) Analyze resources, preferences and behaviors in the target communities, as well as elements of the project design and implementation, that might moderate the impact of the forthcoming solar lantern project in Central Kalimantan. Included in this analysis, we try to assess the degree to which solar lantern technology is needed and valued by the target communities; whether the solar lantern product is appropriate for the context and whether the project's distribution model is optimized for creating impact in the long run.

(4) Synthesize findings to make relevant and actionable recommendations.

2 Methodology

Given our project objectives (See Section 1.1), the methodology of the project occurred in seven phases.

Figure 1 Timeline of Events



Based on these phases, the core elements of our research approach include:

I. Literature Review / Desk Research

Our literature review provided us with background knowledge on solar lanterns, the national and sub-national energy sector in Indonesia, the social and economic context in Central Kalimantan and key methodologies related to our study. This knowledge helped shape our strategy for field-based data collection. An overview of our literature review is provided below:

The landscape of solar lantern technology and its impact on low-income communities

A core part of our research involved reviewing the evidence of the impact of past solar-lantern projects in published journals, policy reports from development agencies and reports from companies and agencies directly involved in the production and distribution of solar lanterns. This review enabled us to gain a better knowledge of the solar lantern sector, the types of impacts potentiated by the technology and an understanding of the aspects of impact with the strongest evidence base. An equally important part of our research involved gaining a better understanding of the cultural, economic and social realities both in Indonesia, but more specifically in Central Kalimantan and the communities where Kopernik's program is being implemented. We assessed the overall energy context in Indonesia and specifically Central Kalimantan, focusing on government policy and current energy pricing and infrastructure investments.

Maintenance and Care

An important sub-theme in projects whose objective is to distribute imported low-cost technologies in low-income communities, is the issue of maintenance and care programs. We examined examples of models and methodologies in practice in Sri Lanka, Laos, Uganda, Afghanistan and Bangladesh.

Below are some sample approaches that are undertaken in these case studies:

- Educate consumers on realistic expectations of technology appliance's performance prior to sale
- Provide user manual including basic training on operation, maintenance and trouble-shooting procedures at time of installation[3]
- Solar company provides Warranty and Money-back Guarantee Scheme[3]

Quality testing upon which manufacturers receive certification: e.g. Barefoot Power is a Lighting Africa "Associate" and its Firefly 12 LED has passed their quality tests[4]

Willingness to Pay (WtP)

During the January trip, the team conducted initial willingness to pay for solar lanterns research using a direct, open-ended question methodology: "how much are you willing to pay?" Following this, during phase IV, we conducted research regarding other potential methodologies for measurement. Our research included:

(1) Example methodologies:

- Contingent-valuation method: increase awareness regarding potential benefits from the new technology which ensures all responders are willing to pay in some form[1].
- Bidding game: "are you willing to pay X? If yes, are you willing to pay X+a? If not, are you willing to pay X+b?"
- Iterative bidding approach: query respondents regarding WtP by starting at some initial monetary value and keep raising (or lowering) the value until the respondent declines (accepts) to pay[2].
- Payment card approach: list a number of possible WtP values in table format and ask the respondent to pick the amount that best represents their WtP.

(2) Considerations that affect willingness to pay:

- Characteristics of the household: age, income, number of members, education
- Access to other energy sources
- Perceived benefits of solar lanterns
- Potential biases as a result of the implied value of the lanterns based on the starting point and range of monetary values

Based on our research, we incorporated a willingness to pay section in the long-form survey utilized by the March team during their trip. (See Annex 6: Sample long-form survey)

II. Collection of Qualitative and Quantitative Data from Primary Sources

A. Research Design

We used a mixed method approach by combining participatory strategies, semi-structured interviews, and survey instruments. The details of this design are as follows:

Three team members (Kevin Hong, Karina Nagin and Alicia Ng) visited the project site from January 2-16 to conduct initial fieldwork and collect base line data for the Kopernik solar lantern project.

The primary purpose of the January trip was to: **First,** verify the objectives of the project; **Second**, gain a better understanding of the local contexts including FNPF's role within the communities, the variety of energy sources used, and current energy consumption in the villages. **Third,** assess the impact on the pilot solar lantern project by talking with community members who had received the solar lanterns.

In between the two field trips, the team analyzed the findings from the January trip, debriefed the client on our preliminary findings, discussed the relevance of our initial findings and obtained feedback.

We also developed the research design and the quantitative and qualitative tools to be used during the March trip. Three team members (Paul Gubbins, Neha Kumar and Erisha Suwal) visited the project site from March 10-27. The team collected information for the baseline study and used a combination of long and short-version surveys to gather data.

Both field research visits were facilitated by Kopernik and FNPF with field staff assisting with community mobilization, translation, and data collection.

B. Research Methods

Method	Description	Reference
Semi-structured Interviews	• Household interviews focused on individual experiences, needs and attitudes. • Interviews were conducted with a variety of stakeholders in the three villages including village leaders, solar lantern users, village staff and storeowners.	Annex 2 – Household/Semi-structured Interview Guide
Focus Group Discussions	• Two FGDs were conducted in each of the 3 villages. Each focus group was composed of one of 3 types of villagers: generator owners, solar lantern owners, and kerosene lamp users (with no other sources of energy). • The FGDs were conducted with a variety of community members to gain an understanding of traditional energy consumption and lifestyle. • This provided the team with an understanding of how the community functioned before solar lanterns were distributed. The focus groups also gauged initial reactions to the solar lanterns.	Annex 3 – Focus Group Discussion (FGD) Guide
Transect Walk	• Mapping the location and energy sources for each household in the villages. Transect Walk was conducted only in Tanjung Harapan and Sungai Cabang.	Annex 4.1: Transect walk for Tanjung Harapa Annex 4.2: Transect walk for

		Sungai Cabang
Individual Semi-structured Interviews	• FNPF staff • Shopkeepers in Kumai • Center for International Forestry Research (CIFOR) staff who have conducted field work in Central Kalimantan • Retired government official from Ministry of Planning	Annex 5.1 – NGO Interview Guide Annex 5.2 Notes from interview with Pak Bayu, the Head of FNPF (in January 2011)
Surveys	• The long-form survey focused on understanding the family's financial background (assets owned and monthly expenditure), key priorities and concerns, energy source ownership, usage and maintenance and also willingness to pay for solar lanterns. • The short-form survey is an edited version of the long-form and focused only on finding out basic data regarding the household's priorities and energy ownership and usage.	Annex 6: Sample long-form survey Annex 7: Sample short-form survey

3 Context

3.1 Economic and Energy Context in Indonesia

3.1.1 National Context

Following the economic crisis in 1997, electricity demand grew at 7% between 1997 and 2005 and at 9% in 2006[5]. Between 2006 and 2026, Indonesia's electricity demand is forecasted to triple[6]. Recognizing rapid increase in electricity demand and the importance of electricity in economic growth, the Government of Indonesia (GOI) has formulated its energy policies based on four overarching principles: 1) reduce oil dependence and expand to coal, gas and renewable sources of energy; 2) eliminate fuel subsidies and implement rational energy pricing; 3) decentralize decision-making in energy sector to increase involvement of regional authority; and 4) increase electrification ratio to 90% by 2020 and bring rural electrification.

Despite GOI's policies and efforts, the rate of electrification is among the lowest in the region at about 64.5%, and 81.6 million people still do not have access to grid electricity[7]. Indonesia is endowed with coal, gas, oil, geothermal and hydro-electricity resources. However, the GOI faces many challenges in providing electricity to its population of approximately 230 million due to geographic constraints and limited capacity to mobilize the investment request to finance expansion of power infrastructure[8]. Rural electrification is particularly difficult in a country with roughly 17,000 islands; most of which are sparsely populated.

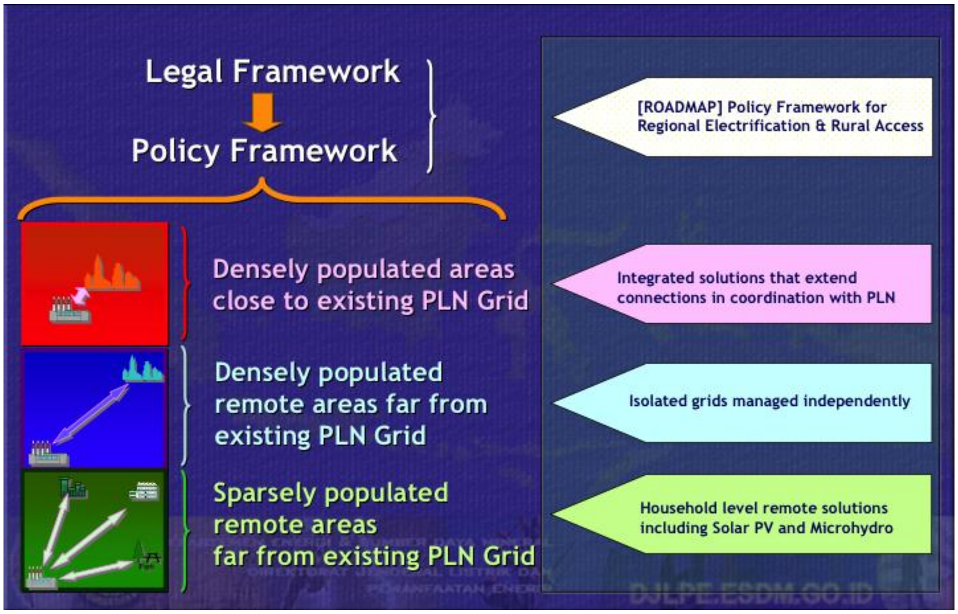
In addition to geographic constraints, heavy subsidies provided by the GOI on electricity create an unsustainable business model that leads to poor financial performance, erosion of revenue base and severe lack of capacity to extend services to rural areas. Indonesia ranks among the top 20 non-OECD countries with the highest energy subsidies[9]. Subsidy spending for the year 2010 was USD 22.3 billion[10]. The GOI subsidizes the price of electricity below the cost of production to all fuel consumers and not just the poorest, resulting in lower energy savings and constrained budgets that could be spent on energy needs[9]. The subsidy provided on domestic fuel prices was regressive, "with the top income decile receiving more than five times what the bottom income decile received[9]." As fuel prices increased in 2004, the subsidies were removed in some instances leading to a 25% fuel price increase in early 2005[9]. The IMF and WB continue to push for removing subsidies to unlock funds for investments in clean energy.

Moreover, the electricity industry in Indonesia is dominated by PT Perusahaan Listrik Negara (PT PLN), a state-owned electric company. Other electricity generating companies include independent power structures and private power utilities with the capacity of generating 3450 MW and 746 MW, respectively. Local governments, particularly in remote areas, tend to obtain electricity from private company providers[11]. The industry's feature also constrains investment in electricity infrastructure. About two-thirds of the population without electricity lives in the rural areas and a majority of them reside outside of Java-Bali. The Indonesian Electricity State Company (PLN) estimated there are over 6,000 villages throughout Indonesia, which will not be reached by the national electrification grid in the near future. Most of these villages are located outside of Java; 28% of the villages without electricity are in Kalimantan[12]. Power restrictions, blackouts, and power quality issues such as voltage variance and frequency fluctuations are common. As electricity demand continues to increase more than supply, the GOI recognizes that it cannot afford supplying conventional energy to rural areas. This is particularly true given the geographic challenge. In an attempt to diversify to more efficient and renewable alternative energy sources, the GOI has looked into harnessing solar, wind and geothermal energy among others. Table 1 shows that the GOI has also explored the use of other renewable energy sources for rural electrification. GOI is also diversifying its approach in distributing electricity in response to population density. Figure 2 depicts regional electrification and rural access channels.

Table 1 Rural Electrification Program: Exploring Different Sources of Energy[12]

2004	2005	2006	2007
Diesel generator: 104 units, 52,430 KW	Solar power system (PLTS) 1422 units/ 7,970 Wp	Solar power system (PLTS) 19,209 units/ 960,450 Wp	Solar power system (PLTS) 34,549 units/ 1,346,210 Wp
	Micro-Hydro (PLTMH) 3 units (40 KW)	Micro-Hydro (PLTMH 22 units/ 2,433 kW)	Micro-Hydro (PLTM) 12 units/ 2,115 kW
	Wing (PLTB) 2 units/ 160 KW	Wind (PLTB) 3 units/ 240 kW	Wind (PLTB) 41 units/ 480 kW
	Diesel Generator (PLTD): 48 units/ 25,350 kW		

Figure 2 Concept for regional electrification and rural access[12]



The GOI emphasized the use of solar home systems for rural electrification. It implemented a pilot photovoltaic solar home system (PV-SHS) project from 1997 to 2002 in partnership with the World Bank. The PV-SHS program targeted remote areas and the poorest sections of the population to install 200,000 SHS[13]. Over the last 10 years local governments had budgets allocated for SHS as part of the electrification program, and several thousands of PV systems were installed, especially in Kalimantan. The end-users received the systems for free but paid approximately Rp.1, 000,000 (USD 115) for transport and accommodation costs for technician installing the system[14]. This money would be collected by the KUD (Local Cooperatives) and used for replacement of the batteries.

Unfortunately most of these projects failed to move beyond the distribution and installation phase as neither maintenance nor collection of fees was ever done afterwards[14]. Production of high quality batteries also remains a challenge. The project also failed to provide means to "mainstream private sector delivery and financing."[13] Limited in-country organizational and financing experience on part of World Bank's staff also hampered the project. Nonetheless, recognizing potential growth in solar energy market, PV manufacturers such as BP Solar, Kyocera, Shell Solar, Siemens, and Solarex have already opened subsidiaries in Indonesia. In addition exploring different sources of energy to generate electricity, the GOI is also adopting different methods to increase rural access to electricity.

3.1.2 Central Kalimantan Context

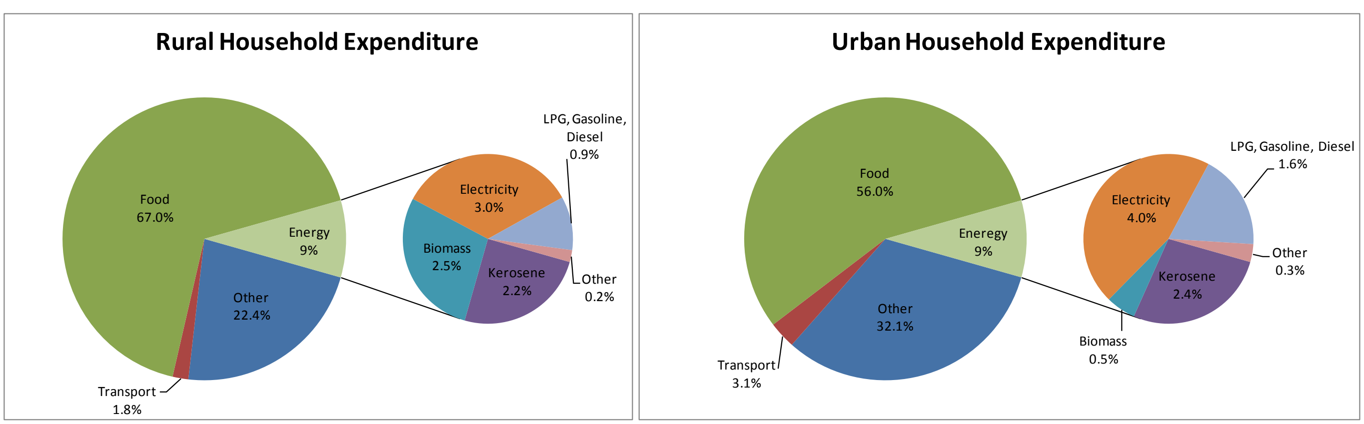
In Central Kalimantan, the rate of electrification is even lower at about 54.8% with almost 860,000 people and 180,000 households without access to electricity[15]. Central Kalimantan is Indonesia's third largest province and is one of the four provinces that make up the Indonesian part of the Borneo Island. It is mostly covered in forests. It is surrounded by West Kalimantan in the west, East and South Kalimantan in the east and the Java Sea in the south. After Indonesian independence, Central Kalimantan seceded from South Kalimantan to become a separate province in 1957[16]. Dayaks were the original inhabitants, but cultural diversity increased with the arrival of Malays, Chinese and Javanese among others. More than 70% of Dayaks in Central Kalimantan are Muslims[17].

Mining, forestry, tourism, fishing and farming are the primary sources of income for inhabitants of Central Kalimantan. With increasing investments from India and China, gold mining activities closer to Tanjung Harapan are expanding[18]. One of the consequences is a higher number of taxi boats carrying miners passing by Tanjung Harapan. The expansion of the mining industry is bound to bring substantial changes in the socio-economic sphere in the long-term. In addition to industrial energy needs, the increase in population resulting from job opportunities near the mines will also add pressure to the already scarce energy sources.

Following the fall of Suharto in 1998, the GOI launched a decentralization campaign. (For a brief historical and socio-economic background on Indonesia and Central Kalimantan, please refer to Annex 8.) Conversations with Stibniati Atmadja, a research fellow at Center for International Forestry Research (CIFOR), revealed that tensions between provincial government and federal government are surfacing over land rights[19]. Ongoing tensions are one of the reasons behind a low NGO presence in Central Kalimantan.

Both rural and urban households in Indonesia spent 8.8% of total household expenditures on energy on average in 2005 (Figure 3; Bacon *et al.*, 2010). For rural households, the expenditure on kerosene was 25% of the total energy expenditures or equivalent to about USD 4.09 per month (2005 $ at PPP) on average. For urban households, the expenditure on kerosene was 27.3% of the total energy expenditures or equivalent to ~USD 7.63 per month (2005 $ at PPP) on average.

Figure 3 Household expenditures in Indonesia[20]



3.2 Village Level Energy Context: Baseline Report

3.2.1 Village Socio-economic & Energy Context

Location and Socio-economy

The data collection sites varied significantly in terms of their economy, degree of isolation and size. With approximately 57 households and 323 residents, Tanjung Harapan is the smallest and youngest of the villages as it was relocated in 1982 from its original location within Tanjung Puting National Park to its current location on the banks of Sekonyer River. A major source of employment for villagers in Tanjung Harapan includes government and non-profit agencies managing, conserving and organizing tourism to the national park as well as palm oil plantations and mining. Sungai Cabang, the most isolated of the three villages, is a coastal community whose economy relies relatively more on the fishing industry. Sungai Pasir with 480 households and approximately 1,800 residents is the largest of the three villages and livelihoods are based mainly on agriculture and fish farming. The closest town to both Tanjung Harapan and Sungai Cabang is Kumai, which is 11.4 kilometers (45 minutes by speedboat) and 87.3 kilometers (1.5 hours by speedboat) away, respectively. Sungai Pasir, which is approximately 1 hour away from Pangkalan Bun, is the largest of the three villages. Based on the information in the FNPF proposal, the average household income in these villages ranges from Rp 500,000-1,000,000 (USD 55-110). Focus group participants consistently pointed out in all three villages that monthly earnings vary significantly from month to month. (The first panel in Figure 4 displays the geographic location of these villages in Kalimantan in relation to the closest urban centers. The second panel provides a satellite image of the environment around two interviewed households in Sungai Pasir).

Figure 4 Location of Villages

Satellite view of two interviewed households in Sungai Pasir

Table 2 Characteristics of villages and socio-economic characteristics of household sample

	All Households	Tanjung Harapan	Sungai Cabang	Sungai Pasir
Total number of households (approximate)	657	57	120	480
Total population (approximate)	2,823	323	700	1,800
Area (square kilometers) (approximate)		1.05	2.4	12
Village population density (people per square kilometer)		307	291	150
Closest town	--	Kumai	Kumai	Pangkalan Bun
Distance to closest town (km)	--	11.4	87.3	54.3
Number of Sampled Households	42	12	15	15
Number of Respondents	62	15	23	24
Respondent Characteristics				
Age (mean)	42.2	46.7	42.7	39.0
Male (%)	48%	47%	48%	50%
No formal education (%)	20%	36%	13%	17%
Primary education or higher (%)	80%	64%	87%	83%
Households with 1 respondent (%)	52%	75%	47%	40%
Households with 2 respondents (%)	48%	25%	53%	60%
Primary Source of income				
Agriculture	21%	8%	47%	7%
Fishing & aquaculture	38%	0%	47%	60%
Services	40%	92%	7%	33%
Family Characteristics (mean values)				
Number of family members living in home	4.6	3.9	5.5	4.3
Number of children	2.6	2.3	3.2	2.4
Number of children going to school	1.3	1.3	1.5	1.1
House Characteristics & Asset Ownership (mean values)				
Number of rooms in house	2.1	2.1	2.0	2.2
Cell phone	79%	83%	60%	93%
Livestock	76%	75%	80%	73%
Boat	50%	50%	53%	47%
Television (% ownership)	45%	42%	47%	47%
Motorbike	45%	42%	20%	73%
Satellite	36%	33%	40%	33%
Radio	33%	42%	40%	20%
Bicycle	26%	67%	0%	20%
Land ownership	79%	67%	87%	80%
Hectares Owned	2.0	3.7	1.4	1.8

Source**: Author's calculations based on household interviews**

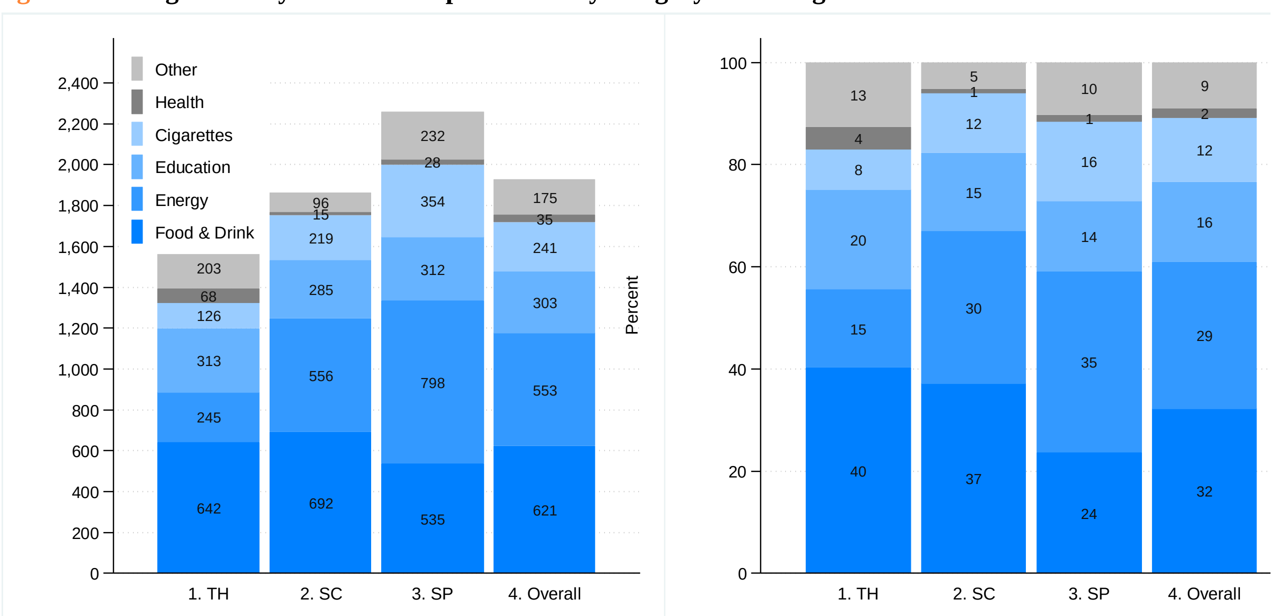
Table 2 provides an overview of the characteristics of the respondents and households interviewed. In total, we visited 43 households and interviewed 62 respondents (in 20 households, we conducted a joint interview with husband and spouse). On average, respondents were 42 years old, were likely to have completed primary education (20% had no formal education and only 15% of respondents completed secondary education) had 3 children of which 1 was going to school and lived in a house with 4 rooms (counting the kitchen and common areas). Over half of all households owned land, cell phones, boats and livestock. Between 30% and 45% of all households owned televisions, motorbikes, satellites and radios.

None of the families owned refrigerators. It is important to note however, that the overall averages mask important differences across the villages. For example, in Tanjung Harapan over one in three respondents had no formal education compared to one in ten in Sungai Cabang and Sungai Pasir. The average household size was considerably larger in Sungai Cabang (5.5 residents per house versus 3.9 and 4.3 in Tanjung Harapan and Sungai Pasir, respectively). Cell phone ownership (60%) was lowest in Sungai Cabang likely due to its relatively higher degree of isolation and poor cell phone reception, while in Sungai Pasir, motorbike ownership was much more likely (73%) given the larger size of the village, the presence of paved roads, and proximity to other towns.

Household Expenditures

Across the three villages, on average, interviewed households spend Rp 1.9 million per month (USD 221 per month or 7 USD per day) of which 32% is spent on food and drink, 29% on energy (primarily on fuels for lighting, cooking, transportation and entertainment), 16% on children's education, 12% on cigarettes, 2% on health care and 9% on entertainment, clothing and communication (cell phone top-ups). Additional detail on energy expenditures is provided in Figure 5 below. Sungai Pasir has the highest spending levels (Rp 2.26 million per month per household or USD 259) while Tanjung Harapan has the lowest (Rp 1.6 million per month per household or USD 183 per month). In terms of energy consumption, households in Sungai Pasir devote a larger share of their household budget to energy (35%) relative to households in Sungai Cabang and Tanjung Harapan (30% and 15%, respectively). Compared to published estimates in the World Bank report, the share of energy expenditures in the household budget found here is substantially higher (32% compared to 8.8%). This difference is most likely due to our focus on three relatively isolated rural villages, while the World Bank estimates average expenditures across both urban and rural households. It is important to note that both men and women carry out fuel purchase and collection and women were active in several of the focus group discussions and interviews.

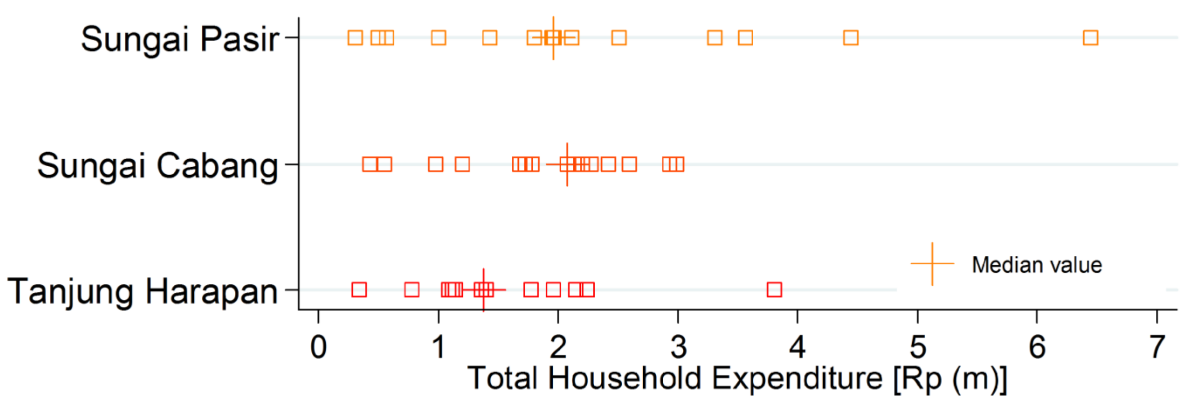
Figure 5 Average monthly household expenditures by category and village



Source: Author's calculations based on household interviews
Note: "Other" includes expenditures on clothing, entertainment and communication

Figure 6 displays total monthly expenditure for each household by village revealing considerable variation in household expenditure and by extension economic status within each village. Sungai Pasir, the largest of the villages, has the widest range of estimated monthly spending: from Rp 305,020 (USD 35) to Rp 6,444,667 (USD738).

Figure 6 Household expenditure by village

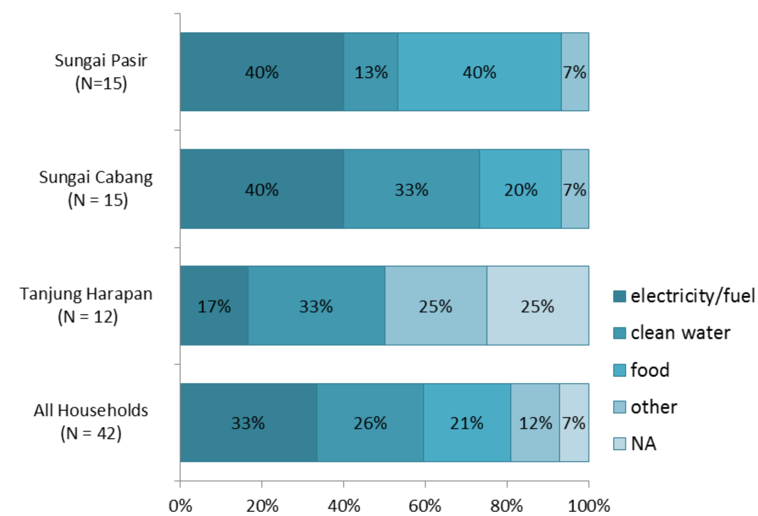


Source: Author's calculations based on household interviews

Household Challenges

In addition to information on household socio-economic status, in an effort to understand perspectives on household-level challenges, we asked each respondent to rank the first, second and third greatest challenges faced by the household from a list that included the following: electricity or fuel, water, food, communication, education, financing, transportation, health care and left an open option for challenges not listed. We followed up with open-ended questions to understand the underlying reasons for their choice. One-third of these sectors (energy, water and food) were selected as the greatest challenge 80% of the time. Overall, 33% of households selected electricity or fuel as the greatest challenge, 26% selected water and 21% selected food. Energy was relatively less of challenge in Tanjung Harapan, access to clean water was relatively less a priority Sungai Pasir and food, while not mentioned as a primary challenge in Tanjung Harapan, was a major challenge in Sungai Pasir. In both Sungai Pasir and Sungai Cabang, the fourth category that was recognized as a major challenge was communication and financing. Among households selecting electricity and fuel as a major challenge, several reasons were mentioned including insufficient lighting and the high costs of fuels. When water was mentioned, the lack of access to clean water was consistently understood as the problem. In the case of food, in the majority of cases, the availability and price of rice was a major concern.

Figure 7 Highest ranked household challenges, by village



Source: Author's calculations based on household interviews
Note: "Other" aggregates transportation, education, financing, transportation and health care. NA represents missing data.

Household Energy Use and Behavior

In Tanjung Harapan, Sungai Cabang and Sungai Pasir, households rely on a diverse mix of energy sources for domestic and productive purposes (including cooking, lighting, transportation and entertainment). Figure 8 provides a mapping between the set of energy sources available to households, the technologies available to convert these energy sources into usable energy and the primary services provided by each. Among the seven energy sources explored in our household interviews (no households were connected to a central electricity grid) - firewood, kerosene, diesel, benzene, candles, batteries and solar – on average, households used 4 of these energy sources. No households relied solely on a single source of energy (such as firewood). Except for firewood, which is gathered locally, all energy sources are available commercially. The primary energy sources for lighting are fuel based (kerosene, diesel, benzene), but several solar home systems distributed through government programs were observed as well.

Figure 8 Energy-Sources to Energy-Services Mapping

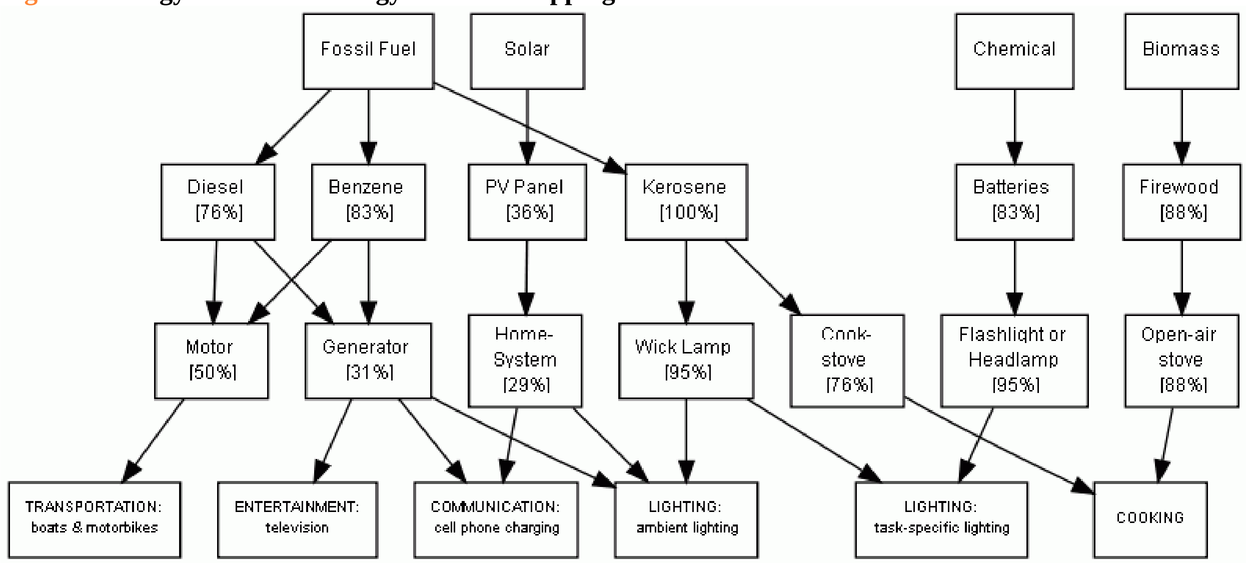


Table 3 provides an overview of the energy sources used by households as well as the applications enabled by each energy source while Table 4 provides an overview of the energy appliances used.

Table 3 Energy Sources and Services

			Among energy source users, percentage using energy source for….									
Energy Source	**Among households N = 42), Percentage Using Energy Source**	**Among energy users, Percentage Borrowing Energy**	**… Cooking**	**…Reading**	**…Working**	**…Walking**	**…Sleeping**	**…TV / Radio**	**…Cell phone Charging**	**…Social Interaction**	**…Transportation**	**…Pumping water**
Kerosene	100%	5%	79%	21%	5%	17%	69%	0%	0%	21%	2%	0%
Wood	88%	0%	92%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Batteries	84%	0%	3%	3%	42%	55%	0%	5%	3%	5%	0%	0%
Diesel	76%	69%	6%	34%	16%	9%	6%	38%	69%	38%	53%	13%

Benzene	48%	0%	5%	10%	10%	0%	0%	15%	10%	10%	75%	10%
Solar Panel	36%	20%	13%	27%	20%	0%	40%	0%	13%	60%	0%	0%
Candles	5%	0%	50%	50%	0%	0%	0%	0%	0%	0%	0%	0%
Solar Lantern	5%	0%	0%	50%	0%	0%	0%	0%	100%	0%	0%	0%

Source**: Author's calculations based on household interviews**

Table 4 **Energy Appliances**

Energy Appliance	Energy Appliance Owned (%)	Energy Appliance Borrowed (%)	Median Quantity Owned	Median Hours Used	Median Price of Purchase (Rp)	Median Price of Purchase (USD)	Energy Appliance Broken (%)
Headlamp or Flashlight	95%	0%	1	1.1	30,000	3.44	5%
Kerosene Wick Lamps	95%	0%	3	10.5	-	-	3%
Wood-burning stove	86%	0%	1	2.0	-	-	0%
Kerosene Cook-stove	76%	0%	1	1.0	200,000	22.90	0%
Light Bulbs	64%	0%	2	4.0	100,000	11.45	0%
Benzene Motor	40%	0%	1	1.8	5,000,000	572.54	0%
Diesel Motor	36%	2%	1	8.5	2,350,000	269.09	0%
Solar Home System	29%	10%	1	11.5	1,050,000	120.23	25%
Diesel Generator	21%	50%	1	3.5	800,000	91.61	30%
Benzene Generator	10%	0%	1	2.5	925,000	105.92	0%
Kerosene Hurricane Lamp	10%	0%	1	1.3	60,000	6.87	25%
Candles	5%	0%	-	-	-	-	0%
Solar Lantern	5%	0%	1	-	-	-	50%

Source**: Author's calculations based on household interviews**

Batteries used to power flashlights or headlamps were the third most used energy source (95% of households owned a battery-powered device, 84% reported using the devices). Flashlights and headlamps were used primarily for illuminating work-related activities such as tending fields, fishing ponds or for walking in the village at night. Most households owned between 1 and 2 portable battery-powered devices and used them between 1 and 2 hours per day. These devices were available commercially from Pangkalan Bun and Kumai at a median purchase price of Rp 30,000 or USD 3.44 (some models cost as much as Rp 200,000 or USD 22).

Diesel and benzene were the fourth and fifth most prevalent energy sources – used by 76% and 48% of households, respectively. The two main uses of diesel and benzene were for the generation of electricity for household lighting, entertainment, cell phone charging and transportation. Interestingly, 69 percent of diesel users either borrowed or rented the electricity generated from the generators owned by neighbors. Households with direct or indirect access to a generator used the electricity for 3.5 hours per day (usually between 6 or 7pm and 9 or 10pm). Generators are available commercially from Pangkalan Bun or Kumai. The median purchase price was Rp 800,000 (USD 91.6) for diesel generators and Rp 925,000 (USD 105.9) for Benzene generators.

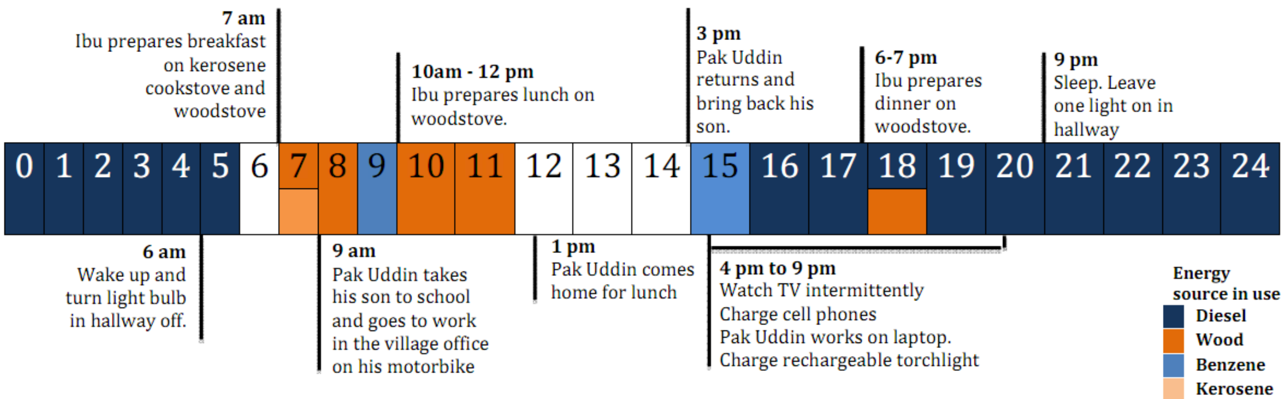
Approximately one third of all households owned a means of private transportation (boat, motorbike or car). Boat owners (33% of households) relied primarily on diesel, while motorbike owners (36% of households) used benzene. Boat owners paid a median price of Rp 2,350,000 (USD 269 USD) for a diesel motor used 8.5 hours per day while benzene-fueled motorbike owners paid a median price of Rp 5,000,000 (USD 572.5) which was used 1.8 hours per day.

Forty one percent of the households interviewed used solar-derived electricity either directly or indirectly (through borrowing or pay-per use arrangements) from solar panel installations (50 Wp power capacity) or from the solar lanterns (1.5 Wp power capacity) distributed in Kopernik's pilot project. Twenty-nine percent of households interviewed owned solar panels while 5% owned solar lanterns. In Tanjung Harapan and Sungai Pasir, 42 and 47% of households, respectively, owned solar panels, none of the households interviewed in Sungai Cabang owned solar panels. The majority of solar panels observed in the villages were procured through a government-sponsored program, with a handful of villagers subsequently deciding to commercially purchase a first or second panel after appreciating the benefits of solar energy (See Box 2 for a profile of a Solar Panel user). On average, households reported paying Rp 1,050,000 (USD 120) per solar panel or its associate costs.

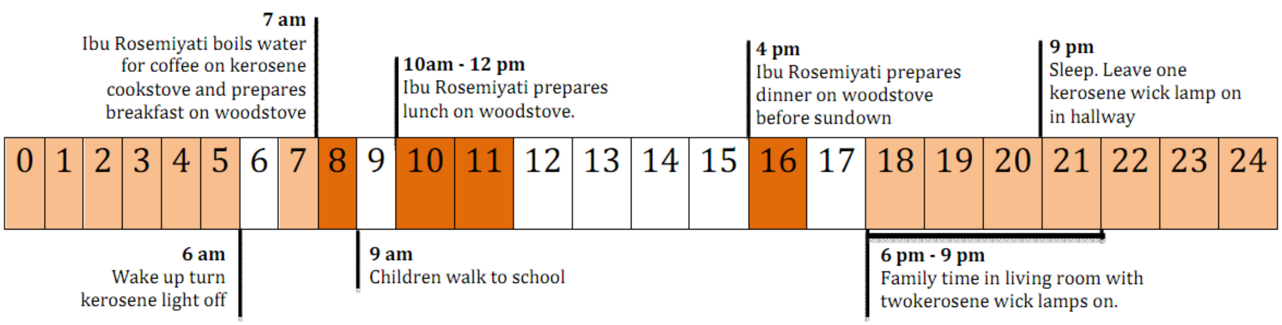
Figure 9 provides an example of how energy use evolves over the course of a day for two prototypical households – one with access to a diesel generator – and another without the ability to generate electricity. Although drawn from individual households, the figure helps compare the diverse energy sources and services used by higher and lower income households. It is important to note that people have adjusted their lifestyles according to energy availability and affordability. In the case of the household without a diesel generator, they cooked dinner before sunset because they could not afford lighting for cooking. An extreme case observed was a household that was cooking in near darkness with a dim line of light coming from the built in flashlight of a cell phone. On the other hand, the household with a diesel generator left one bulb in the hallway on while they slept. This is not very common because many households tend to leave a kerosene wick lamp on throughout the night despite having a diesel generator.

Figure 9 Daily energy use profile

Household with diesel generator



Household relying primarily on kerosene and firewood for energy needs.



Source: Household interviews and observations during March 2011 field work.

Table 5 provides an overview of types of electricity access overall and for each of the villages visited. While 31% of households interviewed own either diesel or benzene generators, only 26% of households had functional generators at the time of interview. Likewise, while 29% of households owned solar panels, only 21% of the households had functional panels at the time of interview.

Table 5 Household electricity access by village

Village	Number of Households	Generator Owners (%)	Solar Panel Owners (%)	Households with means to produce electricity (%)	Non-owners with electricity access via informal arrangement (%)	Households relying primarily on Kerosene for lighting (%)
Tanjung Harapan	12	17%	42%	50%	25%	25%
Sungai Cabang	15	27%	0%	27%	47%	27%
Sungai Pasir	15	33%	27%	47%	33%	20%
Total	42	26%	21%	40%	36%	24%

Overall, 40% of households have direct (ownership) access to electricity either form generators or solar panels. By village, 50%, 27% and 47% of households interviewed in Tanjung Harapan, Sungai Cabang and Sungai Pasir, respectively have direct access to electricity. Expanding the definition of electricity access to include secondary electricity users (non-generator owning) with a regular connection to electricity through informal arrangements, electricity access is 66%. If secondary users with limited access to electricity (only use electricity from a neighbor or family member when re-charging a cell phone, for example), electricity access is 86%. About a quarter of households have no direct or indirect access to electricity - these households rely primarily on kerosene for ambient lighting.

The pattern of informal arrangements with generator owners signals a large demand for the energy-services electricity enables among households that cannot afford electricity-generating technology. Alternative, informal, arrangements have sprung up to meet this need; these work because they provide energy on a per-use basis and do not require large up front outlays of cash to purchase generators or photovoltaic panels. In many cases households with the means to produce electricity allow neighbors to charge cell phones and watch TV at their houses for free. There is a strong culture of sharing resources so few families pay for these ancillary services directly.

An important distinction between the electricity from generators with the electricity from the solar panel models encountered is that diesel or benzene generators provides households with wider access to services than solar panels – including the ability to power a television – which was a highly valued service in each of the villages visited. Indeed, one of the main reasons for purchasing a generator seems to be able to use a television – 72% of generator owners also owned a television. In two households that were paying to share electricity with a neighbor, payments ceased when their television broke, providing anecdotal evidence that demand for electricity is driven to a large degree by the demand for entertainment. In terms of lighting, households with regular access to electricity used – on average – 2 light bulbs per house or one light bulb for every two rooms. Often the lighting sources are strategically placed to get the most benefit from the light (ie in a doorway between the kitchen and living room).

Box 1. In the dark: Ibu Rosemayeti in Tanjung Harapan

As dusk fell in the river village of Tanjung Harapan, the diesel generators came on and filled the air with a humming noise. It was high tide and so we walked over a plank and arrived in Ibu Rosemayeti ‘s home. The houses are raised because of the swampy nature. Ibu Rosemayeti welcomed us and gestured to sit on the floor in the open living room. It was a large open room, without any furniture but with a motorcycle parked on one corner. It belonged to Ibu Rosemayeti’s husband who worked for the Tanjung Putting National Park and was usually away based in a post within the park. He earned about Rp 1,500,000 a month for the family of 7. Ibu Rosemayeti has 5 children, three of whom still go to school. She sat against a wall. Although slightly shy, she prepared for our surveys on household energy use.

An incandescent ambient light powered by solar panels gave shadowy white light. “It rained the whole day so the power is very low,” Ibu Rosemayeti explained. As the night grew darker, kerosene wick lamps were brought out to supplement the solar-powered light. They only had two homemade kerosene wick lamps that they used for about 11 hours every day.

Besides the kerosene wick lamps and the solar-powered incandescent light, the household has 1 flashlight and 1 headlight. However, unable to get batteries from Kumai because it is far and expensive with each costing Rp. 5,0000, they have not been using the flashlight. A cell phone with one in-built LED light is used instead. Ibu mentioned that one of her daughters was using the cell phone to cook. “Normally, we cook around 4 pm before sunset, but today we are late,” Ibu mentioned.

In the kitchen, there was pitch darkness except the light emitted by the fire in the firewood open cook stove. Ibu Rosemayeti’s daughter held a cell phone on one hand and from with the help of the tiny LED light stirred vegetables in a large pan. The cell phone is charged for free in the village leader’s house.

Ibu Rosemayeti’s family uses a combination of energy sources which include, biomass, kerosene, batteries, benzene and solar. Due to low income she cannot afford many kerosene wick lamps or replacement batteries for her flashlight. Solar-powered light bulb fulfills the lighting needs unmet by kerosene wick lamps. However, they are not very dependable especially when the household does not have access to a stable source of electricity such as a diesel generator. Although, Ibu Rosemayeti uses a combination of energy sources she is at the bottom of the energy ladder as her family continues to live in the dark once night falls.

Box 2. Appreciating the Benefits of Solar Power

Thirty-seven years old Sujonal is a fish farmer. He has been using solar panels for the past 10 years. He first learned about solar panel when he visited his friend in another village, Pandulangan, who told him that the government had been distributing solar panelsas a part of its policy to electrify rural areas. Village leaders have to submit a request and if they are selected through a lottery system, they receive solar panels and a liquid battery. The solar panels are subsidized but the recipient has to cover accommodation and transport for the technician who installs the panels. The costs range from Rp. 1 to 1.4 million. Sujonal, however, did not buy his solar panel from the government. When he saw the solar panel at his friend's house, he immediately recognized its benefits and bought secondhand panels for Rp. 1.1 million. "Solar energy is free," he said, sitting next to a window, "they bring in a lot of light." After he bought his solar panel, five of his neighbors followed his example.

He uses the solar panel to light bulbs in the living room, kitchen, bathroom, to charge his cell phone and rechargeable torch light, which he uses at night to check his fish ponds. Sujonol added that he needs strong light when he goes fishing at night or when he is checking his fish farms at night.

"I got a solar panel because it is more economic. My savings have increased with solar panel. We just use 20 liters of kerosene a month. Before we used 40 liters of kerosene for lighting," Lamini, Sujonol's wife, mentioned.

In addition to solar energy, Sujonal and his family depend on wood, kerosene, diesel and benzene for carrying out various activities. Although they own a campor, a kerosene cook stove, they use it for half an hour a day to boil water or to prepare a quick meal like fried eggs. They mostly use wood on a stove that is similar to an open grill. Both Sujonal and Lamini collect wood for an hour each day. They continue to use kerosene wick lamps. They leave one on when they are sleeping.

For work in his fish farms, Sujonol depends on diesel. He uses it to pump water out when he harvests three times a year. He also uses it to pump water into the fish farms during dry seasons. Prior to installing the solar home systems, Sujonol used a diesel generator for electricity as well. Diesel was expensive and his generator broke two years ago. Since then, he has been fully dependent on solar energy for electricity. The solar panel has, however, been broken for a month. It is difficult to get spare parts because of the village's remoteness. Also, spare parts for solar panels are not easy to find, and they are expensive.

Household Energy Consumption and Expenditure

Table 6 provides a breakdown of recurrent consumption and expenditure on kerosene, diesel, benzene and batteries. The hours collecting wood per month (to convey the opportunity rather than monetary cost of firewood) based on a subset of households where we inquired is also included, but this subsample may not be representative of the villages more generally. In as many cases as possible, we inquired about the fraction of kerosene used for cooking and for lighting and the fraction of diesel and benzene used for transportation and electricity generation but this information was not systematically captured. Table 6 reports the median price of purchase for each fuel in each of the villages as well as Kumai and Pangkalan Bun. The largest component of energy consumption and expenditure is on diesel – representing 62% of total household spending on energy. On average, households consume 73 liters of diesel per month, spending USD 54 on these purchases. Purchases on benzene represent 22% of total energy spending. On average, households consume 21 liters of benzene per month and spend USD 19.6 on this amount. Kerosene expenditures represent 12% of total energy expenditures. On average, households consume 17 liters of Kerosene per month and spend USD 10.74 on this amount.

Another way to look at energy consumption and expenditures is by the service delivered by the fuel. Across all villages, approximately 58% of fuel expenditure is used for transportation, 24.5% for lighting, 13.5% for entertainment or communication and 4% for cooking. This disaggregation is a very rough estimate and assumes that out of all diesel and benzene expenditures for electricity generation, half is used for lighting and half is used for powering the television, cell phones and radios.

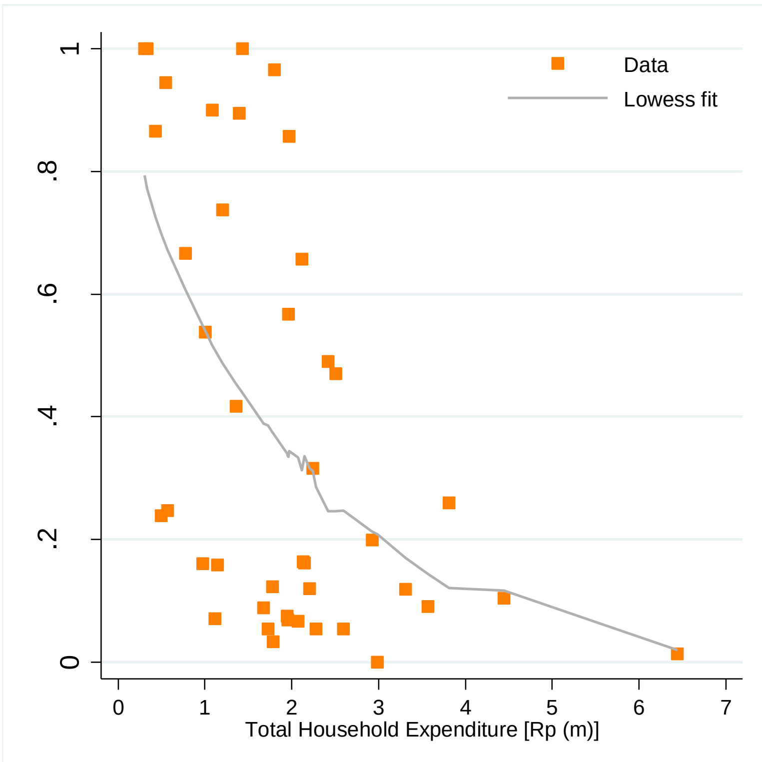
Table 6 Recurrent Energy Expenditures by Energy Source (All Villages)

Energy Source	N	Mean	SD	Min	Max
Kerosene					
Quantity Consumed by Household per month (L)	42	17	15	0	60
Expenditure per month (Rp)	42				
Expenditure per month (USD)	42	10.74	9.53	0	41.22
Pct of total quantity consumed used for cook-stove (%)	18	31%	37%	0%	100%
Pct of total quantity consumed used for wick lamp (%)	18	69%	37%	0%	100%
Wood					
Hours spent collecting wood per month	12	8	6	2	23
Batteries					
Quantity Consumed by Household per Month (units)	38	5	6	0	30
Expenditure per month (Rp)	38				
Expenditure per month (USD)	38	1.99	2.54	0	12.02
Diesel					
Quantity Consumed by Household per month (L)	32	73	111	0	600
Expenditure per month (Rp)	32				
Expenditure per month (USD)	32	54.44	93.62	0	515.29
Pct of total quantity consumed used for generator per month (%)	21	36%	41%	0%	100%
Pct of total quantity consumed used for transportation per month	21	60%	42%	0%	100%
Benzene					
Quantity Consumed by Household per month (L)	20	21	17	0	60
Expenditure per month (Rp)	20				
Expenditure per month (USD)	20	19.62	16.31	0	61.83
Pct of total quantity consumed used for generator per month (%)	18	19%	38%	0%	100%
Pct of total quantity consumed used for transportation per month	18	81%	38%	0%	100%

Note: Currency converted to US Dollars using average exchange rate over the data collection period: 8733 Rp per USD
Source: Author's calculations using household interview data.

Figure 10 displays the relationship between the percentage of total energy expenditures on kerosene and total household expenditure. The graph reveals that richer households prioritize kerosene less in their energy portfolios compared to poorer households. This suggests that as household wealth increases, households spend relatively more on the fuels (and the associated appliances) that give them access to a wider range of services (such as entertainment and transportation).

Figure 10 Percentage of total energy expenditure on Kerosene versus total household expenditure



Source: Author's calculations using household interview data.

4 Impact Evaluation

4.1 General Benefits of Solar Lanterns

The International Energy Agency estimates that around 1.44 billion people or 22% of the global population lives without access to electricity[7]. In the absence of reliable grid electricity, households in many developing countries predominantly rely on kerosene. Kerosene lighting, especially kerosene wick lamps, is often a preferred source of illumination because they are well adapted to a poor household's spending patterns. They require little up-front capital investment and allow households with unstable cash flow to purchase the necessary amount of fuel as needed[21]. They, however, generate extremely low and inefficient lighting and pose significant economic, social, and environmental costs. Solar lanterns are one of the most effective options for replacing kerosene lamps, offering multiple benefits.

4.1.1 Economic Benefits

Cost Savings

Fuel-based lighting is estimated to be responsible for annual energy consumption of 77 billion liters of fuel worldwide or 33% of the total primary energy used for household lighting globally at a cost of USD 38 billion each year[22]. Assuming that a kerosene lamp consumes 0.03-0.06 liters of kerosene per hour and with an average usage of 4 – 6 hours a day, the monthly kerosene consumption is about 7 – 9 liters per household[22, 23]. For rural households in developing countries, recurring expenditures on kerosene can reach up to 25% of household budgets[24] and up to70% of total energy expenditure[25].

Given high energy expenditure among rural households, one of the most significant benefits of solar lanterns is the reduction in energy expenditures for lighting by directly replacing kerosene usage. For example, after an introduction of solar lanterns, the average expenditure for kerosene per year fell by USD 22.88 per family in India. In addition to the reduced use of kerosene, households who received solar lanterns also consumed less electricity and overall each household saved USD 91.55 (±63.06, n=100) in aggregate energy costs per year, a huge savings on an annual family income ranging from USD 150 to 250[26].

Light Quality and Efficiency

Fuel-based lighting sources tend to generate poor quality light at very low efficiencies[21, 22, 27]. For example, over 60% of rural households in developing countries use only kerosene lamps for lighting which produce 95% less intense light while costing approximatelty150 times more per useful lighting energy services than a 100-watt incandescent bulb [22, 28]. In other words, the total annual light output from a simple wick lamp is equivalent to that produced by a 100-watt incandescent bulb in 10 hours[22].

In addition to the inherent light quality of kerosene lamps, behavioral patterns such as adjusting the lamp setting, cleaning glass covers, replacing mantles, and polishing reflectors further reduces the performance of lamps and their resulting illumination[21].

LED-based solar lanterns provide lighting with higher quality and efficiency[22]. According to one estimate, LED lanterns are about four times more efficient than incandescent light bulbs, and can last up to 50,000 hours, offering a superior alternative to kerosene lamps.

Livelihood

Solar lanterns can improve pre-existing livelihood activities by extending working hours beyond sunset and providing better quality illumination. For example, with portable solar lanterns, farmers can go into the fields at night to water crops without fear of snakes. Household members can also continue to carry out income generating activities such as handcrafts at night with additional illumination from solar lanterns (Figure 11). Furthermore, there have been case studies that demonstrated that better lighting from solar lanterns led to extended shop hours and an increase in sales.

In addition to supporting pre-existing livelihood activities, solar lanterns can create new opportunities for employment and supplementary income sources. Companies such as D.Light have hired and trained local entrepreneurs to market and distribute their solar products which not only improved market penetration but also created employment in India[29]. Other companies have explored the dissemination model based on solar lantern rental and charging stations, which would create additional employment opportunities for rural entrepreneurs[30]. In countries with limited access to grid electricity but high level of cell phone use, the owners of solar lanterns with additional features have been shown to create a business of recharging cell phones for a fee in Kenya[31].

Figure 11 Livelihood activities with kerosene lamps and solar lanterns

Handicraft by Kerosene Lamp | **Kiosk with Firefly Solar Lantern**

4.1.2 Health Benefits

Indoor Air Pollution

Kerosene lamps often contribute to increased indoor air pollution by emitting various pollutants such as carbon monoxide, nitrogen oxide, and hydrocarbons (soot) with known health impacts[24]. Carbon monoxide (CO) can replace the oxygen indoors that can lead to fatal suffocation. Nitrogen oxides and sulfur oxides (NOx, SOx) cause lung and eye infections, respiratory problems and cancer while volatile organic compounds (VOCs) from kerosene lamps can cause eye, nose and throat infections, as well as kidney and liver afflictions[23]. In fact, a survey conducted in India reported eye irritation, coughing, and nasal problems associated with the use of kerosene lamps[32]. Replacing kerosene lamps with solar lanterns can mitigates the risk and health problems associated with kerosene lanterns.

Safety

Kerosene lamps can lead to hazardous incidents of fire due to spillage of kerosene from wick lamps, which can cause severe burns, deaths, and loss of properties. Furthermore, accidental ingestion of kerosene by children is a significant safety issue, reported not only in India, but also from other developing countries such as South Africa, Argentina, Senegal, and Kenya where a large population uses kerosene for domestic lighting[30]. A substantial number of children reportedly die of accidental kerosene poisoning every year[33]. These incidents are more common for extreme bottom of the pyramid households, who cannot afford a proper bottle and wick and usually rely on a fragile glass bottle and a piece of rope for the wick. By reducing the amount of kerosene stored and burned, solar lanterns can significantly reduce fire and poisoning hazards associated with kerosene lamps.

4.1.3 Social Benefits

Education

Compared to traditional sources of lighting such as candles and kerosene lamps, solar lanterns provide a much clearer, brighter and more dependable light without eye-burning fumes and they create an environment that is more conducive for studying. According to D.Light, customers often report that their children have increased their studying time each night by one to four hours[29]. A different study in India showed that an introduction of solar lanterns increased study hours of students per household by 1.26 hours on average and the increase in study hours had had a positive impact on student’s performance at school[26].

Social interaction

With affordable and reliable lighting from solar lanterns, people can easily stay up after dark to do chores and talk to neighbors, enhancing social life in the rural off-grid communities[29]. Furthermore, obtaining fuel can be a time consuming task that requires traveling long distances and is often undertaken by women and children[34, 35]. Therefore, solar lanterns can allow women and children to spend less time on collecting fuel and more time on social interaction and education. Some solar lanterns are designed to charge cell phones which can improve communication and social interaction as well.

Consistent access to energy

Even in communities connected to a national grid, the access to electricity can be inconsistent[26]. Combined with a proper energy storage system, solar lanterns can provide people with consistent access to illumination.

4.1.4 Environmental Benefits

Greenhouse gas emission

Used 4 hours a day, a single kerosene lantern emits over 100 kg of the greenhouse gas carbon dioxide into the atmosphere each year[36]. It has been estimated that kerosene lanterns in developing nations alone annually burn 470 million barrels of oil, releasing roughly 400 billion pounds of CO_2 and equivalent gases into the atmosphere[22]. A LED-based solar lantern can reduce the emission of greenhouse gas into the atmosphere by replacing kerosene usage.

Production and transportation of solar lanterns generate some “upstream” greenhouse gas emission. But a study prepared for the World Bank found that for solar lanterns, the upstream emissions are offset by comparable upstream emissions savings associated with displaced kerosene refining and transportation[37].

4.1.5 Macro-economic Benefits

Fuel prices can be highly volatile, which leads to political and social unrest, hoarding, and scarcity. For example, unsubsidized Arabian Gulf kerosene price fluctuated by a factor of 3.5 between January 1998 and January 2001[22]. The large and sustained increase in international oil prices since late 2003 has led many developing countries to adopt pricing policies to protect users from the full impact. But such pricing policies can incur significant government expenditures. In Indonesia, the government's cost was close to USD10 billion in 2005[38]. Subsidies also create price distortions that discourage conservation and encourage dangerous and polluting fuel adulteration in the domestic and transport sectors[38]. Systemic distribution of solar lanterns can reduce the reliance on subsidized kerosene and other fuels while ensuring fair access to energy, reducing government expenditures and subsidy-related market distortions.

4.2 Initial Impact of Firefly Lantern Distribution

We evaluated the initial impact of Firefly solar lanterns, which were distributed during the pilot project between Kopernik and FNPF approximately 6-8 months prior to our visit. Out of 24 lanterns distributed to two communities, Tanjung Harapan and Sungai Cabang, we conducted individual interviews and focus group discussions with 7 community members who received the lanterns (Table 7). Overall, the respondents recognized many advantages of solar lanterns over kerosene lamps. It was, however, premature to conclude on the long-term impact of solar lanterns beyond outcomes and the initial impact we observed given that the lanterns were distributed less than a year ago and that we identified durability and maintenance as major challenges to sustainability. It should also be noted that the evaluation of initial impact was based on qualitative semi-structured interviews and focus group discussions with a small and non-randomized sample. Therefore, the results presented here may not be representative. Furthermore, the lack of a counterfactual or a control group (those who had the same characteristics as the solar lantern recipients but did not receive solar lanterns) prevents us from attributing all the changes observed solely to the solar lanterns distributed. Therefore, we must be cautious about generalizing the findings on the initial impact from the pilot project.

Table 7 Interview & Focus Group Characteristics

	Tanjung Harapan	Sungai Cabang	Sungai Pasir
Interview Respondents	5	2	1
Focus Group Respondents	10	8	11
Focus Groups Conducted	*2*	*2*	*2*
Total Respondents	15	10	12
Respondents by Focus Group Type			
Solar Lantern Users	5	2	0
Number of non-functional solar lanterns	2	2	NA
Kerosene Users	5	6	5
Generator Owners	0	0	6
Average monthly household expenditure for illumination pre-Firefly (Current USD)			
Kerosene	$ 9.31	--	$ 9.07
Diesel	--	--	$ 42.11
Benzene	--	--	$ 33.24
Batteries	$ 1.16	--	$ 0.66

Cost Savings

Before the distribution of the Firefly solar lanterns, the average monthly expenditure on kerosene was USD 9.31, equivalent to 10.6% of the average monthly household income (Table 7). Households who received solar lanterns reported reducing the consumption of kerosene by 6.13 liters (Table 8). The monthly household expenditure on kerosene decreased by USD 3.74 or by 40.2% on average. Given low and unstable income for many households in these communities, this cost saving is significant.

Table 8 Impact & Perceived Benefits of Solar Lanterns

	Tanjung Harapan	Sungai Cabang	Sungai Pasir	Total (N = 37)	
Average Monthly Savings (liters of kerosene)	6.13 L	--	--		
Cost Savings per month (on average) (current USD)	$ 3.74	--	--		
Cost Savings per year (on average) (current USD)	$ 44.83	--	--		
Recognized/Perceived Advantages of Solar Lanterns					
Financial (Cost Savings)	3	2	3	8	22%
Health	0	0	0	0	0%
Safety/ Security	2	2	0	4	11%
Light Quality	4	0	0	4	11%
Features/ Design (Ease of Use, Portability, Durability)	12	4	2	18	49%
Recognized Disadvantages of Kerosene					
Financial (Expensive)	2	0	0	2	5%
Health	2	4	5	11	30%
Safety/ Security	2	1	4	7	19%
Light Quality	1	0	0	1	3%
Features/ Design (Ease of Use, Portability, Durability)	1	3	2	6	16%
Access (Difficulty of Procurement)	4	0	1	5	14%
Willingness to pay for solar lantern device (on average) (Current USD)					
	$ 6.73	$ 3.49	$ 3.27	$ 4.21	

Health

The majority of the community members surveyed identified eye irritation and particulate pollutants as one of the disadvantages of kerosene lamps (Table 8). For example, many community members mentioned that they find soot accumulated in their noses when they wake up in the morning due to the night-long burning of kerosene lamps in sleeping quarters. The recipients of Firefly lanterns preferred solar lanterns over kerosene lanterns because the solar lanterns don't generate such indoor air pollutants and many of the respondents now exclusively use the solar lanterns while sleeping. When probed, however, the recipients did not explicitly recognize an improvement in health such as ease of breathing since the distribution of solar lanterns.

Safety

During interviews and focus groups discussions, many respondents recognized the safety issues of kerosene lamps, recalling incidences in which children or pets knocked over kerosene lamps, causing a small fire. Community members explicitly mentioned that solar lanterns address this issue, improving safety, especially at night when they now can use solar lanterns instead of burning kerosene lamps. One respondent preferred solar lanterns over kerosene lamps because "it won't set children's hair on fire." Kerosene poisoning from ingestion by small children was not mentioned during our research.

Quality of Light

Quality of light is determined by various factors such as luminance, consistency, and color but there is no standardized method to measure an overall quality of light in a comparable manner among different sources of illumination. Many respondents still perceived that solar lanterns provide better quality light which allows household members to have additional hours of social interaction, income-generating activities such as handcrafts, and studying at night. They explained that steady light of solar lanterns reduced eye fatigue compared to flicker of kerosene lamps or diesel-powered incandescent bulbs.

Portability and Convenience

Many respondents value the mobility of the solar lanterns, often using it to walk outside at night where there are no street lights. Even though kerosene lamps can provide similar mobility and community members do use kerosene lamps for transportation, the respondents clearly stated that solar lanterns are preferred because rain or wind cannot extinguish solar lanterns unlike kerosene lamps. It is important to note that villagers have access to alternative forms of lighting for walking outdoors. Almost all community members owned flashlights with disposable or rechargeable batteries or headlamps. Headlamps appear to be particularly popular among the community members. Prices for these portable lights varied between Rp 25,000-85,000 (USD 2.80-9.52). While solar lanterns were seen as superior to these products, community members were content or resigned to their current lighting options and therefore were hesitant to put too high a value on solar lanterns.

Remoteness of the target communities also increased appreciation for solar lanterns. Procuring kerosene is a time-consuming and expensive process, especially when the seas are rough. Residents in Sungai Cabang explained that with rough seas they sometimes go for weeks without obtaining additional supplies of fuel from Kumai. Solar lanterns provide a dependable alternative source for lighting under such circumstances.

Communication

All but one respondent who received the solar lanterns owned a cell phone and they highly valued the cell phone charging capability of the Firefly product. The perceived benefit of this feature was evident even among those who did not receive the solar lanterns. After demonstrating all the features of a Firefly lantern, we asked focus group participants in Tanjung Harapan for their willingness-to-pay for the solar lantern with and without cell phone charging capability. Respondents were willing to pay between 55% and 100% more on average for solar lanterns that have the capacity to charge cell phones. The baseline survey demonstrates that cell phone ownership is highly prevalent in the target communities (

Table 2). Currently, most community members who own cell phones rely on neighbors who own diesel generators or government-provided solar panels to charge their cell phones. Therefore, solar lanterns with cell phone charging capability can have significant impact on providing energy independence for community members who own cell phones and improving communication.

Maintenance and Sustainability

Among 7 respondents who received solar lanterns during the pilot distribution, there were 8 solar lanterns. After his original lantern was broken, one respondent obtained an additional lantern from a community member, accounting for 8 lanterns among 7 respondents. Among 8 solar lanterns we evaluated, 3 of them were no longer functional. Based on descriptions from the owners and visual inspection by the team, it appeared that problems were with the battery in the base of the lamp (one owner recalled liquid coming out of the battery compartment). The 3 lanterns had been broken for 2-4 months, meaning they were functional for approximately 4 months after distribution. In addition to the 3 broken lanterns, approximately half of the 12 LED lights were no longer working in one lantern. This meant that of the 7 solar lantern recipients interviewed only 5 lanterns were still being used, and only 4 were working at full capacity. It is interesting to note that one respondent whose lantern was broken continued to use the solar panel to charge the stereo in his store. Given there is no formal maintenance program associated with the distribution of Firefly solar lanterns and no other sources of technical expertise and spare parts to fix the lanterns, this may pose the most significant obstacle to achieving any long-term impact in the target communities.

4.3 Appropriateness of Technology and Constraints on Impact

Given the low rate of electrification in Central Kalimantan (See section 3.1.2), the full scale distribution of solar lanterns can play an important role in replacing kerosene lamps, providing a sustainable source of illumination and creating impact in various dimensions. It is, however, important to understand how contextual factors may affect the scope of the impact from the solar lantern project. Here we analyze how Firefly lanterns fit into the local energy portfolio and consumption behavior and how the local context in Central Kalimantan may constrain the long-term impact of the lanterns.

4.3.1 Technical Consideration

Design and Functionality

In 2010, the Firefly 12 was one of five solar lantern products that won several awards under the World Bank Group's Lighting Africa Program, including first place for best value and second place for task lighting[4]. The Firefly lanterns have several features appropriate for the local contexts. For example, it weight only about 0.5kg or approximately 1lb, making the lantern highly portable. Community members in the project area are used to mobile sources of illumination such as kerosene wick lamps and flashlights rather than fixed lighting. Therefore, portability of the Firefly lanterns can facilitate uptake of the technology and replacement of kerosene lamps, making impact of the project more likely. As explained in Section 4.2, cell phone charging capabilities of the Firefly lanterns was highly appreciated by community members and will aid adoption of the solar lanterns.

Another feature of the Firefly lantern worth noting is its ability to provide illumination at three different levels. In particular, the low light setting on a Firefly lantern appealed strongly to the local custom of using nightlights and it was one of the most common uses of the lantern among the pilot recipients. This feature allowed the substitution of nighttime use of a kerosene lamp and led to significant cost savings and reduction in the extended exposure to indoor air pollution and fire hazard.

In the meantime, other features of the Firefly lantern are likely to constrain the impact of the solar lantern project. Even though the Firefly lantern was favored over other products for its brightness[39], it is a task light which provides focused illumination with no or little diffused light. While it is appropriate for reading or walking, the Firefly lanterns are unlikely to be useful for other activities such as farming and fishing.

Furthermore, according to the performance review of solar lanterns conducted in Kenya, it appears that the Firefly's 360° swivel gooseneck design made it seem less stable and that potential consumers preferred other brands, especially Nova from D.Light, that had a sturdier design. Similar sentiments were echoed by community members in Central Kalimantan. Often subject to rough handling and stress, such a design prone to mechanical failure would be inappropriate for the local context.

Durability and Maintenance

The Firefly lanterns have an expected lifespan of two to five years with the NiCd battery lasting approximately eighteen months and the LEDs up to five years. Therefore, the replacement of the battery in the Firefly lanterns will be the limiting factor for the useful life of each lantern. Given that some of the impact in, for instance, health and environment requires years to realize, the issue of durability can significantly limit the long-term impact of the solar lantern project.

This challenge is further exacerbated by the remoteness of the target communities. Because these communities (with the exception of Sungai Pasir) are geographically isolated from major towns and the availability of transportation is highly subject to weather conditions, it will be difficult to set up and maintain a supply chain of spare parts for Firefly lanterns. Furthermore, Barefoot Power mandates that only qualified Barefoot Power technicians should make repairs. Otherwise an unauthorized attempt to fix a Firefly lantern will render the warranty invalid[40]. To our knowledge, there is no certified Barefoot Power technician in the region. Unless Kopernik works with the technology provider to train community members and/or local partner staff to become certified technicians, it is unrealistic to expect that the Firefly lanterns will be maintained and create long-term sustainable impact even with the provision of spare parts.

Given these constraints, an alternative product with longer durability may have been a better option for this project. For example, a recent performance review demonstrated that the battery life for the Nova lanterns from D.Light surpassed that of Firefly products, with the Nova S100 exceeding the Firefly 12's battery life by more than twofold[39]. The same study indicated that while the Nova was considerably larger than the Firefly and the Solata, it was still small enough to be carried around. As a result, a single charge of the Nova range of solar lanterns could yield a longer light quality than the Firefly range could achieve.

4.3.2 Contextual Consideration

Energy Portfolio

Rural households in Indonesia rely heavily on biomass, especially firewood, for cooking (Following the economic crisis in 1997, electricity demand grew at 7% between 1997 and 2005 and at 9% in 2006[5]. Between 2006 and 2026, Indonesia's electricity demand is forecasted to triple[6]. Recognizing rapid increase in electricity demand and the importance of electricity in economic growth, the Government of Indonesia (GOI) has formulated its energy policies based on four overarching principles: 1) reduce oil dependence and expand to coal, gas and renewable sources of energy; 2) eliminate fuel subsidies and implement rational energy pricing; 3) decentralize decision-making in energy sector to increase involvement of regional authority; and 4) increase electrification ratio to 90% by 2020 and bring rural electrification.

Despite GOI's policies and efforts, the rate of electrification is among the lowest in the region at about 64.5%, and 81.6 million people still do not have access to grid electricity[7]. Indonesia is endowed with coal, gas, oil, geothermal and hydro-electricity resources. However, the GOI faces many challenges in providing electricity to its population of approximately 230 million due to geographic constraints and limited capacity to mobilize the investment request to finance expansion of power infrastructure[8].

Rural electrification is particularly difficult in a country with roughly 17,000 islands; most of which are sparsely populated.

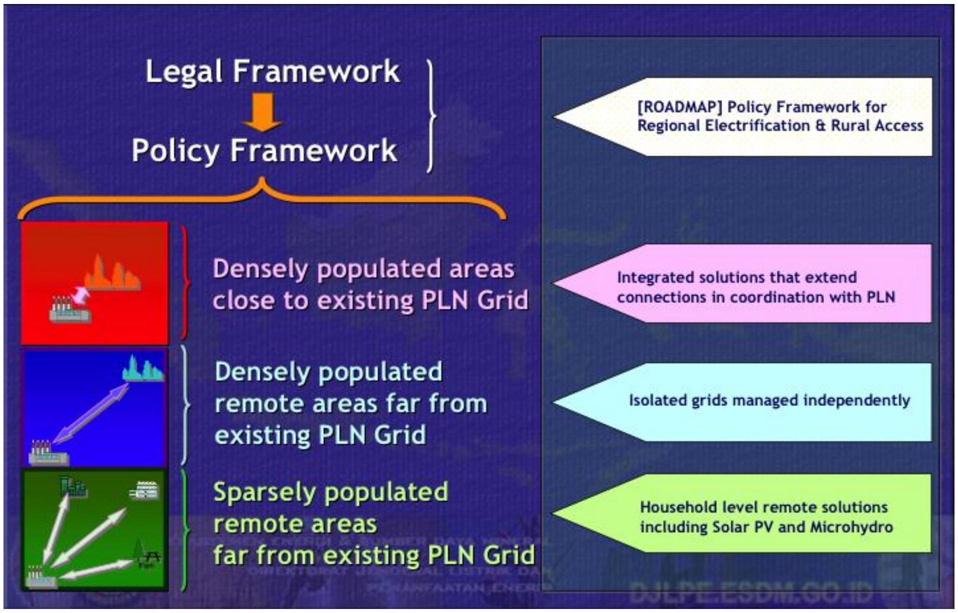
In addition to geographic constraints, heavy subsidies provided by the GOI on electricity create an unsustainable business model that leads to poor financial performance, erosion of revenue base and severe lack of capacity to extend services to rural areas. Indonesia ranks among the top 20 non-OECD countries with the highest energy subsidies[9]. Subsidy spending for the year 2010 was USD 22.3 billion[10]. The GOI subsidizes the price of electricity below the cost of production to all fuel consumers and not just the poorest, resulting in lower energy savings and constrained budgets that could be spent on energy needs[9]. The subsidy provided on domestic fuel prices was regressive, "with the top income decile receiving more than five times what the bottom income decile received[9]." As fuel prices increased in 2004, the subsidies were removed in some instances leading to a 25% fuel price increase in early 2005[9]. The IMF and WB continue to push for removing subsidies to unlock funds for investments in clean energy.

Moreover, the electricity industry in Indonesia is dominated by PT Perusahaan Listrik Negara (PT PLN), a state-owned electric company. Other electricity generating companies include independent power structures and private power utilities with the capacity of generating 3450 MW and 746 MW, respectively. Local governments, particularly in remote areas, tend to obtain electricity from private company providers[11]. The industry's feature also constrains investment in electricity infrastructure. About two-thirds of the population without electricity lives in the rural areas and a majority of them reside outside of Java-Bali. The Indonesian Electricity State Company (PLN) estimated there are over 6,000 villages throughout Indonesia, which will not be reached by the national electrification grid in the near future. Most of these villages are located outside of Java; 28% of the villages without electricity are in Kalimantan[12]. Power restrictions, blackouts, and power quality issues such as voltage variance and frequency fluctuations are common. As electricity demand continues to increase more than supply, the GOI recognizes that it cannot afford supplying conventional energy to rural areas. This is particularly true given the geographic challenge. In an attempt to diversify to more efficient and renewable alternative energy sources, the GOI has looked into harnessing solar, wind and geothermal energy among others. Table 1 shows that the GOI has also explored the use of other renewable energy sources for rural electrification. GOI is also diversifying its approach in distributing electricity in response to population density. Figure 2 depicts regional electrification and rural access channels.

Table 1 **Rural Electrification Program: Exploring Different Sources of Energy**[12]

2004	2005	2006	2007
Diesel generator: 104 units, 52,430 KW	Solar power system (PLTS) 1422 units/ 7,970 Wp	Solar power system (PLTS) 19,209 units/ 960,450 Wp	Solar power system (PLTS) 34,549 units/ 1,346,210 Wp
	Micro-Hydro (PLTMH) 3 units (40 KW)	Micro-Hydro (PLTMH 22 units/ 2,433 kW)	Micro-Hydro (PLTM) 12 units/ 2,115 kW
	Wing (PLTB) 2 units/ 160 KW	Wind (PLTB) 3 units/ 240 kW	Wind (PLTB) 41 units/ 480 kW
	Diesel Generator (PLTD): 48 units/ 25,350 kW		

Figure 2 **Concept for regional electrification and rural access**[12]



The GOI emphasized the use of solar home systems for rural electrification. It implemented a pilot photovoltaic solar home system (PV-SHS) project from 1997 to 2002 in partnership with the World Bank. The PV-SHS program targeted remote areas and the poorest sections of the population to install 200,000 SHS[13]. Over the last 10 years local governments had budgets allocated for SHS as part of the electrification program, and several thousands of PV systems were installed, especially in Kalimantan. The end-users received the systems for free but paid approximately Rp.1, 000,000 (USD 115) for transport and accommodation costs for technician installing the system[14]. This money would be collected by the KUD (Local Cooperatives) and used for replacement of the batteries.

Unfortunately most of these projects failed to move beyond the distribution and installation phase as neither maintenance nor collection of fees was ever done afterwards[14]. Production of high quality batteries also remains a challenge. The project also failed to provide means to “mainstream private sector delivery and financing.”[13] Limited in-country organizational and financing experience on part of World Bank’s staff also hampered the project. Nonetheless, recognizing potential growth in solar energy market, PV manufacturers such as BP Solar, Kyocera, Shell Solar, Siemens, and Solarex have already opened subsidiaries in Indonesia. In addition exploring different sources of energy to generate electricity, the GOI is also adopting different methods to increase rural access to electricity.

4.3.3 Central Kalimantan Context

In Central Kalimantan, the rate of electrification is even lower at about 54.8% with almost 860,000 people and 180,000 households without access to electricity[15]. Central Kalimantan is Indonesia’s third largest province and is one of the four provinces that make up the Indonesian part of the Borneo Island. It is mostly covered in forests. It is surrounded by West Kalimantan in the west, East and South Kalimantan in the east and the Java Sea in the south. After Indonesian independence, Central Kalimantan seceded from South Kalimantan to become a separate province in 1957[16]. Dayaks were the original inhabitants, but cultural diversity increased with the arrival of Malays, Chinese and Javanese among others. More than 70% of Dayaks in Central Kalimantan are Muslims[17].

Mining, forestry, tourism, fishing and farming are the primary sources of income for inhabitants of Central Kalimantan. With increasing investments from India and China, gold mining activities closer to Tanjung Harapan are expanding[18]. One of the consequences is a higher number of taxi boats carrying miners passing by Tanjung Harapan. The expansion of the mining industry is bound to bring substantial changes in the socio-economic sphere in the long-term. In addition to industrial energy needs, the increase in population resulting from job opportunities near the mines will also add pressure to the already scarce energy sources.

Following the fall of Suharto in 1998, the GOI launched a decentralization campaign. (For a brief historical and socio-economic background on Indonesia and Central Kalimantan, please refer to Annex 8.) Conversations with Stibniati Atmadja, a research fellow at Center for International Forestry Research (CIFOR), revealed that tensions between provincial government and federal government are surfacing over land rights[19]. Ongoing tensions are one of the reasons behind a low NGO presence in Central Kalimantan.

Both rural and urban households in Indonesia spent 8.8% of total household expenditures on energy on average in 2005 (**Figure** 3; Bacon et al**., 2010). For** rural **households**, the *expenditure on* kerosene was 25% of the total energy expenditures or equivalent to about USD 4.09 per month (2005 $ at PPP) on average. For urban households, the expenditure on kerosene was 27.3% of the total energy expenditures or equivalent to ~USD 7.63 per month (2005 $ at PPP) on average.

Figure 3). In this case, burning biomass for cooking is the predominant source of indoor air pollution such as particulate matter and carbon monoxide. In these settings, solar lanterns replace only a small portion of indoor air pollution. Furthermore, households use kerosene for cooking both directly (kerosene stoves) and indirectly (to start a fire in a wood-burning stove). Therefore, unless the use of biomass as the primary cooking fuel is addressed by additional technology such as improved cook stoves, household members in rural Indonesia will continue to be exposed to a significant level of indoor air pollution which can cause various respiratory and other ailments even after the distribution of solar lanterns. This limitation might help explain the low level of perceived health impact among the respondents who received the solar lanterns during the pilot distribution.

Energy Consumption Behavior

Regardless of whether households have access to electricity or not, households in Central Kalimantan keep at least one kerosene lamp burning throughout the night for a sense of security. This leads to higher expenditure on kerosene and more prolonged exposure to indoor air pollution compared to other countries. In this context, the cost savings and health impact of solar lanterns will be more significant in this region compared to others.

It is noted, however, that in Central Kalimantan, most households own and use multiple kerosene lamps at a given time. Therefore, the exposure to indoor air pollution from kerosene lamps will continue unless the distribution program replaces all the kerosene lamps in each household. Therefore, it would be necessary to distribute multiple solar lanterns per household to replace all the kerosene lamps and eliminate both the direct costs of expenditure on kerosene for lighting as well as the associated health and environmental costs.

Many community members identified the low-light setting of a Firefly lantern as one of their favorite features of the product because it allows households to substitute nighttime burning of kerosene lamps. This evidently reduces prolonged exposure to indoor air pollution while sleeping. However, all the households continue to use kerosene lamps in the evening in addition to solar lanterns. This again emphasizes the need to distribute multiple solar lanterns per household.

Non-energy Related Behavior

Smoking is highly prevalent in the region. In 2001, Central Kalimantan had the 7th highest average smoking prevalence in Indonesia with 60.2% of adult males and 1.0% of adult females smoking[41]. This is consistent with the high allocation of household expenditures on cigarette purchase, which we observed in the target communities (Figure 5). We also observed that much of the smoking takes place indoors, exposing family members to a substantial level of second hand smoke. Thus it is likely that community members continue to get exposed to a high level of harmful chemicals from tobacco, which cannot be mitigated by solar lantern distribution.

Unproven Long-Term Impact

As it is unclear how cost savings on kerosene are redistributed, a long-term longitudinal study is needed to determine whether additional savings among households with solar lanterns leads to positive impact through increased expenditures on, for example, education and health. In addition, it should be noted that in our initial assessment solar lanterns did not entirely replace the expenditure on kerosene. Households in this region typically own and use multiple kerosene lamps at a given time (See Section 3.2.1). Because each household received one solar lantern, they continue to use kerosene lamps in addition to solar lanterns.

Awareness Building

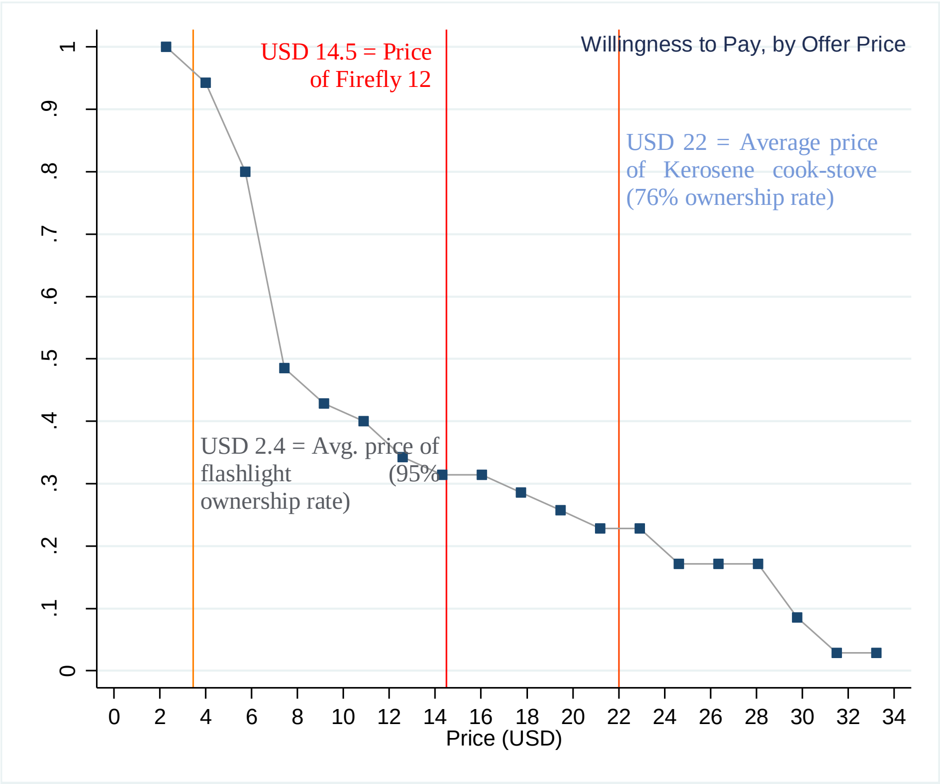
From our field research, community members in the region seem to be well aware of solar technology and the energy service it provides. It is, however, unclear whether they fully recognize how the use of solar lanterns translates to long-term impact in energy expenditure, health, livelihood, education, etc. For example, there seems to be paucity of knowledge on the health impact of traditional sources of energy such as kerosene and firewood. This is not to say there is general lack of understanding on health issues. Quite to the contrary, the interviews and focus group discussions revealed that community member were highly cognizant of health consequences of consuming local water polluted by nearby mining operation and palm oil plantations and identified the issue of access to clean water as one of the major challenges they face. This indicates that it is possible to educate community members about potential impact of solar lanterns, which will not only increase the uptake and utilization of the technology but also may encourage community members to adapt their behavior to maximize the benefit. It would mean that the distribution of solar lanterns should be accompanied by awareness-building activities on why solar lanterns are being provided, what long-term impact they may have, and what community members can take the most advantage of solar lanterns.

Community Sharing

In many developing countries, the poor generate income with solar lanterns by charging fees for others to use advanced features such as cell phone recharging. In most rural communities in Indonesia, households that own diesel or benzene generators often share electricity with their neighbors at no cost or at cost. A strong sense of community and familial relationship among neighbors are attributed to such a social arrangement on energy consumption. Given this context, it is not clear whether distribution of solar lanterns will lead to similar income-generating activities in Central Kalimantan.

4.3.4 Appropriateness and locally driven demand

Figure 12 Willingness to Pay for Firefly Lanterns and Other Energy Appliances



One way to gauge the degree to which households value the Firefly 12 solar lantern is by gauging their willingness to pay for the device. Figure 12 Willingness to Pay for Firefly Lanterns and Other Energy Appliances displays the percentage of interviewed respondents willing to purchase the device at various price points. The willingness to pay for Firefly 12 solar lantern ranges from USD 2 to USD 33. The range in willingness to pay is reflective of the economic status of households and is also influenced by prior conversations that the villagers had with FNPF staff on the subsidized prices for solar lantern distribution. This can be seen in the large drop in the number of respondents willing to pay 5 versus 7 dollars (USD 5 being the subsidized price offered to villagers). Nonetheless, it illustrates local demand for the solar lantern at different offer prices. The graph shows that only 30% of the respondents were willing to pay the wholesale price of USD 14.5 for the solar lantern indicating a relatively weak demand at a price point that is more reflective of the actual costs of the technology. Extrapolating this finding to the population of the three villages studied, this suggests that the market size for the device if sold at full price is approximately 200 households, This is significantly smaller than the amount being provided in the forthcoming project. This highlights an important tension between the subsidized versus market distribution model - that is that households who arguably can benefit most from the technology are most likely to be excluded from the market given their lower incomes and lower ability to pay if the product were sold at full price. That said, further research is needed to determine how sensitive willingness to pay is to: (1) the level of understanding regarding the benefits of the technology (for example the savings enabled over the lifetime of the product) and (2) the prospect of providing an installment or credit plan with purchase. These issues were explored in our interviews but not comprehensively studied. The market probably could be expanded to include lower income households by creating demand through clearer explanation of the delayed benefits of the technology through savings and (2) creating ways for lower income households to access affordable installment or credit plans that better match their cash flows.

5 Evaluation of Project Design and Implementation

Kopernik's unique model informs many aspects of the solar lantern project in Kalimantan. The approaches for financing, partnerships and distribution used in Kalimantan reflect not only Kopernik's model but also contain unique attributes specific to this project. In addition there are critical socio-cultural aspects that must be considered when examining the design and implementation in these specific communities. By examining the project design and implementation used in Kalimantan, both strengths and limitations can be identified. These observations aim not only to improve the site-specific project but also inform Kopernik's overall model for future projects with solar lighting and other technologies.

5.1 Financing

Kopernik Model

Kopernik finances projects by showcasing technologies on their website and allowing local NGOs to submit proposals for the technologies their communities require most. These proposals are then funded through crowd sourced donations. Donors browse proposals on Kopernik's website and donate funds to a project of their choice. This funding covers the cost of the product and the shipping costs to the country. In addition Kopernik asks NGOs what the "contribution of the organization" will be to the project (both financial and non-financial). Therefore it is assumed that all NGOs will be making some form of contribution to the proposed project.

Kalimantan Campaign

The proposal that was submitted by FNPF stated that the NGO would use a cost sharing structure to help finance the solar lanterns. The proposal stated that the FNPF staff:

> *…recently discussed the opportunity with the elders of both villages. Both villages have great desire for the solar lights and can afford to pay Rp. 40,000 per unit (USD 4.49).*

This price was included in the original proposal, and according to the proposal, income generated from the sale of the lanterns will help supplement the overall cost to Kopernik.

Strengths and Limitations

While Kopernik does not require cost-sharing models of financing, there are obvious benefits to this approach.

- FNPF staff used a participatory approach in deciding the amount villagers were willing to contribute to the cost of the lanterns.
- It is often assumed that products will be valued more if the recipient has contributed financially (rather than receiving a free gift).

However during on-site visits the SIPA team found certain weaknesses to this financing approach, which may be improved for future projects.

- Clarity on how the cost-sharing model would be implemented was a main concern for this project. After speaking with village leaders and FNPF staff it was unclear how the Rp. 40,000 would be collected and who would receive these funds.

- Cost sharing was used in this specific proposal but is not a requirement in the Kopernik model. Therefore it may not be implemented in future projects unless initiated by the partner NGO.
- Offering products at a subsidized price may undercut the future potential for a market-based approach to selling solar lanterns in these communities.
- Financing is based on a one-time donation and does not include continued financial support for maintenance. However it is important to note that the shipment of 316 lanterns includes additional lanterns, above the amount requested in the proposal, to act as replacements in the event of any malfunctions.

5.2 Partnerships

Kopernik Model

One of the strengths of Kopernik's model is that local NGOs choose what technology is most needed in their communities and apply directly for those products. This approach addresses a common problem of outside groups importing inappropriate technologies to communities due to a lack of local knowledge.

Kalimantan Campaign

In Kalimantan FNPF is very connected to the community and works closely with the villagers. The FNPF staff live in the villages and have a clear understanding of the community and its needs. While FNPF is a conservation organization focused primarily on wildlife protection and habitat restoration, they see the solar lantern proposal as an opportunity to:

> *…win greater trust and support from the communities, and/or reduce their pressure on wildlife and habitat due to an improvement in economic, education and social conditions.*

FNPF believes that:

> *Bringing solar lamps to the villages helps demonstrate that FNPF is not only concerned about wildlife and habitat but also about the people.*

Strengths and Limitations

FNPF's proposal accurately presented the NGOs relationship with the community and this positive relationship is one of the main strengths of the partnership.

- FNPF is a grassroots organization and has close ties with the community.
- The NGOs strong reputation in the villages creates trust with the villagers and will be beneficial to the implementation of the project.

However, FNPF's main mission of reforestation is not directly tied to the energy impacts that solar lanterns would bring. While the NGO can use the solar lanterns as an incentive to help gain the community's good will for reforestation projects, their long term interests are not closely aligned with solar lanterns.

- FNPF is a small organization and does not have the financial resources or capacity to provide ongoing support for solar lantern maintenance.
- During the pilot distribution of a small number of lanterns, it appeared that recipients had not received any training on the use or maintenance of the lanterns.

- Villagers did not know who to contact when lanterns broke, and FNPF staff was unaware of a warranty provided by the manufacturer.

5.3 Distribution

Kopernik Model

Kopernik requires NGOs to describe how the technology will be distributed, and how beneficiaries will be selected in their proposals. However Kopernik is not directly involved with distribution at the village level. Once the technology and NGO have been matched, funding has been raised, and products have been delivered, Kopernik is no longer directly involved in the project.

Kalimantan Campaign

While the initial fieldwork for this project was done prior to the main distribution of lanterns, a small pilot of 24 lanterns were distributed 6-8 months prior to the SIPA team's on-site visits to the villages. For this initial distribution FNPF staff distributed several of the lanterns to National Park employees as well as to FNPF staff (who also live in the village). The remainder of the recipients appeared to be chosen by FNPF staff with the input of the village leaders. Recipients appeared to be chosen by their need (one recipient was a single mother of 3 children, with sporadic source of income and no access to electricity besides kerosene lamps). When asked about plans for distribution of the large shipment of lanterns there did not appear to be a concrete plan in place. In their proposal FNPF stated:

> *Neither village has electricity supply and all residents in both villages have a similar profession (farmer or fisherman) and average monthly income (approx Rp. 700,000 – 1,000,000 / USD 79 – 112). Hence we believe any resident from either village that requests the lamp deserves to get help.*

Strengths and Limitations

In person both FNPF staff and village staff agreed that lanterns should be distributed to the neediest, but there did not appear to be a plan for reconciling need with the ability to pay Rp 40,000.

It was not discussed if recipients could purchase more than one lantern, if families with generators would be allowed to purchase lanterns, or if a family with great need but no ability to pay would still be given a lantern.

Through on-site visits the SIPA team found that while no villagers are connected to grid energy, many households have the ability to generate electricity through generators. However with the prevalence of kerosene lamps, it is apparent that almost all residents in the villages would benefit to some extent from the solar lanterns, however the degree of impact would vary depending on the recipient. Therefore the question of *how* the lanterns will be distributed may be of equal concern to *whom* the lanterns will be distributed.

It became apparent that no training material or information about maintenance was distributed with the lanterns during the pilot. During the on-site visits 3 broken lanterns were identified. Recipients had either tried to fix the lantern themselves, or threw the lantern away. None of the recipients or NGO staff knew about the manufacture's warranty and there was no mechanism for the recipients or NGO to report malfunctioning lanterns to Kopernik in order to receive replacements.

6 Recommendations and Strategic Development

We have encompassed our recommendations in a Recommendations Framework. This framework depicts both the short-term and long-term strategies which can support and strengthen the impact Kopernik can achieve with its program.

6.1 Format of the Recommendations Framework

The framework consists of a set of objectives, along with recommendations and actions that can be undertaken to achieve the recommendations.

Objectives are structured as a pyramid with the base containing the fundamentals that form Kopernik's vision and mission. These lay the base for achieving the long-term objective of ensuring impact and sustainability of solar lanterns as an energy source in Central Kalimantan. The objective pyramid is followed by a group of recommendations that are proposed for achieving Kopernik's objectives. Below each recommendation is an illustrative list of actions.

Situating the proposed recommendations in a time-frame (short or long) refers to the time of the inception, and not the implementation or completion. Furthermore, given Kopernik's organizational and structural model, the proposed recommendations would best be utilized in a holistic manner that utilizes different components as appropriate rather than approaching the framework as an action package that has to be utilized and implemented simultaneously.

6.2 Context for Framing Recommendations

One of the objectives of this study is to assess the impact (post-distribution) of Kopernik's pilot solar lantern project. In assessing impact, however, it is also important to understand whether the project objectives are being met and to understand how those objectives can be met more effectively. Another approach is to look at the design of the project and assess how that affects the ability of the project to create impact.

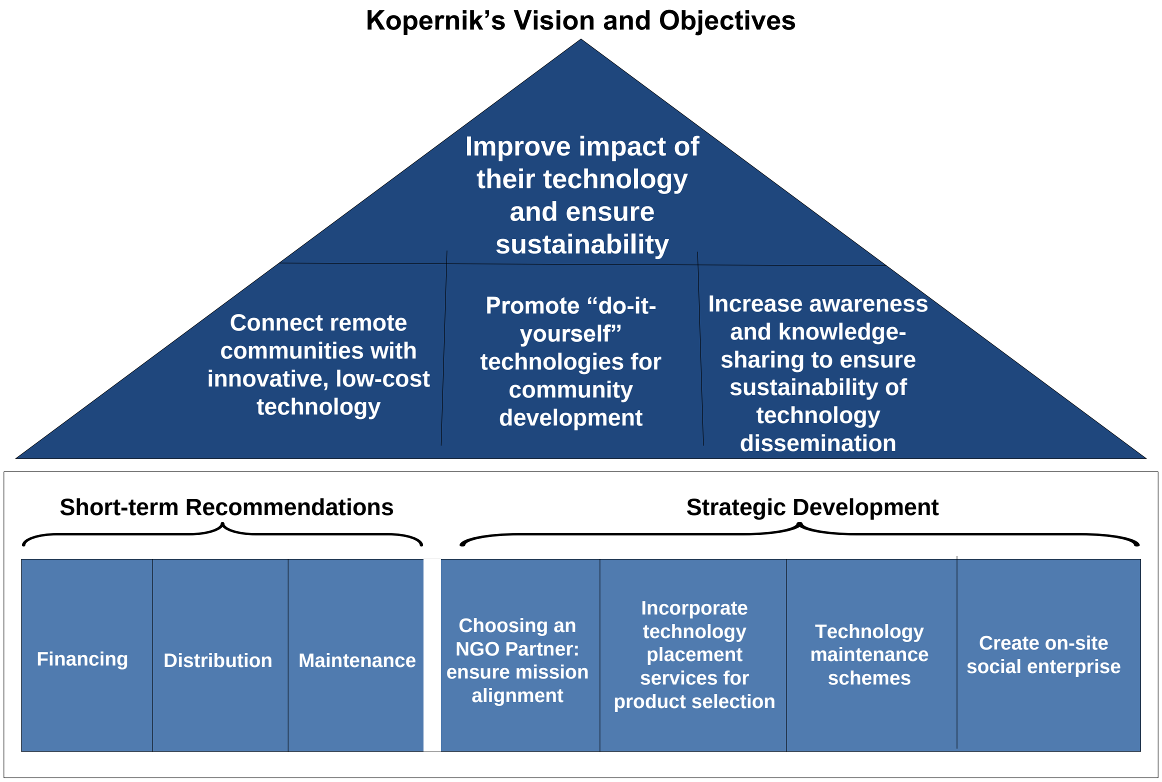
We apply this second approach in our recommendations framework which is framed around two questions for the larger solar lantern project Kopernik is currently undertaking in Central Kalimantan:

1. What are the determinants of impact?
2. Based on the above determinants, how do you design the project to ensure impact?

1. Thinking about impact broadly, there are four major determinants:
   a) Local context
   b) Reach of the technology within the population
   c) Effectiveness of technology: the strength of the impact for the household as a direct result of the technology
   d) Sustainability over a time horizon in terms of the amount of time the technology is used in a household

2. The number of people the project is able to reach and its viability over time is very closely related to how the project is financed and how the technology is distributed. A one-time project to distribute 316 lanterns with fixed funding creates limitations. From an impact and sustainability standpoint, greater impact might be attained by incorporating elements of a locally funded, market-oriented distribution model or by engaging donors over a longer time horizon to ensure that there are funds for maintenance or replacement of damaged lanterns. That said, from a cost – benefit perspective looking only at the private

financial savings enabled by reducing kerosene expenditures (and not positive externality benefits such as reduced greenhouse emissions or increased education – for which there is little quantified evidence of impact) the estimated net present value of the planned project in Central Kalimantan is positive – even without significant investments in maintenance or continued funding past 18 months (this estimate is based on a conservative and rough modeling based on the available evidence from our field data collection in January and March and is presented in Annex 8).



Recommendation Framework

6.3 Short-term Recommendations

The following recommendations are based on finding ways to overcome the limitations of the pilot project discussed in Section 5 and to ensure maximum impact of the solar lantern project in the context of the framework discussed above.

We have attempted to give deep consideration to Kopernik's organizational structure and available resources while assessing short-term recommendations that would be helpful for Kopernik to ensure meeting their objectives. It is our hope that these recommendations present a platform for implementing changes on the ground in combination with support from the local NGO.

A. Financing

Current Situation: As discussed in Section 5.1, there is a lack of clarity regarding the implementation of the cost-sharing model and offering the lanterns at a subsidized price risks future potential for a market-based distribution strategy. We conducted an initial Willingness to Pay study during both the January and March travel (For more details, see Sections 2). The range of results indicates that (a) willingness to pay (price and quantity demanded) is influenced by access to credit; (b) availability of options beyond single-payment-cash purchase influence ability to pay and quantity demanded; and (c) lack of local financing options constrain people's purchasing power and hence willingness to pay.

Recommendation: Under the FAQ section, Kopernik states on their website that:

"We encourage all technology seekers to devise a system of distribution which could include the following: selling the products at a locally appropriate price, with locally appropriate payment scheme; renting the products; developing a lease to buy system."

In order to ensure the intended impact and sustainability of the solar lantern project, Kopernik can encourage and actively help the local NGO to implement this approach. This would move towards a more market-oriented approach, which then helps ensure impact (by making the product more affordable according to the WtP of intended recipients) and sustainability.

Proposed Action(s): Kopernik can help FNPF understand the importance of conducting a feasibility study for distribution and pricing to be more market-oriented by exploring (a) in more detail, how the cost-sharing model will be implemented and (b) potential partnerships with local distributors.

B. Distribution

Current Situation: As discussed in Section 5.3, once the solar lanterns are received in the local community, there is no particular methodology for ensuring that those most in need of a solar lantern in their homes have access to it. Even within a community, household access to energy sources varies and for some houses the lantern would be an additional source that can be utilized in a particular way but in some other houses, it would be *the* energy source that allows the wife to cook past sunset in the kitchen, for example.

Recommendation: In each village community that Kopernik operates, set up a methodology for ensuring households that could get on the energy ladder or 'make a jump' along the ladder, are able to access solar lanterns.

Proposed Action(s): Conduct a village-wide assessment to understand which households would benefit the most from the solar lanterns with regards to their current energy use and sources for use.

C. Financing, Partnerships and Distribution → Maintenance

Current Situation: As discussed in Section 5, the current financing, partnership and distribution approach has implications for maintenance: (a) financing does not include continued support for maintenance programs; (b) FNPF staff are not trained and knowledgeable to provide support and (c) no training material or information was distributed with the solar lanterns in the pilot project.

Recommendation: Building local knowledge, awareness and capacity are cornerstones of Kopernik's vision and objectives. Hence, a user-friendly training program can be disseminated through the local NGO.

Proposed Action(s):

(a) Conduct simple training for FNPF staff to understand the nature of the technology.

(b) Create a one-page visual pamphlet with user-friendly instructions regarding initial set-up, usage and proper care & maintenance.

(c) Develop a feedback mechanism for recipients to inform FNPF regarding malfunctioning units and damaged/broken units.

(d) Share information from the feedback mechanism with the technology provider to improve project sustainability by involving all agents along the supply chain. This information-sharing will allow the technology provider to better understand the nature of the technology when it is in use and help them improve and develop locally appropriate products.

(e) Ensure quarterly reporting on projects. As indicated in FNPF's project proposal to Kopernik, FNPF would provide a 3 month progress report to Kopernik. For measuring impact and ensuring sustainability of the project, this report is crucial. It would help Kopernik ensure that all aspects mentioned in the proposal are being addressed and if certain aspects are not addressed, to understand the constraints and limitations faced.

6.4 Strategic Development

Despite being a relatively young organization, Kopernik has generated an impressive portfolio of successful projects across various parts of Asia and Africa. To date, the technologies featured on Kopernik's online marketplace have reached 20,000 recipients and have an aggregate technology rating of 4.5 on a scale of 5[42]. These technologies, which encompass a range of solar lanterns, water and sanitation systems, telecommunications solutions and farming tools, are pivotal contributions to communities of developing countries, especially for rural villages that experience severe challenges of extreme poverty and poor accessibility. It is therefore crucial to ensure that Kopernik's efforts translate into a beneficial change within the community and serve as a platform for them to climb up a rung on the development ladder.

The strategic development options raised in this section address concerns about sustainability in providing low-cost technology to communities that need it the most. The options are initiatives to be considered as Kopernik continues to grow.

a) Ensure mission alignment of technology seekers and reinforce their roles in the communities

Kopernik's operational model is structured upon due diligence and transparency when it comes to assessing intentions, reliability, and implementation capacity of NGOs that submit a proposal for a technology. Kopernik is known to conduct legal, financial and reference checks on the NGO, as well as interviews with the organization head with regard to the capabilities of the NGO.

Although selection through the proposal submission and a subsequent vetting process is in place, challenges to sustainability may arise due to weak mission alignment. In Central Kalimantan, the local NGO, FNPF, works on reforestation. Its primary objective behind solar lantern distribution is to build relationships in its working areas. The short-term nature of FNPF's objectives behind providing solar lanterns raises concerns about the sustainability of technology introduction.

Strategic partnership beyond approving a compelling proposal can contribute towards sustainability of Kopernik's campaigns. For strategic partnerships, Kopernik can consider the following:

- Ensure mission alignment and compatibility with long-term goals of the NGO in relation to the technology the NGO is seeking to address risks of mission drift.
- Conduct due diligence beyond legal and financial aspects to ensure that local NGOs have existing knowledge about the technology and to gauge implementation and monitoring capacity.

- Encourage NGO to collaborate with other local organizations such as microfinance partners, distribution partners, or social marketers when initiating a campaign[43].
- Engage with the technology seeker for a deeper understanding of technology selection.

b) Expansion of Kopernik's operational model to include technology placement advisory services for product selection

As Kopernik continues to grow its portfolio and expertise in working with new technologies and new regions, it could consider expanding its operations model to include an advisory service to strengthen technology matching between technology seekers and providers. This can be implemented by having a representative (i.e. Technology Placement Advisor) in Kopernik, who would work closely with technology seekers on deciding which life-changing technology is most appropriate for their cause. Kopernik's current model allows technology seekers to choose a desired product among the ones showcased in the website. The underlying assumption is that the technology seeker, a local NGO, knows the communities' energy needs the best. While this is true, it is also essential to ensure that the technology selected is indeed the most appropriate. In the case of Central Kalimantan, Firefly 12 was selected among 8 solar lighting devices. Many fishermen questioned the luminosity power of Firefly 12 because they wanted to use it for fishing. Therefore, in a community that depends largely on fishing, perhaps a D-light would have been more appropriate. These are some of the nuances that need to be considered.

In order to address concerns on product selection, Kopernik may alter its proposal submission process for technology seekers to select a product range within a certain category such as lighting devices. Kopernik's Technology Placement Advisor can guide the technology seeker to select the most suitable product based on the information that is provided by the technology seekers in their proposals. Please refer to the Appendix for a sample of an alternate proposal form giving technology seekers the option of the technology placement service.

As part of Kopernik's growing capacity as an NGO technology specialist, it may also consider collaborating with technology providers to bring these technologies a step closer to beneficiary societies. One way of doing so is to issue samples of the said technology to interested technology seekers, if Kopernik has the means to do so. Another alternative would be to showcase these technologies and a demonstration of their use via a video that can be embedded on the Kopernik website at www.kopernik.info.

c) Expansion of Kopernik's operational model to include technology maintenance schemes

The Firefly 12 has an estimated lifespan of two to five years. However, malfunctioning and damaged Firefly 12 lanterns in the pilot project in Central Kalimantan were recently reported. This unfortunate outcome prevents villagers from reaping the full benefits of the solar lantern. Although there is no need for specific technical expertise when it comes to handling the solar lanterns[42], recurring malfunctions that are not adequately addressed could potentially damage the reputation and credibility of Kopernik and of its technology providers as well. Steps to avoid such an outcome should be taken, including heightened efforts in due diligence of technology providers and investigations into the root causes of poorly performing solar lanterns. The Firefly 12 is an award winning solar lantern[4] and the malfunctions that were reported in Central Kalimantan's pilot project are therefore unexpected. An investigation could allow both Kopernik and its technology provider in this case, Barefoot Power, to better understand the context in which these solar lanterns are being used and any external factors that could have contributed toward the malfunction.

In the event that Kopernik and/or its technology provider is unable to carry out such a task due to financial or other constraints, it is worth considering the implementation of a maintenance scheme to complement the project. The purpose of having a maintenance scheme goes beyond the purposes of maximizing returns on purchase or protecting Kopernik's reputation, but also to ensure consumer protection. In similar projects executed by different organizations, such as Sri Lanka's Renewable Energy for Rural Economic Development (RERED) Project, a great deal of importance is placed on quality control and certification of the solar lanterns, as well as the provision of after-sales service to generate consumer confidence[3].

Keeping future growth and sustainability in mind, Kopernik may also consider providing maintenance training to local NGOs or a community member. Kopernik can provide this training in two ways. First, it can directly train the NGO staff, which will depend on the nature of partnership. Local NGOs can play a part in ensuring the sustainability of projects on site, due to their proximity and familiarity with the communities there and of its members. For instance, they can train a few villagers on the proper use and/or repair of solar lanterns so that the average lifespan of the technology is improved.

Kopernik can also partner with a second NGO engaged in community development to train people in repairs and provide trouble-shooting services. This will increase community participation, increase lifespan of the technology and provide an income source. Such a service is beyond the scope of Kopernik's current model. Managing different partnerships can also be challenging. Nonetheless, maintenance is a crucial component to providing longer-term solution. Grameen Shakti in Bangladesh provides trains rural women as technicians to increase the benefits of the technologies introduced to the communities[44].

Understanding that Kopernik may not have the resources at this stage to launch large-scale initiatives like maintenance scheme or training services, it may instead wish to consider embarking on a project that serves as a 'follow up' to existing or former campaigns. This can be done by introducing the option for donors to contribute toward a maintenance fund for a project. This aspect allows donors to fund the provision of a small supply of replacement parts or spare solar lanterns into the community which otherwise would have very little means of obtaining the necessary components to get their faulty lanterns working again. The additional parts and products can be sent together with the inventory of solar lanterns, or at subsequent intervals, i.e. every few months from the date of solar lantern delivery.

d) Expansion of Kopernik's operational model to include the creation of on-site social enterprise

This strategic development option is another 'follow-up' scheme to complement existing or former projects that Kopernik has worked on. Reinforcing the need for beneficiary societies to reap the maximum returns from these technologies, it would be worth considering any opportunity for these communities to use an excess supply of solar lanterns as a launchpad for a social enterprise revolving around renewable energy leasing.

Implementing this movement is not easy, and in order to do so, it is crucial for Kopernik to have a firm working relationship and deep trust in its technology seeker NGO group to carefully execute this plan in the communities. For instance, with an excess supply of perhaps 50 solar lanterns, it is possible to initiate a leasing station to cater to villagers who are unable to afford their own solar lantern or who do not have any need to purchase one. This can be done via leases (short-term or long-term), or on a per-usage basis. In Kibera, Kenya, it is not uncommon for poor villagers to charge their cell phones on a pay-per-charge basis, where the cost to an off-grid mobile customer was approximately KES20 (USD 0.25) for a full charge in two hours[45]. Executing an initiative on this level not only offers opportunities of job creation, skills training and education while priming the communities for greater use of solar technology, ultimately allowing the villagers to take ownership of the benefits that are generated.

In a similar strategy that is employed in the implementation of a maintenance scheme, Kopernik may choose to offer its donors the option of funding a social enterprise option within these communities. Launching a social enterprise option will not yield immediate results in the short term and it is therefore essential for Kopernik and/or the local NGO to perform enhanced due diligence exercises with cautious planning and assistance to ensure that these communities are on track to achieving a self-sustaining operational model.

Acknowledgement

This report presents the initial impacts of a pilot solar lantern distribution in remote river communities of Central Kalimantan. It also provides a snapshot of the energy portfolio and consumption behavior based on a baseline study conducted in three villages – Tanjung Harapan, Sungai Cabang, and Sungai Pasir – to be utilized for future solar lantern impact evaluations.

Experiences and insights of many made this report possible. We are grateful to all the respondents and other community members for sharing their experiences and welcoming us into their communities and homes. For arranging the opportunity to carry out the initial evaluation and baseline study, we thank all staff of Friends of National Parks Foundation, particularly, Pak Bayu, Basuki and Pak Hadran.

The report relies on the guidance from experts coming from diverse backgrounds including the energy sector and forestry in Central Kalimantan. We would like to thank Phillip LaRocco, Ellen Morris, Christine Padoch, Stibniati Atmadja and Manuoto. We are truly grateful to our advisor Dr. Miguel Angel Pinedo-Vasquez for his support throughout.

Finally, we would like to thank Toshi Nakamura and Kopernik, and Eugenia McGill and the School of International and Public Affairs for giving us the opportunity and support to work on this project.

References

1. Roy, J. and S. Jana, *Solar lanterns for rural households.* Energy, 1998. 23(1): p. 67-68.

2. Alberini, A. and J. Cooper, *Applications of the contingent valuation method in developing countries*, in *FAO Economic and Social Development Paper 146*. 2000, FAO: Rome, Italy.

3. Renewable Energy for Rural Economic Development (RERED) project. *Consumer Protection for Solar Home Systems and Solar Lanterns*. April 25,2011]; Available from: http://www.energyservices.lk/customerservice.htm.

4. Lighting Africa. *Lighting Africa Newsletter – July / August 2010 edition*. Available from: http://www.lightingafrica.org/files/Product_Awards___Products_Tests_0.pdf.

5. International Energy Agency, *Energy Policy Review of Indonesia*. 2008, International Energy Agency: Paris, France.

6. Perdanahari, E., *Increased Access to Rural Electrification*, Directorate General for Electricity and Energy Utilization, Minustry of Energy and Mineral Resources.

7. International Energy Agency, *World Energy Outlook 2010*. 2010, International Energy Agency: Paris, France.

8. World Bank, *World development indiactor*. 2009.

9. World Bank, *Winds of Change: East Asia's Sustainable Energy Future*. 2010, The World Bank: Washington D.C.

10. Jakarta Globe, *Indonesia's Fuel Subsidies Help Rich, Not Poor*, in *Jakarta Globe*. 2010.

11. Provincial Government of Central Kalimantan. Available from: www.kalteng.go.id.

12. Intelligent Energy-Europe, *Reinforcing provision of sustainable Energy services in Bangladesh and Indonesia for Poverty alleviation and sustainable Development.* 2008.

13. Global Environment Facility. *Solar Home Systems Project*. Available from: http://207.190.239.143/Outreach/outreach-PUblications/Project_factsheet/Indonesia-sola-2-cc-wb-eng-ld.pdf.

14. *Author interviews in March 2011*.

15. World Bank. *Asia Sustainable and Alternative Energy Program - Indonesia*. Available from: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/EXTEAPASTAE/0,,contentMDK:21042053~menuPK:2900515~pagePK:64168445~piPK:64168309~theSitePK:2822888,00.html.

16. Schiller, A., *An "Old" Religion in "New Order" Indonesia: Notes on Ethnicity and Religious Affiliation.* Sociology of Religion, 1996. 57(4): p. 413.

17. International Crisis Group, *Communal Violence in Indonesia: Lessons from Kalimantan*, in *Asia Report Number 18*. 2001.

18. *Informal conversations with Tanjung Harapan's village leader and Pak Hadran*.

19. *Interview with Stibniati Atmadja, research fellow at CIFOR.*

20. Bacon, R., S. Bhattacharya, and M. Kojima, *Expenditure of Low-Income Households on Energy: Evidence from Africa and Asia*, in *Extractive Industries for Development Series No. 16*. 2010, World Bank: Washington D.C.

21. Van der Plas, R.J. and A.B. de Graaff, *A comparison of lamps for domestic lighting in developing countries*, in *Energy Series Paper 6*. 1988, World Bank: Washington D.C.

22. Mills, E., *The Specter of fuel-based lighting.* Science, 2005. 308: p. 1263-1264.

23. Pode, R., *Solutions to enhance the acceptability of solar powered LED lighting technology.* Renewable and Sustainable Energy Reviews 2010. 14: p. 1096-1103.

24. Peon, R., et al. *Solid-state lighting for the developing world – the only solution*. in *Proceedings of SPIE 5941*. 2005.

25. Meritec, *Niuatoputapu and Niuafo'ou Electrification Feasibility and Design Study*. 2000, Ministry of Foreign Affairs and Trade.

26. Agoramoorthy, G. and M.J. Hsu, *Lighting the Lives of the Impoverished in India's Rural and Tribal Drylands.* Human Ecology, 2009. 37: p. 513-517.

27. Dutt, G.S., *Illumination and sustainable development. Part I: technology and economics.* Energy for Sustainable Development 1994. I(1): p. 23-35.

28. Rajvanshi, A.K., *R & D strategy for cooking and lighting energy for rural households.* Current Science, 2007. 82: p. 632-637.

29. Ashden Awards (2010) *Case Study Summary: D.light Design, India and Global*.

30. Chaurey, A. and T.C. Kandpal, *Solar lanterns for domestic lighting in India: Viability of central charging station model.* Energy Policy, 2009. 37: p. 4910-4918.

31. Rosenthal, E., *Beyond fossil fuels: African huts far from the grid glow with renewable power*, in *The New York Times*. 2010.

32. Tata Energy Research Institute, *Evaluation of SPV Systems Installed Under INDO-US Collaboration Programme, Sundarbans, West Bengal*. 1998, TERI: Arlington, VA.

33. Smith, K.R., *Biofuels, Air Pollution and Health: A Global Review* 1987, New York, New York: Plenum Press.

34. Batliwala, S. and A.K.N. Reddy, *Energy for women and women for energy (engendering energy and empowering women).* Energy for Sustainable Development 2003. VII(3): p. 33-34.

35. Laxmi, V., et al., *Household energy, women's hardship, and health impacts in rural Rajasthan, India: need for sustainable energy solutions.* Energy for Sustainable Development 2003. VII(1): p. 50-68.

36. Ganju, K.K. and R. Mathur, *The environmental benefits of solar lighting alternatives over kerosene: an input–output approach.* Energy Security Insights, 2010. 5(1): p. 10-16.

37. Alternative Energy Development Inc., *Non-Conventional Energy Projects for Global Environment Facility Funding, Vol. I: Main Report*. 1991, World Bank: Washington D.C.

38. Bacon, R. and M. Kojima, *Phasing Out Subsidies*, in *Public Policy for the Private Sector Note No. 310*. 2006, World Bank: Washington D.C.

39. Tracy, J., et al., *Market Trial: Selling Off-Grid Lighting Products in Rural Kenya* in *Technical Report #6.* 2010, The Lumina Project.

40. Barefoot Power. *Firefly 12 Instruction Manual*. Available from: http://kopernik.info/en-us/technology/firefly-12-mobile.

41. Republic of Indonesia Ministry of Health (Indonesia MOH), *The tobacco source book: Data to support a national tobacco control strategy*. 2004, Indonesia MOH: Jakarta, Indonesia.

42. Kopernik. Available from: http://kopernik.info/en-us/page/impact-summary.

43. Hystra, *Access to Energy for the Base of the Pyramid*. 2009.

44. Barua, D.C., *Grameen shakti: pioneering and expanding green energy Revolution to rural Bangladesh*. 2007.

45. GSMA Development Fund, *Green Power For Mobile: Charging Choices*.

46. Guidestar.org. Available from: http://www2.guidestar.org/organizations/27-0962978/kopernik-solutions.aspx.

47. *Interview with Pak Bayu, conducted Jan 4th, 2011*.

48. FNPF. Available from: http://www.fnpf.org/index.htm.

49. Barefoot Power. Available from: http://www.barefootpower.com/.

Annex 1 – Client, Partner and Solar Lantern Project Background

Kopernik

Background

Kopernik is a non-profit organization that links the providers of innovative technology with technology users in the developing world and donors worldwide together via an online marketplace. Co-founded in 2010 by former United Nations and McKinsey management consultant Mr. Toshihiro Nakamura, and Ms. Ewa Wojkowska, who was formerly with the United Nations and the World Bank, Kopernik's revolutionary model matches the needs of technology seekers most closely and transparently by bringing technology providers into the equation. Kopernik does so by openly showcasing on their website the latest breakthrough technologies targeting the developing world and allowing local NGOs to select which technologies they require most and donors to direct their funding to a project of their choice[42].

Figure 13 **Kopernik's operational model**

Activities

To date, Kopernik has linked numerous successful partnerships in Africa and Asia, between providers of ready-to-go technology, open-source technology and emerging technologies with members of the developing world seeking technology solutions across various sectors such as agriculture, education, health, water and sanitation, energy and environment and information and communication. Kopernik continues to expand its outreach to maximize the benefits of life-changing technology to developing communities, and its solar lantern project has been successfully executed in Nigeria, Kenya, Timor-Leste, China and Indonesia.

The extent of Kopernik's activities has also been observed beyond developmental purposes. Most recently, Kopernik contributed toward humanitarian efforts by delivering solar lanterns and solar-powered hearing aids to victims of the Japan earthquake and tsunami that struck in March 2011.

Financing

In order to support its operations, Kopernik has secured significant funding from various sources[46]. In October 2010, Kopernik was awarded a USD100,000 grant from ExxonMobil to cover operational costs and seed-funding for Indonesia-focused projects on the economic advancement for women through improved energy access. This grant was a part of the USD 1-million pledge that ExxonMobil announced during the Clinton Global Initiative's Sixth Annual Meeting to support innovative technologies that address the energy gap and help women increase their productivity and effective participation in the economy. Kopernik also raised USD 80,000 from Daiwa Corporation of Japan and USD11,000 from Russell Investments.

Kopernik generates its revenue by imposing a 10% fee on the budget proposal for each project, which includes the cost of the products, shipping, transaction, duties, and wire transfers. These revenues allow Kopernik to maintain their online marketplace and conduct adequate due diligence to ensure that each project and their partners are accountable for deliverables on behalf of donors and recipients.

Friends of National Parks Foundation

Background

Friends of the National Parks Foundation (FNPF) is a local NGO with offices and representatives in various parts of Indonesia including Bali and Central Kalimantan. Founded by Drh I.G.N. Bayu Wirayudha, or Pak Bayu, FNPF gained its official NGO status in 1999. Pak Bayu is based in the Bali office while FNPF operates with one manager and about 12 staff in Central Kalimantan[47].

FNPF is largely focused on environmental conservation efforts of the lush tropical rainforests of Kalimantan such as the Tanjung Puting National Park, which is the natural habitat for a diverse ecosystem and home to South East Asia's orang-utans. FNPF's efforts have focused closely on reforestation, wildlife conservation and conservation education for young people[48]. FNPF works mostly with the community at Tanjung Harapan, which is near the Tanjung Puting National Park, and in Sungai Cabang, which is slightly more remote. Both villages are accessible only by boat from the nearest city of Kumai in Pangkalan Bun, Central Kalimantan. Many staff of FNPF lived in these villagers as well and therefore had exclusive local knowledge of the communities and their way of living, including local farming and conservation practices.

Pilot Distribution – "Green light for forest community"

Background

In 2010, Kopernik and FNPF conducted a pilot solar lantern project in the village of Tanjung Harapan and Sungai Cabang in Central Kalimantan, Indonesia. A total of 24 solar lanterns (Barefoot Power's Firefly 12 Mobile) of two kinds[47] – one with a cell phone charging function and the other without such capacity – were randomly distributed to villagers, some of whom included mothers with young children, older village folk, representatives of FNPF and park rangers. These lanterns were provided to FNPF at no cost as part of Kopernik's promotional exercise. While no formal training was issued upon distribution of the solar lanterns, one of the representatives of FNPF gave a short briefing to the recipients on how to operate the lanterns.

Table 9 Stakeholder analysis on the execution of a full-scale solar lantern project

Stakeholder	Status/ Role	Potential impact on project	Capacity/ Resources/ Constraints	Relative importance	Relative influence	Relationships/ Links to other stakeholders	Strategy to engage/ involve
Primary							
Kopernik	Links FNPF with technology from Barefoot Power	High	Decentralized control due to distance from site; lack of familiarity with communities and their needs	high	moderate to high	Reliance on FNPF for effective execution of project and on Barefoot Power to provide the technology	Involvement in meetings with FNPF/ Village Leaders on distribution and maintenance
FNPF	Exclusive knowledge of community and its needs	High	Mismanagement of roles and responsibilities due to lack of knowledge/ experience or resistance	high	high	Reliance on Kopernik as a contact point for incoming technology products	Involvement in meetings with Kopernik on distribution, maintenance and training
Village Elders	Encourage adoption of solar lanterns in the villages	High	Mismanagement of roles and responsibilities due to lack of knowledge/ experience or resistance	high	high	Commitment to welfare of community members	Involvement in meetings with FNPF on distribution and maintenance
Community members							
-Men	consumer	Medium to high	Willingness to buy (i.e. need for solar lantern); affordability of solar lanterns	moderate to high	moderate to high	support is essential in terms of purchase and correct use and care of solar lanterns	Attend training sessions on proper use and care for solar lanterns
-Women	consumer	High	Willingness to buy (need for lanterns in making handicrafts); affordability of solar lanterns	moderate to high	moderate to high	support is essential in terms of purchase and correct use and care of solar lanterns	Attend training sessions on proper use and care for solar lanterns
-Children	consumer	High	Willingness to buy (need for lanterns in reading/studying); affordability of solar lanterns	low	low	support is essential in terms of purchase and correct use and care of solar lanterns	Attend training sessions on proper use and care for solar lanterns
Secondary							
Kerosene vendors	supply and price of kerosene	Low to medium	NA	low	low	kerosene is still needed for cooking; risk of price hike to compensate vendors for loss on sale of kerosene for lighting	NA
Barefoot Power	technology provider	Low	challenges of outreach to and familiarity of poor communities	medium	medium	Needs to ensure its products are reliable	Competition for solar lantern products from other technology providers

Main project – "Reduce dependency on kerosene for forest communities"

Background

Kopernik and FNPF have joint plans to introduce a full-scale solar lantern project across three villages in Central Kalimantan. In 2011, a total of 316 lanterns are to be distributed to community members across the villages of Tanjung Harapan, Sungai Cabang and Sungai Pasir. In contrast to the pilot project, these solar lanterns will not be distributed free of charge. FNPF intends to work with these communities to assess their willingness to pay for the solar lantern and to establish a market price for such an item. It is expected that FNPF will work with a main contact in each community to provide the quantity of lanterns needed while the communities will handle sales and distribution exercises.

Firefly 12 Mobile

The technology provider of the solar lantern, Firefly 12, is Australia's Barefoot Power, a social enterprise that focuses on clean and affordable lighting solutions to energy poverty. Most of their products also support the charging of cell phones. Barefoot Power has won numerous awards for their solar lantern designs and mission, including the Lighting Africa's 2010 award for Outstanding Product[49].

Figure 14 Firefly 12 Mobile Model: VLP09S010NC1

Firefly 12 Super Bright LED Lamp

Model: VLP09S010NC1

Technical Specifications

Battery:	900mAh NiCd (2 year); 1200mAh NiMh (4 year)
Solar Panel:	1.0W Polycrystaline
Panel Wire:	4 meters
Battery protection:	Overcharge and Overdischarge
Runtime high setting:	4 hours
Runtime medium setting	7 hours
Runtime low setting:	50 hours
Charging time:	5 hours of Solar or 3 hours of AC
AC charging:	An AC charger is also available

Figure 15 50 Ways to end kerosene lighting - Renewable Energy and Energy Efficiency Partnership with Barefoot Power, May 2009

Description Single or multiple LEDs in desklamp, rechargeable battery inside, charged by a 1W solar panel

Hours/day of service	4	**Number of households**	1
Lumens/Watt	50	**Estimated retail price**	$20
Average Lamp Power (W)	0.8	**Battery life (years)**	1.5
Battery capacity (Ah)	0.65	**Battery replacement cost**	$2.00
Hours runtime/charge	4	**Lamp life (years)**	2
Charging hours from flat	4	**Lamp replacement cost**	$3.00
Lumens	40	**5-year replacement costs**	$14
Lumen-hours/year @ 4hr/day	58,400	**5-year ownership cost**	$34
Service delivered (lm.hr/$)	8,546	**Payback in weeks @ $1/week saved**	21
Kerosene service (lm.hr/$)	872	**Rating**	A

COMMENTS
Broad angle LEDs are very helpful for task lighting when light is close, or room lighting when placed up high. Payback for kerosene user is quite rapid, and more lumens are produced than a keronsene lamp. A nightlight feature is provided.

SUPPLIERS
Barefoot Power, Australia - www.barefootpower.com

The Firefly 12 weighs about 0.5kg and has a reported product lifespan of two to five years if used correctly[40]. While the light emitting diodes (LEDs) are estimated to last five years, replacement of the NiCd battery is possible to extend the working life of the Firefly 12. Replacement batteries and LEDs are sold separately. Some versions of the Firefly 12 also support cell phone charging capabilities, and an adapter that is compatible with several cell phone models is provided.

The Firefly 12 has 12 LED lights, and each lamp is reported to be five times brighter than an average kerosene lamp. The light quality is consistent and shows no signs of flickering that is commonly observed in kerosene lamps. The solar panel is a 1.5W polycrystalline enclosed in an aluminium frame. Barefoot Power currently offers a warranty of six months of the lamp and one year for the solar panel, valid for manufacturing defects only.

Performance relative to other products

Range of solar lanterns on Kopernik's online technology marketplace

The performance of the Firefly 12 was observed from two different performance reviews. The first was a comparison of all portable task and ambient lighting products that Kopernik features on its online marketplace. The Firefly 12 was the highest rated technology product on Kopernik's website, garnering an impressive 5 out of 5 stars, and continues to be featured on many ongoing campaigns, along with D.Light's Nova S250 solar lantern. A full charge of 3 hours yields a runtime of 5 hours on high and 50 hours on low setting.

Figure 16 Solar lanterns featured on Kopernik's online marketplace

a) Barefoot Power's Firefly 12 Mobile

b) D.Light's Nova S250

c) D.Light's Nova S100

d) Solanterns' Solantern

e) ValuLamp's Mega Brite 1000

f) Pisat Solar's K-Light

Table 10 Technical comparison of solar lanterns

	Firefly 12 Mobile	D.Light S250	D.Light S10	Mega Brite 1000	Solantern	K-Light
Manufacturer	Barefoot Power	D.Light	D.Light	ValuLamp	Solanterns	Pisat Solar
Dimensions	unknown	Width: 14cm Height: 16cm Length: 15.5 cm	Width: 9.4 cm Height: 9.4 cm Length: 20.4 cm	unknown	comes in packaging that is about 5cm X 50cm X 20cm per lantern	Lantern: Height: 19cm Length: 10.2cm Width: 7.6cm Solar panel: Length: 16.8cm Width: 8.6cm Thickness: 1cm
Weight	about 0.5kg	1.082 kg	0.3 kg	0.5 kg	0.2 kg	about 0.62kg
Average product lifespan	LEDs last approx 2-5 years and NiCd battery (900 mAh) approx 18 months. If used properly, product could last 5 years	5 years (with battery replacement every 1-2 years)	at least 3 years (with battery replacement every 1-2 years)	7 years, with battery replacement every 2-3 years	10yrs, with a battery replacement every 3 yrs.	10 years (full, daily use) or lifetime (recreational and/or emergency use)
Cell phone charging capacity	-Charges most cell phones with an adaptor direct from the solar panel -Replacement LEDs available, batteries sold separately.	6 connectors for different phones included	na	na	na	na
Charging time	3 hours solar or 3 hours AC	1 full day	1 full day	unknown	unknown	unknown
Runtime bed setting	na	100 hours	na	na	na	na
Runtime low setting	50 hours	12 hours	8 hours	unknown	unknown	20 hours
Runtime medium setting	7 hours	6 hours	na	unknown	unknown	na
Runtime high setting	5 hours	4 hours	4 hours	Lasts 3 hours per night at 50 lumens (about equal to S10 from Dlight)	unknown	10 hours
Other features	-Panel wire is 4m long	-Robust circuitry for long-life performance -Deep discharge/ overcharge protection to preserve battery life	-Multiple-setting handle allows flexible usage -Protection from overcharging -Tough and sturdy design	unknown	-Comes with a stand for desk lighting or hanging from the roof or wall.	-Water-resistant and can be converted into a flashlight -Safe, durable carrying handles that rotate 360°, locking every 30° for 12 different position -Solar Panel Cord is about 1.45m long
Batteries	NiCd battery (900 mAh) lasts approx 18 months	Easy to replace, high-performance NI-Mh battery	Replaceable NiMH battery	unknown	Replaceable Li-ion battery	Rechargeable 7.2 volt, 1.6_Ahr NiMH Battery (last more than 3,000 charges)

	Firefly 12 Mobile	D.Light S250	D.Light S10	Mega Brite 1000	Solantern	K-Light
Solar panel	1.5W Polycrystalline, Aluminium frame	-Weather resistant'-High efficiency polycrystalline solar panel-Solar LED charge indicator showing the level of battery charge	Solar panel integrated into lantern	unknown	expected to last 20 years	Shatter-resistant 1.5 Watt Solar Panel
Lights	12 LED lights, one lamp is 5 times brighter than one kerosene lamp	bright white light illuminates a room similarly to a 3 to 5 Watt CFL lamp	Suitable as general or task lighting	unknown	twice as bright as a kerosene lantern; expected to last 10 years	16 bright white LEDs that last for 100,000 hours.
Technical expertise required to put the product into use	none	none	none	none	none	none
Maintenance requirements	none	Battery replacement needed when performance degradation occurs (typically after 1-2 years)	Battery replacement needed when performance degradation occurs (typically after 1-2 years)	battery replacement every 2-3 years	battery replacement every 3 years	To "condition" and ensure proper working order of the K-Light, fully charge the K-Light and allow it to operate on high until the battery is fully drained, before fully recharging the K-Light again. Repeat at least once a year.
Warranty	Warranty of 6 months for the lamp and 1 year for the solar panel (for mfgtrs' defects only)	Warranty, Return and Refund policies depend on the country where the equipment will be delivered, and on the degree of coordination we will be able to set up with local organizations/distributors.	Warranty, Return and Refund policies depend on the country where the equipment will be delivered, and on the degree of coordination we will be able to set up with local organizations/distributors.	1 year warranty	1yr warranty against manufacturer diffect. Return within 30 days no questions asked. Customer must pay for shipping and a 10% restocking fee.	A period of one (1) year this product will be free from defects in its workmanship and materials. No warranty is provided for batteries and light bulbs.

The Lumina Project – Market Trial: Selling Off-Grid Lighting Products in Rural Kenya

The second performance review is based on a 2010 study conducted by a team at The Lumina Project in Kenya[39], where it was concluded that the Firefly range was a less favorable option amongst Kenyan villagers for various reasons. The team behind The Lumina Project – Market Trial: Selling Off-Grid Lighting Products in Rural Kenya – tested the sales potential of D.Light's Nova range of solar lanterns (Nova S201 and Nova S100) and Solata, and Barefoot Power's Firefly 5 and Firefly 12. From their results, it appears that the Firefly's 360° swivel gooseneck design made it seem less stable than its competitors in Nova. Moreover, the battery life for the Nova range surpassed that of Firefly products, with the Nova S100 exceeding the Firefly 12's battery life by more than twofold. While the Nova was considerably larger than the Firefly and the Solata, it was still small enough to be carried around. As a result, a single charge of the Nova range of solar lanterns could yield a longer light quality than the Firefly range could achieve. One of the reasons that the other solar lanterns outperformed the Firefly range was because these versions of the Firefly also did not offer cell phone charging capabilities, which was also another reason why they were less likely to be purchased. The Firefly was however, favored for its brightness.

Figure 17 Solar lanterns used in study on off-grid lighting products conducted by The Lumina Project in Kenya

a) D.Light's Nova S201

b) D.Light's Nova S100

c) D.Light's Solata

d) Barefoot Power's Firefly 5 Mobile

e) Barefoot Power's Firefly 12 Mobile

Annex 2 – Household/Semi-structured Interview Guide

Methodology

This is a sample interview guide. The methodology used, questions asked and data analysis will depend on the subject and their energy usage and consumption. Possible subjects include household heads (male and female), young women with family of children, older woman, business owners, and youth (15-18 years of age).

Sample Questions

Energy Needs and Access

1. For what purposes do you need lighting on a daily basis (regardless of the types of lighting)?

Further details: What time of the day do you need lighting? How many hours a day do you typically need lighting? Where do you use the lighting the most? (do you primarily use the lighting indoors or do you need portable light sources outdoors?)

2. How has the solar lantern affected your access to lighting?

Further details: What types of fuel did you use for lighting before receiving the solar lantern? How many hours of lighting did you use per day on average before receiving the solar lantern? How many hours of lighting do you use now?(How many hours of these do you use the solar lantern? For the other hours, what sources of lighting do you use?) How has the purpose/use of lighting changed with the solar lantern?

3. How is the quality of light from the solar lantern different from other sources?

Further details: Please describe the differences between various sources of lighting you have used. How has the change in the quality of lighting affected how you use lighting?

4. How is the use of the lantern allocated?

Further details: What is the primary use of the lantern? Who uses it the most? Who makes the decision on who will use the lantern?

Financial savings

5. You mentioned a few types of fuel you have bought for lighting. How much did you spend on purchasing the fuel before receiving the lantern?

Further details: How often did you buy the fuel? Would you describe the process of purchasing fuel? (Where did you go to buy the fuel? How did you get there? How did you get the money? How did you bring the purchased fuel back and store it?, etc.)

6. How much do you spend on fuel now after receiving the solar lantern?

Further details: Would you tell us why there is/there is not a difference in the expenditure on fuel? If there has been no savings, probe further to understand why.

7. (If there have been cost savings) What have you done with the money saved from purchasing fuels?

Further details: Would you describe to us how you have used the savings? Ask for a few examples if possible.

Livelihood

8. What are the livelihood activities of your household?

9. How has the solar lantern affected your livelihood activities?

Further details: Would you describe the benefits and disadvantages of the solar lantern on your livelihood activities? How has the changes in the livelihood activities affected your income and consumption?

Education

10. Do you have any children who are attending school?

Further details: If so, how many? What are their names and what grades are they in?

11. How has the solar lantern affected your children?

Further details: How did children study at night before you received the solar lantern? How has it affected their performance in school? (Probe for both positive and negative consequences. For example, they may be able to study more and perform better. Or they may stay up later so they are sleepy at school during the day).

Quality of life

12. Have there been other major changes in your and your family's lives since the distribution of the solar lantern? If so, please tell me about them.

Further details: Health. Safety (fire hazard, etc.). Security. How/why?

13. Has there been any change in your relationship with other members in the family?

Community

14. How do you think the distribution of solar lanterns affected your community?

Further details: What have been positive impacts? Do you think there have been any negative impacts on other members of the community? Would you describe who got the lanterns and who didn't? What do you think those who did not get the lanterns think of solar lanterns?

15. Has there been any change in your relationships outside the home? With neighbors who have a lantern versus those who do not?

Future plans

16. What are your hopes/plans/dreams for the future? Have they changed since receiving the lantern?

Annex 3 – Focus Group Discussion (FGD) Guide

This guide is for conducting a FGD with 1) men and women, who are heads of households who own and primarily use kerosene lamps as an energy source, 2) household heads who own solar lanterns (in addition to other energy sources) and 3) household heads who own a generator.

Mixed FGDs will inform us about what the community thinks and how members of the community interact with each other.

Date: ____________________________
Time: ____________________________
Location: __________________________
Interviewer: ________________________
Moderator: _________________________
Note-Taker: _________________________
Translator: _________________________

# of participants: ________________________
Participant: (Name) __________________________ (Title) __________________________
Participant: (Name) __________________________ (Title) __________________________
Participant: (Name) __________________________ (Title) __________________________
Participant: (Name) __________________________ (Title) __________________________
Participant: (Name) __________________________ (Title) __________________________
Participant: (Name) __________________________ (Title) __________________________

Background/ self-Introduction

[If possible the FGD should be set up in a comfortable environment. The participants should be sitting in a circle so that everyone can see each other.]

Good morning/afternoon. My name is ______________ and this is ____________. We are a consulting group working FNPF. We are helping them identify the impacts of solar lanterns in your lives. We appreciate your willingness to meet with us, and will try not to take up more than [1 or 2 hours] of your time. If you wish, we will be happy to keep your identity anonymous, and to keep in confidence any personal or sensitive information you share with us. Please don't hesitate to interrupt us at any time, and to stop the interview if you prefer. Also, this is a safe space and we would request to keep the discussions that happen today within the group. Would we have your permission to tape record our conversation, so that we accurately reflect your views in our analysis? Do you have any questions at this time?

Let us first start with everybody's introduction. But, we will introduce each other in a more interesting way. We will also mention what we do and what form of energy we use in our homes. Any questions so far?

[Conduct the icebreaker introduction.]

Opening questions

- Job description
- What is your monthly household income?
- Biggest purchase in the past year?
- Estimated monthly income for household
- What is the biggest problem in the village?
- What does new technology or new source of energy mean to you or to the community?

- What are your traditional energy sources? What energy sources were you using before the solar lanterns?
- For what purposes were you using them? (i.e. cooking/ lighting/ heating etc) What portion went for cooking and what portion for light or other purposes?
- How long have you been using traditional energy sources?
- Where do you get your energy sources?
- How much does it cost?
- Who goes to get it?
- Do you borrow electricity from friends?
- Do you own a cell phone?
- Where do you charge it?
- Do you pay to use generator?
- If you don't have flashlight what do you use outdoors at night?
- How much do you pay for a headlamp/flashlight?

Template for key questions per discussant group

A. Men and women, who are heads of households who own and primarily use kerosene lamps as the key energy source

Kerosene usage

- How much kerosene do you use per month (on lighting)?
- Where do you get kerosene?
- Who goes to buy the kerosene?
- The number of times a month you get kerosene
- What do you like about kerosene fueled lighting?
- What don't you like about kerosene?
- How many kerosene lamps do you use at home?
- Any trouble finding kerosene in the village?
- Any fires from kerosene usage? Any personal experience with fire?

Solar lanterns

- Have you seen a solar lantern before? Do you know about it?
- What do you think of the lantern (demonstrate lantern)
- What don't you like about the lantern?
- Do you think it's useful for you? Would you want one?
- If you can decide the price, how much would you pay? (demonstrate features)
- If the solar lantern cannot charge cell phones, how much would you be willing for the lantern?
- Anything else you want to ask/tell us about the lanterns?
- How do you want to pay? One time or installments?

B. *Household heads who own solar lanterns (in addition to other energy sources)*

Preferences

- Before solar lanterns, what lighting source did your family use at home?
- Now with the lantern, how often do you use kerosene lamps?
- Which do you prefer solar lanterns or headlamp/flashlight?

Solar lanterns

- What factors led you to buy solar lanterns? Does majority of the community have their own lanterns? Were you influenced to buy one because your neighbor/friend had one? Were you forced to buy one?
- Now that you have solar lanterns, what do you use solar lanterns for and what do you use other sources of energy for?
- What are you concerns about using solar lanterns for a long time?
- How long do you use the lantern every day?
- How many solar lanterns do you have?
- Does your lantern work?
- What do you use the solar lantern for?
- Number of hours per day the lantern is used?
- How often do you charge the lantern?
- Have you borrowed a solar lantern before?
- How many solar lanterns do you want?

Benefits/concerns

- What do you think about solar lanterns?
- What are the pros and cons of solar lanterns?
- Out of all the pros and cons, which ones are the most important?
- Do your children use the solar lantern to study?
- Do you still buy diesel and kerosene?
- Approximately, how much money are you saving every month on fuel after buying the solar lanterns?

Pricing

- How much is a good price for solar lanterns?
- Would you prefer a payment plan or one-time payment? (didn't specify a price-just in general)

C. *Household heads who own a generator*

- What type of generators do you have?
- Do you have any solar panels from the government?
- How much benzene do you buy each month for lighting only?
- How much kerosene do you purchase per month for lighting?
- Where do you buy fuel?

- [Demonstrate the solar lantern] Do you have any questions?
- How much are you willing to pay for the solar lantern? (hand out strips of paper to write down individual willingness to pay)

Conclusion/Confidentiality (to summarize the discussion or share the findings)

- Is there anything else that you would like to share with us…something that we missed out?
- Do you have suggestions of anyone else we should contact?
- Would you have any objection if we include your name in the list of persons met in our report to Kopernik?
- Is there any information you shared with us that you would prefer we NOT include in our report?
- If we have any further questions, may we contact you?

[Summarize some important points that came up in the discussion.]
Thank you very much for your time.
Here is our contact information. Please let us know if you have any other questions.

Annex 4.1: Transect walk for Tanjung Harapan

Tanjung Harapan													
Benzene Generator	**Diesel Generator**	**Solar Panel**	**Firefly Solar Lantern**	**TV**	**Remarks**	**Left of the Road**	**Right of the Road**	**Benzene Generator**	**Diesel Generator**	**Solar Panel**	**Firefly Solar Lantern**	**TV**	**Remarks**
		Govt			wife and husband	L1	NH						
			Broken		Mulyadi house, ex-deer hunter, use to take electricty from L3's diesel generator (Photo# KN 0899-0905)	L2	NH						
	X			X	use diesel only until 9pm, husband works at the river hotel (Photos# KN 0894-0895)	L3	NH						
	X			X		L4	NH						
				X	Satellite dish in the front yard, use electricty from L4's diesel generator but not everyday	L5	R5						ex-FNPF staff
						NH	R6						House under construction
			Broken		Ibu Manti and 3 kids	L7	NH						
		Govt		2 broken	Used to have benzene generator but broke 3 yrs ago (Photo# KN 0909)	L8	NH						
		Govt				L9	NH						
						L10	NH						
					Get electricity from L16	L11	NH						
		Govt			Get electricity from L16, used to have diesel generator and pay L16 voluntarily	L12	Mosque			Govt			Get electricity from L16 (Photo# KN 0911)
					Get electricity from L16	L13	R13						
					Get electricity from L16	L14	R14						empty house
						NGO Library	NH						
	X			X	Tuan's house (Photo# KN 0912)	L16	NH						
Here is the folk in the village road. Three entries below are on the road on the sharp left.													
					get electricty from diesel generator at homestay	Village store							
					on the small stretch on the right	House 1							
					on the small stretch on the right	House 2							
From here on, we are following the left branch of the road as we enter the village													
					Electricty from diesel at homestay	L17	Village office						Electricity from homestay
		Govt		X	Used to have diesel generator but broken now, get electricty from L16	L18	NH						
		Govt	X		Electricity from homestay	Clinic	R19		X			X	
						L20	R20						Abandoned house
			X			L21	NH						
						L22	R22						
						L23	NH						
						L24	NH						
						L25	NH						
		Govt				L26	NH						
						NH	R27						Abandoned house
						NH	R28						FNPF staff who worked in Serimbun, currently unoccupied
					Pak Hatta, get electricity from R29	L29	R29		X				Village secretariat's house, has pool table
					Teachers' home with 3 separate rooms, 2 rooms get elecrity from R29, 1 room get electricity from L31	L30	NH						
	X	Govt		X	Satellite dish in the front yard	L31	NH						
					Get electricity from L31	L32	NH						
					Empty house	L33	NH						
		Telecom company		X	Village leader's house, two sallelite dishes	L34	R34						Village leader's father's house, share electricity from L34
X		Govt		X	Satellite dish in the front yard	L35	R35						
						NH	R36						
					Old lady	L37	R37			Govt			L37's son
		Govt				L38	R38					Broken	
X			X	X	Pak Hadran, satellite in the front yard	L39	R39						Empty house
					Fuel seller's house	Behind L39							
					Pak Mirun, get electricity from School	L40	School	X	Broken				
		Govt	X		Aribyah' house	L41	School						
						NH	R42				X		Teacher's residence, the teacher moved away with her firefly
		Govt			Used to share diesel from R43	L43	R43		Broken (2 mo.)				
					Used to share diesel from R43	L44	NH						

Annex 4.2: Transect walk for Sungai Cabang

Sungai Cabang													
Benzene Generator	Diesel Generator	Solar Panel	Firefly Solar Lantern	TV	Remarks	Left of the Road	Right of the Road	Benzene Generator	Diesel Generator	Solar Panel	Firefly Solar Lantern	TV	Remarks
From the end of the main village, there is a small satellite community called Te Lukranggo													
							R1						
							R2						
							R3						
							R4						
					abandoned	L5							
							R6						abandoned
							R7		X			X	
							R8						
					Generator for R9	NH	R9		X			X	2 buildings
	L11					L10							
	X			X		L11							
							R12		R13				
							R13		X			X	
							R14		R15				
							R15		X			X	
							R16		R15				
							R17						
							R18						
	R20					L19	R19		R20				
							R20		X			X	
							R21		R20				
							R22		X			X	
	R23					L23	R23		X			X	
							Kiosk		X		2		
							R24		Kiosk				
							NH						Generator for Mosque
							R25						
	X					Mosque	R26						
					abandoned	L27							
	L29					L28/kiosk							
						Little shack							
	X			X		L29	R29		L29				
	L29					L30							
	L29					L31							
						L32							
						L33	R33						
							R34						
							Village office		X				three buildings
							R35						
	X			X		L36/kiosk	R36		L36				
	L36					L37	R37	Sometimes					2 buildings
							R38		?				Village secretariat
						L39							
							R40		R42				
	R42				Village secretariat	L41	R41		R42				
	R42					L42	R42		X			X	
	R42					L43							
	L46			X		L44/kiosk							
	L46					L45							
	X	m telesekom		X	Village leader's house	L46	Educatio n Center		L46				
	L46					Kiosk	R47		L46			X	
							R48						
							R49		R51				
	R51				There is a house behind L50 across the river that uses electricity from R51	L50	R50		R51				
							R51		X			X	
	R51					L52	R52		R51				

Sungai Cabang

Benzene Generator	Diesel Generator	Solar Panel	Firefly Solar Lantern	TV	Remarks	Left of the Road	Right of the Road	Benzene Generator	Diesel Generator	Solar Panel	Firefly Solar Lantern	TV	Remarks
						L53	R53						
							R54		R55				
	R55					Clinic	R55		X				Diesel generator here supports 13 families and 4 TVs
	R55				3 families	L56	R56		R55				
	R55					L57	R57		R55			X	
							R58		R55				
							R59		R55				
							R60		R55				
							R61		X				
							R62		R61				
							R63		R61				
							R64						
							R65						
							R66		R67				
							R67		X			X	
	X			X		L68							Generator for L68
	X			X		L69							
	L69					L70							
					Generator for L69								
Bridge to school (which has a benzene generator)													
					There is a house behind L71 which uses only MT	L71							
						L72							
	L74					Mosque	R73						
	X			X	has 2 diesel generators	L74	R75	X	L74				Benzene generator used for work
							R76		L74				
						L77	R77		L74				
	L74			X	There is a house behind L78 with only MT	L78/kiosk	R78		L74			X	
							R79		X				
							R80		X				Located behind R79
							R81		R79				
							R82						Located behind R81
							R83						Located behind R81
							R84						
There is a small road on the left. The following three entries are on this small road.													
							R92		X			X	
							R93		R92				
							R94		R92				
Back to the main road!													
Long stretch with no houses for a while													
							R85						
							R86		R87				
					There is a house behind with only MT	L87	R87		X			X	
							R88		R87				
		R87				L89	R89		R87				
						L90							
		X		X		L91							
		X				L92							
		L92				L93	R91						
End of village													

Annex 5.1 – NGO Interview Guide

Interviewee: Dr. Bayu Wirayudha
Title: Director of Friends of the National Parks Foundation (FNPF)
Location: FNPF Office
Interviewers: Alicia, Karina & Kevin

1. Introduction (5 min.)
Good morning Dr. Bayu Wirayudha. My name is Karina Nagin and this is Kevin Hong. We are both graduate students at Columbia University in New York and our team is working with Toshi at Kopernik for our capstone project. As you know we will be doing a rapid impact assessment of the solar lantern project for Kopernik, and we are thrilled to be working with Friends of the National Parks Foundation (FNPF).

Thank you very much for taking the time to meet with us. We were hoping to take about an hour of your time to get a better understanding of FNPF and the work you do and specifically about the solar lantern project. Kevin and I are looking forward to visiting the project sites in Kalimantan and 3 other team members will come over in March to do follow up interviews and surveys in the community. Do you have any initial questions for us?

2. Background questions (10 min)
We've seen your website and I know you have several projects working on reforestation and environmental education. There was also mention of community development and skills training. I was hoping you could give us a brief synopsis of FNPFs main mission and projects?

How many staff do you have? How many in Kalimantan and where are they located?
How long has FNPF been working in the different communities in Kalimantan?

3. Solar Lantern Questions (20 min)
We were told that the solar lanterns have been distributed in Tanjung Harapan and Sungai Cabang. Is this correct? When were they distributed?
Why did FNPF want to implement the solar lantern project ?
How does this benefit your mission?
Have you done other solar lantern projects in the past? Can you give us background on these projects and their impact? What was the result of these projects good/bad?

4. Community Questions (10min)
Can you tell us a little bit about these communities and how they are different?
Why were these communities chosen for lantern distribution?
How were individual households chosen to receive lanterns?
How did you choose who to distribute the lanterns to?
Do you have a list of census data on the recipients of the lanterns?
Gender/socio economic context in the communities?

5. Impact Questions (10min)
What impacts do you hope the lanterns will have?
What are the biggest challenges to this project?
Are you interested in measuring the continued impact of the lanterns?
If we provided you with a survey tool would you continue to collect data?

6. Technical/Pricing/Distribution Questions (10min)
How are the lanterns distributed?

How did you choose the price?
How do people pay for the lanterns (individually/as a community)?
Is there a plan for maintenance of the lanterns?
Do you see solar lanterns as part of your skills building/alternative income stream/livelihood projects? Could there be a market for resellers?

7. Environmental Questions (10min)
What are the environmental/sustainability challenges in these communities?
How do you think solar lanterns will address these issues?

8. Field Work Questions:
Who will be taking us to the village?
Are they from that village? How long have they worked there?
Men/women?
Do you have translators for us?
Who/how is the best way to be introduced into the community?
Ease of focus groups/interviews?
Are there any cultural taboos we should be aware of before visiting the communities?

9. Conclusion (5 min.)
Is there anything else you would like to add or ask us?
Do you have any suggestion of anyone else we should contact?
If we have further questions, would you mind if we contact you again?
Thank you very much for answering our questions and sharing the valuable insights.
Please feel free to contact us at any time.

Annex 5.2 Notes from interview with Pak Bayu, the Head of FNPF (in January 2011)

History of Friends of National Parks Foundation (FNPF)

FNPF began in 1997 as a CSR initiative with contributions from the travel agency with which Pak Bayu was working at that time. A major support came when a client cancelled their trip but donated their money to the project. Later, donors asked Pak Bayu to separate the tour agency and the social work Pak Bayu was doing to obtain an NGO status.

In 1999, FNPF gained its official NGO status. Ironically, the tour agency that gave birth to the initial activities of FNPF is no longer in business but FNPF continues to operate with 1 manager and around 12 staff members in Borneo and 2 management team members (Pak Bayu and an assistant) in Bali. Pak Bayu has emphasized greater involvement of community members in FNPF's activities over the hiring of more permanent staff.

Communities in which FNPF operates and its activities

FNPF works mostly in a community called Tanjung Harapan near Tanjung Puting National Park. Because of the size of the national park, which is approximately as big as Bali, communities around the park are remote and far from one another, making travelling to and working in these communities challenging. Even though FNPF operates in multiple communities around the park, its focus remains in Tanjung Harapan because of these challenges.

FNPF focuses on conservation education among young people. They initially focused on working with senior high students because they are mobile, independent, and in the position of positively influencing their parents' behavior. They also often help out with livelihood activities to which they can apply what they learned from conservation education. After 7 years of operation, 2 schools have officially adopted FNPF's conservation education into their curriculum.

Developing relationship with communities

It took a long time to earn the trust of the communities. At the beginning, the communities wanted people who gave them things, not knowledge. At first, the communities only wanted fish but now they appreciate learning how to fish, reflecting the truth in the age-old proverb of "Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime."

How FNPF learned about Kopernik

FNPF originally learned about Kopernik through an Australian intern named Joanie who found Kopernik on the internet. Pak Bayu wanted to work with Kopernik because FNPF wanted to gain additional support from the communities with a project that provides both direct and indirect benefits (such as financial and education benefits respectively). Moreover, the government is unable to provide electricity to these isolated communities and solar lanterns would provide an alternative energy source.

Development of the solar lantern projects

The initial project was a pilot project with 24 lanterns of 2 types, one of which provides only lighting and the other providing both lighting and cell phone charging capability. The lanterns were provided to FNPF for free as a promotional activity for Kopernik, and these were in turn passed on to some households and other community members, including park rangers. In this project, the lanterns were distributed to recipients for free and randomly to avoid jealousy within the communities.

Impact from the initial solar project

Even though there was no official impact assessment, from personal experience, FNPF found that the capability of the solar lantern to charge mobile phones was really helpful for the community members. Cell phones are quite prevalent in Indonesia and even in these remote communities, where cell phone reception is not always available but community members use mobile phones for music and for communication when they visit larger communities with reception.

In these communities, batteries are expensive and therefore most households use kerosene. Diesel engine provides electricity but because of its slow rotation, lights are often blinking, leading to poor quality of light and causing strain to eyes.

Current solar lantern project

In contrast to free distribution of the lanterns to the communities, FNPF plans to work with communities to determine the pricing of the lantern by explaining the costs involved to get the lanterns (including customs fee) and letting people decide on their willingness to pay. FNPF finds it important to tie the pricing with the current fuel expenditure.

The distribution of the lantern will be decided by the communities. FNPF will work with a main contact in each community to provide needed lanterns and sales and distribution will be handled by the communities.

In this region, solar panels are already in sale and communities are aware of solar products but they perceive them as luxury goods. Sungai Cabang showed greater interest in acquiring lanterns because of their remoteness and difficult access to fuel (it takes 6 hours by boat from Sungai Cabang to get fuel even with good weather). In Tanjung Harapan, the demand is not as high as in Sungai Cabang because they have easier access to fuel.

Intended impacts of the solar lantern project

The main goal of FNPF is to gain support from the communities for their conservation work. This project will be hopefully mutually beneficial, showing mutual respects. This will be a trade of merits, not a bribe, to show the communities that FNPF is not only asking the communities to do things for FNPF but also providing the communities with benefits.

The benefits to the households include reduction in fuel expenditure, improved quality of light, and extended hours for livelihood activities (some households in these communities make handicrafts as a part of their livelihood and with solar lanterns, they will be able to work at night). FNPF also hopes that solar lanterns will be continuously used as the primary source of lighting with other fuels as back-up.

Palm oil plantation is a popular livelihood option in this region because big companies pay farmers well, providing short-term profits. However, because of the poor soil quality in Borneo, many chemical fertilizers are needed and it is not sustainable in the long term. FNPF hopes to create alternative sustainable income sources for these communities.

Future plans for the solar lantern project

While there is no concrete plan for community-based maintenance of the lanterns, FNPF believes in the durability of the products (from their experience, batteries last 2-3 years and LED is good for almost lifetime). Pak Bayu mentioned that Kopernik has spare parts and they may provide replacement batteries.

Advice from Pak Bayu for the Columbia team

People in isolated area are always curious as well as suspicious that outsiders would want to take something from them. It is important for our team to reduce this type of tension. Pak Bayu hopes that a more scientific review of FNPF’s work will be beneficial in promoting its mission.

Annex 6: Sample long-form survey

Kopernik - Baseline Energy Survey - March 2011 [In depth household interview]

1. Survey Details

Date ____________
Interviewer ID ____________ [PG = Paul Gubbins, NK = Neha Kumar, ES = Erisha Suwal]
Village ID ____________ [1=Tanjung Harapan, 2 = Sungai Cabang , 3 = Sungai Pasir]
Household number ____________
Household GPS Coordinates ____________
Picture Numbers ____________

2. Household and Respondent Characteristics

Name ____________
Age ____________
Education ____________

Gender | M | F |

How many family members live here? [ ]
How many children do you have? [ ]
How many children are going to school? [ ]

What is your household's main source of income? ____________

Approximately how much does the household spend per month? ____________ Rp

Approximately how much does the household spend per month for the following?

Food & Beverages ____________ Rp
Entertainment (Social events, festivals) ____________ Rp/yr
Education ____________ Rp
Health Care ____________ Rp/yr
Transportation ____________ Rp/yr
Cigarettes ____________ Rp
Communication ____________ Rp
Clothing ____________ Rp/yr

How many rooms does your house have? [ ]

Does the household have the following...?			If yes - How many?
Television	Y	N	
Radio	Y	N	
Scooter	Y	N	
Bicycle	Y	N	
Boat	Y	N	
Livestock	Y	N	
Hand Phone	Y	N	
Satellite	Y	N	

Do you own land? | Y | N |

NOTES

3. Household Priorities

What are the three biggest challenges your household is facing? [Open ended]

Food [ ]
Education [ ]
Clean Water [ ]
Electricity & Fuel [ ]
Health Care [ ]
Transportation [ ]
Financing (Credit/ Savings) [ ]
Other 1 [ ] *Write in* ____________

Notes: (i.e. why are these salient issues?)

4. Energy Use/ Services

Which of the following source of energy does your household use?

What do you use this energy source for? [Please Check All that apply]

			Quantity	Cooking	Reading	Working	Walking	Sleeping	TV/Radio	Handphone charging	Social Interaction	Motorcycle/ Boat	Water Pump
Wood	Y	N											
Candles	Y	N											
Kerosene	Y	N											
Diesel	Y	N											
Benzene	Y	N											
Batteries (Flashlights/ Headlamps)	Y	N											
Solar - Solar Home System	Y	N											
Solar - Lantern	Y	N											

5. Energy Consumption & Expenditure

	When was the last time you purchased this item?	The last time you purchased this item, how much did you buy?	*[Unit (litres, kilograms, units)]*	How much did you pay (Rp) for that amount?	How often do you buy this?	Where do you purchase this?
Candles						
Kerosene						
Diesel						
Benzene						
Batteries						

	Do you own the following?		How many do you own?	How many hours per day do you use this?	Where did you purchase these items?	Price
Kerosene Cookstove (Campor)	Y	N				
Wood-burning stove	Y	N				
Kerosene wick lamps	Y	N				
Kerosene Hurricane Lamp	Y	N				
Candles	Y	N				
Headlamp or Flashlight	Y	N				
Diesel Generator	Y	N				
Benzene Generator	Y	N				
Solar Lantern	Y	N				
Solar Home System (Solar Panel)	Y	N				

What do you do when one of these devices breaks?

6. Willingness to Pay

Will you pay for the lantern(s)?

Will pay	Y	N
Won't pay	Y	N
Don't know	Y	N

For each of the following price points, please tell us how much you are willing to pay for the lantern(s)?

Price (RP)	YES	NO
20,000		
35,000		
50,000		
65,000		
80,000		
95,000		
110,000		
125,000		
140,000		
155,000		
170,000		
185,000		
200,000		
215,000		
230,000		
245,000		
260,000		
275,000		
290,000		

To pay for the solar lantern - which of the following would you choose?

Single payment	Y	N
Buy in installments	Y	N

Is there a reason you would not like to pay or are unsure?

Can't afford the full cost	
Don't believe the lantern is useful enough to pay for	
Don't believe the lantern is reliable	

Other ____________

NOTES

Annex 7: Sample short-form survey

Kopernik - Baseline Energy Survey - March 2011 [SHORT]

1. Survey Details

Date __________

Village ID __________ [1=Tanjung Harapan, 2 = Sungai Cabang , 3 = Sungai Pasir]

Household number __________

2. Household and Respondent Characteristics

Name __________

Age __________

Gender | M | F |

How many family members live here? [ ]

How many children under the age of 5 live here? [ ]

How many children are going to school? [ ]

What is your household's main source of income? __________

Approximately how much does the household spend per month? __________ Rp

Approximately how much does the household spend per month for the following?

Food & Beverages	Rp
Entertainment (Social events, festivals)	Rp
Education	Rp
Health Care	Rp
Transportation	Rp
Cigarettes	Rp
Communication	Rp
Clothing	Rp

How many rooms does your house have? [ ]

Does the household have the following...?			If yes - How many?
Television	Y	N	
Radio	Y	N	
Scooter	Y	N	
Bicycle	Y	N	
Boat	Y	N	
Livestock	Y	N	
Hand Phone	Y	N	

Do you own land? | Y | N |

3. Energy Use/ Services

Which of the following source of energy does your household use?

Wood	Y	N
Candles	Y	N
Kerosene	Y	N
Diesel	Y	N
Benzene	Y	N
Batteries (Flashlights/ Headlamps)	Y	N
Solar - Solar Home System	Y	N
Solar - Lantern	Y	N

	What do you use for cooking? [Please check all that apply]	What do you use for lighting? [Please check all that apply]
Wood		
Candles		
Kerosene		
Diesel		
Benzene		
Batteries (Flashlights/ Headlamps)		
Solar - Solar Home System		
Solar - Lantern		

4. Energy Consumption & Expenditure

	When was the last time you purchased this item?	The last time you purchased this item, how much did you buy?	*[Unit (litres, kilograms, units)]*	How much did you pay (price) for that amount?	How often do you buy this?	Where do you purchase this?
Wood						
Candles						
Kerosene						
Diesel						
Benzene						
Batteries						

	Do you own the following?		How many do you own?	How many hours per day do you use this?	Where did you purchase these items?
Kerosene Cookstove (Campor)	Y	N			
Wood-burning stove	Y	N			
Kerosene wick lamps	Y	N			
Kerosene Hurricane Lamp	Y	N			
Candles	Y	N			
Headlamp or Flashlight	Y	N			
Diesel Generator	Y	N			
Benzene Generator	Y	N			
Solar Lantern	Y	N			
Solar Home System (Solar Panel)	Y	N			

Annex 8: NPV Model

Scenario 1 (Households reduce Kerosene Expenditures by 41 percent)						
Month	Monthly Household Kerosene Expenditures (USD)	Monthly Kerosene Expenditure Savings with Lantern (%)	Monthly Savings (USD)	Number of Functional Lanterns	Total Village Savings	Prob Defect (No Maintenance Plan)
0	10.7	0	0	0.0	0	0.00
1	10.7	0.41	4.387	316.0	1,386	0.00
2	10.7	0.41	4.387	316.0	1,386	0.00
3	10.7	0.41	4.387	316.0	1,386	0.00
4	10.7	0.41	4.387	316.0	1,386	0.00
5	10.7	0.41	4.387	316.0	1,386	0.00
6	10.7	0.41	4.387	300.0	1,316	0.05
7	10.7	0.41	4.387	270.0	1,184	0.10
8	10.7	0.41	4.387	230.0	1,009	0.15
9	10.7	0.41	4.387	184.0	807	0.20
10	10.7	0.41	4.387	138.0	605	0.25
11	10.7	0.41	4.387	97.0	426	0.30
12	10.7	0.41	4.387	63.0	276	0.35
13	10.7	0.41	4.387	38.0	167	0.40
14	10.7	0.41	4.387	21.0	92	0.45
15	10.7	0.41	4.387	11.0	48	0.50
16	10.7	0.41	4.387	5.0	22	0.55
17	10.7	0.41	4.387	2.0	9	0.60
18	10.7	0.41	4.387	1.0	4	0.65

Cumulative Village Savings	Discount Factor	PV Monthly Project Costs (Subsidized)	PV Monthly Benefits	PV of Cumulative Project Costs	PV Cumulative Project Benefits	Cumulative NPV	Discount Rate		
0	1	4,570	0	4,570	0	-4,570	0.05	Investment	4,570.13
1,386	0.995942	0	1,380.67	4,570.13	1,380.67	-3,189		Fees	
2,773	0.991901	0	1,375.06	4,570.13	2,755.73	-1,814			
4,159	0.987877	0	1,369.49	4,570.13	4,125.22	-445			
5,545	0.983868	0	1,363.93	4,570.13	5,489.15	919			
6,931	0.979876	0	1,358.39	4,570.13	6,847.54	2,277			
8,248	0.9759	0	1,284.38	4,570.13	8,131.92	3,562			
9,432	0.97194	0	1,151.25	4,570.13	9,283.18	4,713			
10,441	0.967997	0	976.72	4,570.13	10,259.89	5,690			
11,248	0.964069	0	778.20	4,570.13	11,038.10	6,468			
11,854	0.960157	0	581.28	4,570.13	11,619.38	7,049			
12,279	0.956261	0	406.93	4,570.13	12,026.31	7,456			
12,556	0.952381	0	263.22	4,570.13	12,289.53	7,719			
12,722	0.948517	0	158.12	4,570.13	12,447.65	7,878			
12,814	0.944668	0	87.03	4,570.13	12,534.68	7,965			
12,863	0.940835	0	45.40	4,570.13	12,580.08	8,010			
12,885	0.937017	0	20.55	4,570.13	12,600.64	8,031			
12,893	0.933215	0	8.19	4,570.13	12,608.83	8,039			
12,898	0.929429	0	4.08	4,570.13	12,612.90	8,043			

Benefit to Cost Ratio: 2.76