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Data Collection for the Solar Photovoltaic (PV) based Electricity Access assessment to Replace Diesel generators in Refugee Camps in Southern Bangladesh and Northern Uganda

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Abstract:

This report details the data collection methodology employed in the study, which investigates the potential for solar photovoltaic (PV) based electricity supply to support refugee camp operations and provide electricity access to refugee households, replacing the prevalent use of diesel-based electrification by aid agencies. The study focuses on refugee camps in Uganda and Bangladesh as case studies. Both structured and semi-structured interviews were conducted to gain insights into the current diesel-based electrification practices and the electrical demands across various segments of the refugee settlements. Collected data and insight were used to model range of PV-battery energy supply systems with detailed techno-economic analyses to be included in a separate publication. Such field data based renewable energy based alternative solutions to diesel power systems would enable aid agencies to make informed decisions in deploying clean energy supplies for refugee camps and their operations.

Abbreviations

AC	Alternating Current
AIRD	African Initiative Relief and Development
DC	Direct Current
IOM	International Organization for Migration
RRRC	Refugee Relief and Repatriation Commissioner (Bangladesh)
UNHCR	United Nations High Commissioner for Refugees

1. Background

Humanitarian agencies like the United Nations High Commissioner for Refugees (UNHCR), the World Food Programme (WFP), the International Organization for Migration (IOM), the Norwegian Refugee Council (NRC) and others address the refugee crisis by delivering emergency relief in vital areas including food, shelter, water, energy, health and sanitation. There's no doubt that, among these, access to electricity is crucial for successfully delivering other services in refugee camps. Historically, electricity supply for camp operations around the refugee settlements has been based on diesel generators, primarily because they are readily available and do not require significant initial capital expenditure (CAPEX) compared to Photovoltaic (PV) energy systems [1]. Aid organisations engaged in refugee welfare and support works lack the necessary resources and organisational policy support to create long-term sustainable provision to energy access, especially access to electricity for the refugee households. Nevertheless, providing access to electricity for refugee households by the aid organisations traditionally considered a secondary need [2]. However, relief situations persist for years and sometimes decades, and the temporary refugee camps turn into permanent shelters in many cases. Therefore, there is a growing need for sustainable solutions for electricity supply for the refugee families that go beyond the short-term emergency aid provision. Long term and sustainable electrification solutions require integration of multi-agency efforts supported by multi-lateral data from relevant stakeholders including energy requirements by the refugee households.

A study was carried out in 2018 and 2019 to explore the potential of replacing diesel generators with solar photovoltaic (PV) to provide electricity access for refugee camps including refugee households. This report details the data collection approach applied for the assessment of PV based electricity access for refugee camps in two different continents, (i) refugee camps in Yumbe district, northern Uganda, and (ii) Rohingya refugee camps in Cox's Bazar district, southern Bangladesh. The report includes data collection approach, methods and challenges in both countries to understand the present energy uses and explore the possibilities of sustainable energy access provision(s) for these displaced people.

2. Data collection approach

Both structured and semi-structured interviews were used to collect data for this study as indicated in Table 1 below.

Table 1 Different data segments with their geographical locations and type of surveys used for the study.

Sl.	Data segment	Geographical location	Type of survey	Comment
1.	Refugee household electricity demand assessment	Kutupalong refugee camp, Cox's Bazar, Bangladesh	Structured interview	Adult male member of the household were interviewed in most cases.
2a.	Stakeholder survey: • UNHCR • Mercy Corps • AIRD	Uganda	Semi-structured interview	Members of the organisation from the procurement, operation, administration and field deployment teams were asked the relevant questions.
2b.	Stakeholder survey: • UNHCR • IOM • RRRC	Bangladesh	Semi-structured interview	
3.	Trading centre electricity demand assessment	Imvepi refugee settlement, Yumbe, Uganda.	Structured interview	Data was collected from 12 shops of different types.

4.	Base camp offices electricity demand assessment	Bidi-bidi base camp, Yumbe, Uganda	Structured interview	Data was mainly collected from the AIRD and UNHCR officials on site at the time of the study.
5.	Cost of diesel generator based electrification	Bidi-bidi base camp, Yumbe, Uganda	structured interview and record checking	Cost data from UNHCR and operational data from AIRD.

2.1 Refugee household electricity demand assessment, Bangladesh

A small subsection of Kutupalong refugee camp (Figure 1), which had around 300 Rohingya families arrived from Myanmar just before undertaking the study, was selected for the survey. This subsection was selected after consultation with the RRRC, UNHCR and IOM officials as this represents the actual status of electrification in the new camps, and household's aspiration for access to electricity. The questionnaire used for data collection (see Appendix I) also covered household income, intention to pay for electricity, current cooking methods and intention to use electric cooking. However, data related to cooking was not further analysed.

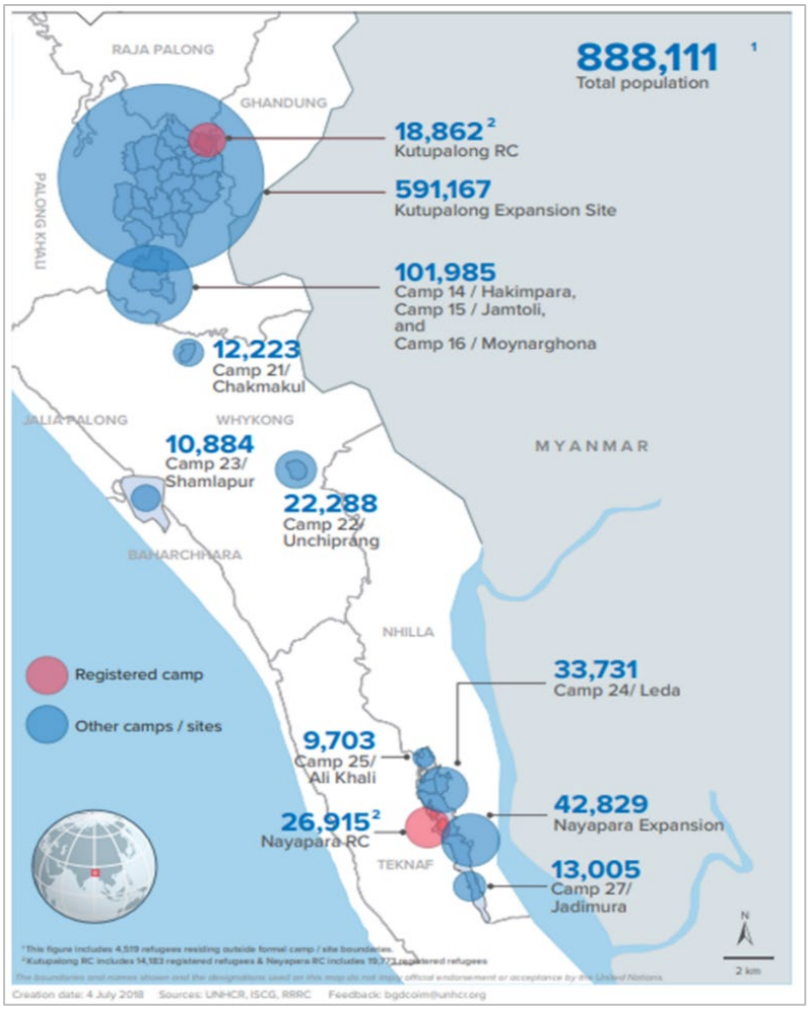

Figure 1 Rohingya refugee camos in Cox's Bazar, Bangladesh showing the location of Kutupalong camp (Source: unhcr.com).

The study settlement at Kutupalong was off-grid and densely populated (Figure 2) with no identification numbers or marks of refugee dwellings. Data was collected during the daylight hours and samples were selected randomly without looking at their roofs whether there are any solar home systems available. Data collected from 60 households was scaled to 400 similar samples including

Figure 2 Surveyed subsection of Kutupalong refugee camp, Cox's Bazar, Bangladesh.

required numbers of street lights, toilet lights etc. The estimated electrical load profile is presented in Table 3.

2.2 Stakeholder survey: Uganda and Bangladesh

Semi-structured interviews with the Key stakeholders associated with refugee camp operation and electrification in Uganda (UNHCR, Mercy Corps and AIRD) and Bangladesh (UNHCR, IOM, RRRC) were conducted. A common survey questionnaire (Appendix II) was used for all stakeholders to understand the current trend of electrification for camp operation, electrification of refugee households and aspiration for switching from diesel generator based electrification to renewables, especially solar PV. It is notable that all the questions (as in Appendix II) were not applicable to all stakeholders. For example, RRRC in Bangladesh do not invest themselves into refugee camp electrification but they advocate such initiatives from other aid agencies and organisations.

2.3 Trading centre electricity demand assessment

Although there are not many opportunities of formal economic activities for the refugee communities within the camps, some informal trading centres grow and thrive organically. Imvepi trading centre in Imvepi refugee settlement, Uganda is an example of such thriving economic activities within the settlement (Figure 3). Structured surveys, using a questionnaire (Appendix III), were carried out to access the electrical demand and cost of electricity for different businesses in the trading centre. The trading centre was powered by several small diesel generators. Businesses used to pay for using pre-agreed amount daily for specific consumptions. It is notable that both the refugees and local people run business in the trading centre. A total of 15 shops including a welder, small grain mills, pharmacy, grocery shops, bike repair shop and barbers were found active during the time of the study. Twelve shops were randomly selected from all the categories for the survey, ensuring representation from each category. It was observed that many shops were using DC appliances by converting the AC power supply from the diesel generators. Furthermore, DC appliances were available locally in Yumbe town. Therefore, electrical demand was assessed both for AC and DC loads (Table 3).

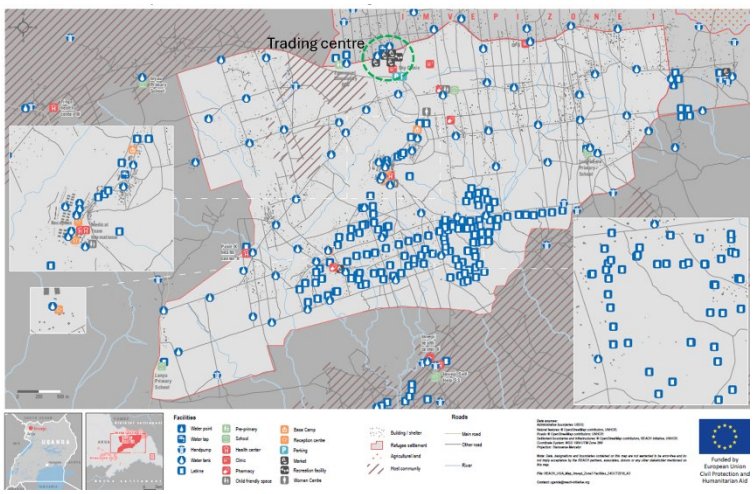

Figure 3 Surveyed trading centre (marked green dotted circle) in Imvepi refugee settlement, Uganda (Source: reliefweb.com)

2.4 Base camp offices electricity demand assessment

Electricity demand data, related to appliances used and consumption patterns of AIRD office in Bidi-bidi base camp, Mercy Corps West Nile office and UNHCR temporary office in Yumbe were collected during the field visit using a questionnaire (Appendix III), and were analysed to have clear insight about usages pattern. Same questionnaire was used to collect data from the members of other partner NGOs which were supposed to be shifted to Bidi-bidi base camp. Number of potential appliances and their daily usages are presented in Table 2, and the daily estimated hourly consumption in Table 3.

Table 2 Number of appliances and their usages at different times of the day

Appliances	Power rating (W)	Number of appliances	
		Daytime	Evening/night
Light bulbs	20	40	40
Security light	100	-	15
Computers	80	30	3
Cooling fan	60	25	10
TV	40	4	10
Fridge/freezer	120	6	2
Flat iron	1000	-	2
Water pumping	250	1	-
Printer/scanner	80	10	-
Communication system	60	3	3
Communication Backup power	2 kWh	1	-

2.5 Cost of diesel generator based electrification

This study explores the real life cost of diesel generator based power supply and their operations in refugee camp context in Northern Uganda, and compares such cost with the like for like solar PV-battery solutions. The novelty of this work is that it encompasses some costs and issues that have not been addressed before to drive the real cost of diesel generator based electricity supply in such a landscapes (Figure 4). For example, cost of supply chain in operation and maintenance of fuel transportation, handling and cost of value chain.

Figure 4 Bidi-bidi base camp secured fencing (top left), UNHCR staffs are checking a reported diesel fuel contamination issue (top middle), a 50kW diesel generator (top right) and relief storage facilities that require uninterrupted power supply (bottom).

Diesel generators in different refugee camps around the world operate without consistence standards and operating guidelines. Humanitarian agencies start procurement, installation and operation of DG on an ad hoc basis as a results of urgent responses to new refugee settlement. Therefore, their sizing, installation, environmental issues and fuel procurement process remain responsibilities of multiple departments/ wings of the participatory organizations and real cost perspectives are on the whole not thoroughly accounted for.

A questionnaire (Appendix V) was used to record all the related cost of three different diesel generators (10kW, 25kW and 50kW) form the UNHCR and AIRD officials in Uganda.

2.6 Estimated load profiles

Electricity consumption data collected through the structured and semi structured interviews as detailed above were used to develop electrical load profiles to be used for modelling of different PV-battery based electricity supply systems in the refugee camps.

Table 3 Estimated average hourly load profiles derived from the surveys for modelling different PV-battery energy supply systems for the refugee camps in Uganda and Bangladesh

Hour of the day	Household and amenities load (kW)	Bidi-bidi base camp load (kW)	Imvepi trading centre AC load (kW)	Imvepi trading centre DC load (kW)
	Bangladesh		Uganda	
0	1.5	2.6	0.4	0.2
1	1.3	2.6	0.32	0.2
2	1.2	2.6	0.2	0.13
3	1	2.9	0.2	0.12
4	1	2.9	0.3	0.15
5	1	2.9	0.4	0.24
6	1.3	3.4	0.45	0.28
7	1.2	4.62	1	0.72
8	1	5.26	1.7	1.2
9	1	5.26	2	1.4
10	0.85	5.26	6	4.5
11	0.85	5.26	6.5	5.2
12	0.85	4.68	6.5	5.4
13	0.85	4.68	7	6
14	0.85	4.68	7.2	6.1
15	0.85	4.68	7	5.8
16	1.2	4.68	2.3	1.7
17	1.4	4.4	2.3	1.9
18	4.3	4.4	2.6	2.1
19	4.5	4.02	2.8	2.2
20	4.5	4.02	2.5	2.3
21	4	4.02	2.5	2.2
22	3	3.2	2.2	1.8
23	2.3	3	1.4	1

3. Economic modelling of different energy generating systems

Data used for economic modelling (Year on year accumulated cost, Net Present Cost (NPC) and Levilised Cost of Electricity (LCOE)) of different energy generating systems, i.e., diesel generators, PV-battery systems in AC and DC are included in in the accompanying spreadsheet (Data_economic_modelling_energy_systems).

4. Conclusions

Data collected for the assessment cost of diesel generator uses by aid agencies, estimation of electrical demand at different segments of refugee settlements, i.e., refugee households, camp operations, communal securities and trading centres within the settlements can be used to develop different solar PV-battery based alternative electrification solutions. The methodologies applied in this study can be replicated for future studies in similar context.

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Appendix I

Energy access data collection questionnaire used in Kutupalong Refugee camp, Cox's Bazar, Bangladesh

1	Name: ……
2	Family member: Total: .. 0-6:…. 6-18:… 18+: Male: …. Female: ….
3	School going kids? Y/N? Number: …
4	Income: if any: Y /N Source:… Frequency: …day/week Amount: Tk…. / week
5	Have you had electricity in Rakhine before coming to Bangladesh? Y/ N Source: …..
6	Current source of lighting? Kerosene / SHS / Paraffin
7	Any monitory support for lighting cost? Y/N If yes: …….
8	Lighting cost per month? TK. …….
9	Intention to have electricity? Y/N
10	Electricity requirement for: 1 LED / 2 LED / others (Hours of usages: …..)
11	Intention to pay for electricity for lighting? Y / N
12	Reason for paying for electricity? Cheaper option / Better quality light/ security
13	Way of cooking: Firewood.. / LPG… / Kerosene…
14	Average spending on cooking (on top of support from NGOs): Tk./month
15	Intention to join communal cooking? If cheaper than current cost / If cost is same as now
16	Intention to spend on electric cooking?
17	Any other information related to energy access: …..
18	Any other information or comment …..

Appendix II

Semi-structured questionnaire for the stakeholders to understand the current trend of electrification for camp operation and electrification of refugee households.

Name of the aid agency: ……..	
1.	What are the priority areas of electrification by your organisation related to refugee settlements? ☐Camp operation, ☐education, ☐health, ☐water, ☐sanitation, ☐security, ☐anything else

2.	Does your organisation see access to electricity for the refugee families as a primary objective? ☐Yes ☐No
3.	Why diesel generators are deployed to deal with refugee camp setups? ☐No other options available, ☐Low CAPEX, ☐reliability, ☐easy to source
4.	Does your organisation use/provide diesel generator (and fund the operation) for refugee support activities? ☐Yes ☐No
5.	Do you keep records of fuel uses for diesel generators? If yes how? ☐Yes ☐No I ……
6.	How diesel fuel is stored on site and transported (distribution) to different locations? ☐Storage: … ☐Transportation: …
7.	Is there any wastage, loss and theft cases related to diesel fuel for generators? ☐Yes ☐No
8.	If answer is Yes (to the above question), what is the extent of it and how do you control it?
9.	Does your organisation feel the importance of renewable (mainly PV) technology based electricity form the sustainability view points? ☐Yes ☐No (Please explain if answer is No).
10.	If answer is Yes (to the above question), what are the main challenges in deploying renewable based electricity generating systems in the context of your organisation's policy? ☐High CAPEX ☐local supply chain ☐Long term funding issue ☐Other (please specify)
11.	Is there any challenges from the government or local communities in building renewable based electricity generating infrastructures? ☐Yes ☐No
12.	If answer is Yes (to the above question), name the most common challenges.
13.	What is needed to prioritise renewable based electricity supply over the uses of diesel generators?

Appendix III

Questionnaire for the assessment of electrical load requirement and the cost of electricity at the Imvepi trading centre, Uganda

Shop Sl. No.	**Shop type: …….**			
1.	What electrical appliances are used and when?			
	Name of appliance	Power rating (W)	Hours they running (hrs, AM/PM)	Type, AC or DC
	1.			
	2.			
	3.			
2.	How much do you pay? (*estimate cost per kWh*)			
3	Is the electricity supply reliable?			
4.	If answer is No to the above question, indicate why? ☐Many outages ☐Voltage issue ☐Limited hours of supply			
5.	Do you use a Solar Home System besides power supply from the diesel generator?			

Appendix IV

Questionnaire for the assessment of electrical load requirements by the proposed offices in Bidi-bidi base camp, Uganda

Name of the organisation: ……	
1	How many rooms in the office (proposed)?
2	Number of employees?
3	How many shifts you operate a day? ☐1, ☐2, ☐3
4	How many light bulbs in each room (approx. number)?
5	How many cooling fans in each room?
6.	How many computers all together in the office?
7.	Number of fridge/freezer?
8.	Number of printer scanner?
9.	Any water pump? (if Yes, how many)
10.	Any flat iron? (if accommodation attached)

11.	Any communication device?
12.	Back up storage capacity of communication device (if any)?

Appendix V

Questionnaire for the assessment of diesel generator based electrification of refugee camps.

Generator Size:	
A	**Fixed capital cost**
1.	Generator (delivered to site)
2.	Fuel storage tank (proportionate cost)
3.	Tank related installations (proportionate cost)
4.	DG housing/ power plant room
5.	Miscellaneous
B	**Operational cost per month**
1.	Operator wages
2.	Indirect staff cost (if any)
C	**Fuel consumption and cost per month**
1.	Fuel cost (per litre)
2.	Total fuel consumption (l)
D	**Maintenance cost (each service)**
1.	When generator services take place (how many times a year or at what hours of operation)
2.	Cost of oil filter replacement
3.	Cost of lubricant change
4.	Change of seals and other small parts (i.e., air filter)
5.	Cost of service contract
E	**Cost of fuel loss/ unaccountable uses per month**
1.	Set cost of fuel loss or unaccounted usages (%)
F	*Any other information?*