

# **E-cooking Feasibility Study**

(1<sup>st</sup> Draft: Please Don't Cite)

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## **Executive Summary**

### **Introduction and Background**

This report analyzes the feasibility of introducing solar-powered electric cooking (e-cooking) solutions in Rohingya refugee camps and host communities in Cox's Bazar, Bangladesh. These communities face significant challenges related to cooking fuel, including deforestation, health issues from indoor air pollution, and financial burdens associated with subsidized Liquefied Petroleum Gas (LPG). The study aims to identify viable alternatives to LPG that are both environmentally sustainable and economically feasible, with a focus on e-cooking systems using solar energy. The main research questions addressed include barriers to diversifying cooking fuel options, feasibility of adopting solar-based modern cooking solutions, and strategies for enhancing fuel use concerns and community resilience without compromising the environment.

### **Methodology**

The study employs a mixed-methods approach, including baseline surveys, field-based demonstrations, and economic and financial analyses. Baseline surveys were conducted in refugee camps and host communities to understand current cooking practices, dietary habits, fuel consumption patterns, and socioeconomic characteristics. Field experiments involved installing solar panels and e-cooking appliances in selected households to observe user behavior and collect feedback. The economic analysis assesses the costs and benefits of different solar e-cooking packages, considering factors like carbon credits and LPG savings.

### **Key Findings**

#### ***1. Current Cooking Fuel Usage:***

- Refugee Communities: Primarily rely on subsidized LPG, but face shortages. These households supplement LPG with firewood.
- Host Communities: Use a mix of cooking fuels, including firewood, LPG, and electricity. Firewood remains a dominant fuel source.

#### ***2. Socioeconomic and Demographic Factors:***

- Refugee households generally have lower incomes, lower educational attainment, and limited access to electricity compared to host communities.
- Refugee households tend to have a higher percentage of young children and fewer earning members than host households.

### ***3. E-Cooking Adoption Potential:***

- A high percentage of refugee households (82.8%) expressed willingness to switch to e-cooking, driven by anticipated time savings, reduced fuel costs, and health benefits.
- Among host communities, interest in switching to e-cooking is also high (63.3%), but concerns about product costs and unreliable electricity remain barriers.

### ***4. Solar E-Cooking System Performance:***

- Installed solar systems generated more electricity than was consumed, indicating potential for system optimization.
- E-cooking appliances, particularly rice cookers and infrared cookers, were well-received, with high user satisfaction.

### ***5. Economic Feasibility:***

- Two solar e-cooking packages were evaluated: one with battery storage and one without.
- The package without battery storage (Package 2) demonstrated better financial viability, with a positive net present value (NPV) and a shorter payback period.
- Carbon credit revenues significantly improve the economic viability of solar e-cooking.
- Sensitivity analysis reveals that the carbon market price and the adoption rate are key factors influencing the economic outcomes.

## **Detailed Findings:**

### ***1. Socioeconomic Context***

The study highlights disparities between refugee and host communities. Refugee households have lower incomes, less education, and rely more on humanitarian assistance.

### ***2. Cooking Practices and Energy Consumption***

Refugee Households: Cooking is typically completed by 5:30 PM, aligning well with peak solar radiation, but households frequently run out of subsidized LPG. Firewood serves as an alternative.

Host Communities: Cooking is more evenly distributed, with significant activity after peak solar hours, necessitating battery storage or alternative energy sources.

### ***3. E-Cooking Adoption***

Refugees: Display a strong willingness to adopt e-cooking.

Hosts: adoption hampered by price, unreliable electricity, and cultural preferences

### ***4. Solar Potential and System Sizing***

Solar generation potential exceeds current demand. System adjustments could offer more efficient resource use.

### ***5. Financial analysis***

The analysis shows that Package 2 (without battery storage) is more viable, has positive net present value, shorter payback. Carbon credits enhance viability.

## **Recommendations**

- Further research needed on Package 2 to gain a deeper understanding of its implications,
- Implement systems design with a focus on the refugee community, to alter cooking behaviors to minimize the use of LPG,

## **Conclusion**

This study demonstrates the potential for solar e-cooking to address the challenges of cooking fuel in Rohingya refugee and host communities. By carefully considering the specific needs and circumstances of each community and addressing the economic and technical barriers to adoption, solar e-cooking can contribute to improved health, environmental sustainability, and community resilience in Cox's Bazar, Bangladesh. This can create a model for other refugee situations.



## **1.0 Introduction**

Since 2018, over 200,000 refugee households are receiving fully subsidized liquefied petroleum gas (LPG) as cooking fuel to reduce deforestation and improve social cohesion with host communities in Cox's Bazar, Bangladesh. In a study carried out in 2019 by the International Union for Conservation of Nature (IUCN), it was found that LPG rollout contributed to a decline of 80% in forest reliance by households among the refugees (IUCN, 2019). By the year 2020, LPG distribution had expanded to include all households living in the camp settlements. During the initial phase, local host communities also received a complimentary LPG stove along with six months of LPG support, to foster better relations between host and refugee communities within camp areas. Additionally, increased LPG availability supported the development of a market for LPG in the surrounding areas, and many host community households started using LPG in place of traditional firewood, further reducing the pressure on forest resources.

Despite these positive impacts, rising price of LPG and cuts in available funds threatened the viability of maintaining a stable LPG supply which increased the likelihood of a return to environmentally unsustainable practices, including gathering firewood from forests. In view of these challenges, there is a need to find alternative, new, and clean cooking technologies that will reduce fund requirement for supplying LPG to refugee families and increase resilience of the host and refugee populations.

To address this issue, UNITAR in collaboration with IUCN, and Practical Action (PA) has conducted a study to explore the possibilities of introducing e-cooking system among the host and refugee communities smart subsidy designs, carbon financing, and modern cooking technologies. The intention of the study is to evaluate the possibility of providing clean and affordable cooking solutions using solar-powered electricity plus electric pressure cooker (EPCs), induction cooker, and infrared cooker. These solutions are evaluated using economic and financial feasibility analyses. In addition, for introducing them on a large scale within the host and refugee communities, the analysis also included analysis of supply chain, and analysis of user behavior. The main research questions are: (a) what are the barriers, costs and opportunities for diversification of cooking fuel options in the refugee camps and the surrounding host communities? (b) Is introducing solar based modern cooking solution at all feasible to adopt in refugee camps? (c) What can be done to enhance the concern for the fuel use and the community resilience without compromising the environment?

## **2.1 Baseline Data Collection and Sample Frame**

To understand the current cooking pattern and food intake behavior of the communities, a separate baseline survey was conducted in both host and refugee communities. The objective was to have a representative

sample so that the pattern of cooking, food and also sources of energy for cooking in each community is quantified.

Since the experiment was to be conducted across eight locations, including four within refugee camps and four within host communities in Ukhiya and Teknaf upazila of Cox's Bazar district. Four refugee camps were selected for the baseline survey. The chosen refugee camps were Camp-1W, Camp-19, Camp-20 Extension, and Camp-21. Among these, Camp-1W and Camp-21 are managed by the United Nations High Commissioner for Refugees (UNHCR), while Camp-19 and Camp-20 Extension are under the administration of the International Organization for Migration (IOM). According to data from December 2024 provided by UNHCR, the total number of households in these four camps was 20,085. Specifically, Camp-1W had 8,364 households, Camp-19 had 5,488 households, Camp-20 Extension had 2,537 households, and Camp-21 had 3,696 households.

In the host community, four areas were selected from two upazilas of Cox's Bazar. This includes Raja Palong and Holodia Palong from Ukhiya, as well as Rajarkul and South Mithachhari from Ramu. According to the 2022 Population and Housing Census provided by Bangladesh Bureau of Statistics (BBS), Ukhiya upazila has an estimated 55,102 households while Ramu upazila has an estimated 68,486 households which sums up to 123,088 households in the two upazilas.

Before the e-cooking demonstration, a baseline survey was conducted in these communities to collect preliminary data on cooking practices, dietary habits, fuel consumption, and the socioeconomic and demographic characteristics of both the refugee and host populations. A systematic random sampling strategy was implemented for the surveys in both the refugee and host communities.

## 2.2 Determination of Sample Size

The sample size for both refugee and host community households was determined using the following standard statistical formula to ensure representativeness.

$$SS = \frac{p * (1 - p) * z^2}{e^2}$$

Here,

SS = Sample size

p= 0.5 (proportion of male-female ration within the HH)

z=1.96 (Sample variant considering 95% confidence level)

e= 5% (margin of error) [option 1] or 4% (margin error) [option 2]

Correction for Finite Population

$$New\ SS = \frac{SS}{1 + \frac{SS - 1}{Household\ Size}}$$

For refugee households, a 5% margin of error and a 95% confidence level were applied, resulting in a required sample size of 384 households. However, to improve accuracy, this number was planned to increase to 400 households. In addition, the baseline survey at refugee camps included 25 households (*five extra sample were selected to avoid potential non-absentee during demonstration survey*) pre-selected for e-cooking demonstration survey.

For the host community participants, 4% margin of error with 95% confidence requires 600 participants for greater accuracy and precision. Additionally, the baseline survey at the host community included 20 participants selected for the e-cooking demonstration survey.

Due to the relatively higher similarity in households between Ukhiya and Ramu, increasing estimates beyond these sample sizes will not yield significantly different insights regarding the variations in cooking habits and appliance usage. Practical Action conducted the baseline survey for the host communities and IUCN conducted the survey for the refugee camps. IUCN and PA each conducted separate market surveys in different marketplaces of Ukhiya and Ramu to assess the current demand and supply of e-cooking appliances, as well as the prevailing prices of various traditional cooking fuels and e-cooking appliances.

## 2.2 The Sample

The sample distribution of baseline survey conducted by IUCN in camps and PA in Ukhiya and Ramu in 2024 are presented in Table 1. At the baseline, IUCN conducted survey of 425 individuals in the four camps and the highest was in the Camp 19 (25.4%) followed by Camp 21 (25.2%). Camp 1W and Camp 20 Extension contributed equally 24.7%.

**Table 1: Sample Size by Communities**

| Refugee Camp | Sample     | Percent      | Host Community           | Sample     | Percent      |
|--------------|------------|--------------|--------------------------|------------|--------------|
| Camp_21      | 107        | 25.2         | Raja Palong (Ukhiya)     | 152        | 24.5         |
| Camp_1W      | 105        | 24.7         | Holodia Palong (Ukhiya)  | 166        | 26.7         |
| Camp_19      | 108        | 25.4         | Rajarkul (Ramu)          | 156        | 25.1         |
| Camp_20Ext   | 105        | 24.7         | South Mithachhari (Ramu) | 147        | 23.7         |
| <b>Total</b> | <b>425</b> | <b>100.0</b> | <b>Total</b>             | <b>621</b> | <b>100.0</b> |

Source: IUCN and Practical Action Baseline Survey, 2024

In the host community, PA collected responses from 621 individuals in four locations. Holodia Palong (Ukhiya) had the highest proportion (26.7%), followed by Rajarkul (Ramu) (25.1%) and Raja Palong (Ukhiya) (24.5%). South Mithachhari (Ramu) had the lowest proportion (23.7%).

### **3.0 The Experiment**

To analyze the behavior of users both within the host communities and the refugee households, a field-based demonstration was designed with strategies to install solar panels on the rooftop of a household and observe their usage behavior of e-cooking facilities in their daily life. The e-cooking experiments within refugee and host community households evaluated adoption of these appliances for cooking meals within the household. Since installation of the complete e-cooking solution is costly, so the experiment was design with 5 households at a time in each community and it was repeated 4 times in different camps – to avoid spill-over changes. A baseline survey for three days was conducted on the households at the beginning of the experiment and it was followed by a weeklong monitoring of their behavior in cooking – an endline survey.

Alongside the economic and technical analysis of alternative cooking fuels, this research aims to look into the broader political and economic environment that influences the transition to clean cooking in and around refugee camps. The findings are expected to provide actionable information to government ministries, donors, and humanitarian agencies, hence enabling evidence-based decision-making on sustainable cooking interventions in the future.

#### **3.1 Sample Selection for the Experiment and Equipment Distribution**

A total of 40 households were chosen for the experimental survey, comprising 20 from the refugee community and 20 from the host community, with 10 households participating at a time. Each round of the experiment included 5 households from each community, and this process was repeated four times. Furthermore, the study team collected feedback on the performance, affordability, and sociocultural acceptance of the e-cooking technologies through community consultations.

Each of these households received e-cooking technology, which included a uniform set of equipment and appliances: a 3KW solar panel, a hybrid inverter, a battery box, a digital energy meter for measuring electricity consumption, a 6L electric pressure cooker, an infrared cooker, an induction cooker, and two cooking utensils for their use. The experiment lasted for 10 days in each location.

##### **Installation and Training (Day 1-2)**

Installation and training were the first phase of the demonstration process, conducted over a period of two days. Field teams installed the solar-powered energy system and appliances in each household, with correct installation and functionality verified. Households received hands-on training in the use, maintenance, and safety of the cooking appliances distributed. Live demonstrations of basic cooking techniques, with emphasis on energy efficiency, temperature control, and best practices in cooking, were used to conduct

training sessions. Participants were encouraged to practice under the observation of trainers, with on-the-spot troubleshooting to address technical or usability problems.

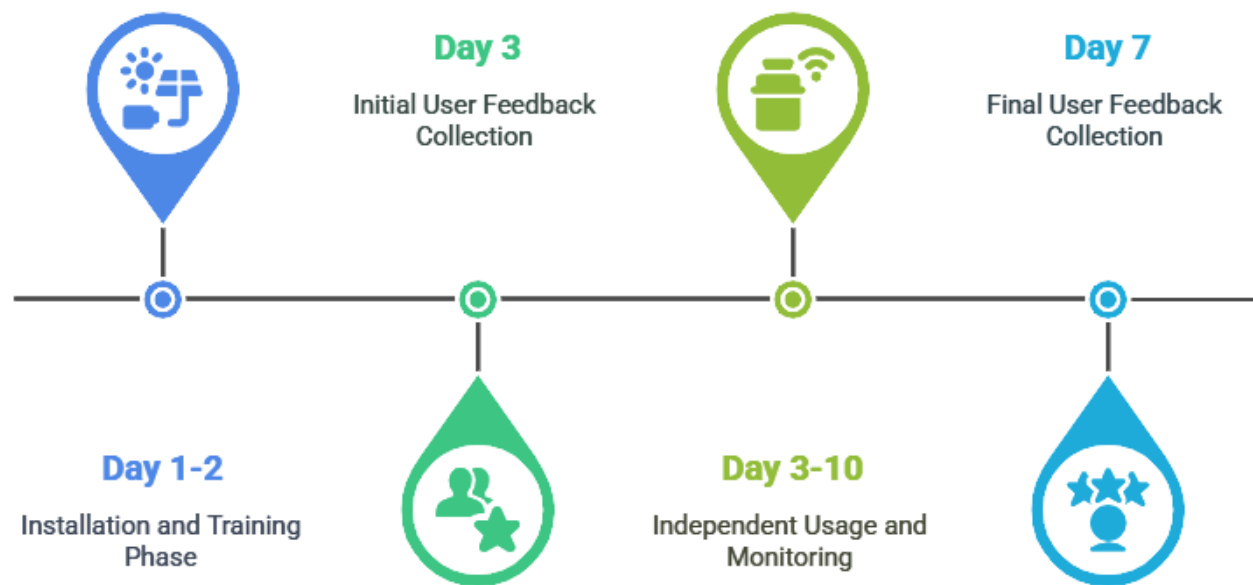
### **Independent Usage and Monitoring (Day 3-10)**

Following the training, the households operated the appliances independently for seven days. Both cooking habit and energy consumption were monitored using electronic energy meters, and field teams made regular household visits to oversee actual use practices, offer further support, and verify proper function. A daily use diary was kept by the household members, in which the frequency of the meal, the meal type cooked, and whether they faced a problem was recorded. Field teams reviewed the diaries during household visits, cross-referencing observed behavior and user-reported experience.

### **3.2 User Feedback Collection**

User feedback was collected at two points at the stage of independent use. On day 3, the initial feedback regarding the use of the e-cooking appliance was gathered. There, households provided initial impressions of the cooking appliance. Also, ease of use, handling, and technical problems were captured by the appliances. Primary comparison of the conventional cooking habits and power supplies was provided by the participants. On data gathering day 7, the last set of the feedback was gathered by the households that provided general experience and adoptability of the e-cooking (Figure 1). Changes in cooking habits, meal preparation time, and energy efficiency were evaluated. In addition, participants expressed their willingness to continue using electric cooking and identified potential barriers to long-term adoption.

**Figure 1: Summary of Demonstration Survey Approach at HH Level**



**Source: Author's Development**

### 3.3 Data Collection Methods

The study employed a mixed-methods approach to ensure comprehensive data collection. Quantitative data was gathered from digital energy meter readings to measure actual power consumption, along with structured post-demonstration surveys assessing user satisfaction and behavioral shifts. Qualitative data was collected through focus group discussions (FGDs) and demonstration campaign at the community level to capture social and economic factors influencing the acceptance of e-cooking. Comparative assessments between refugee and host community households highlighted variations in adaptation rates, cultural influences, and economic feasibility.

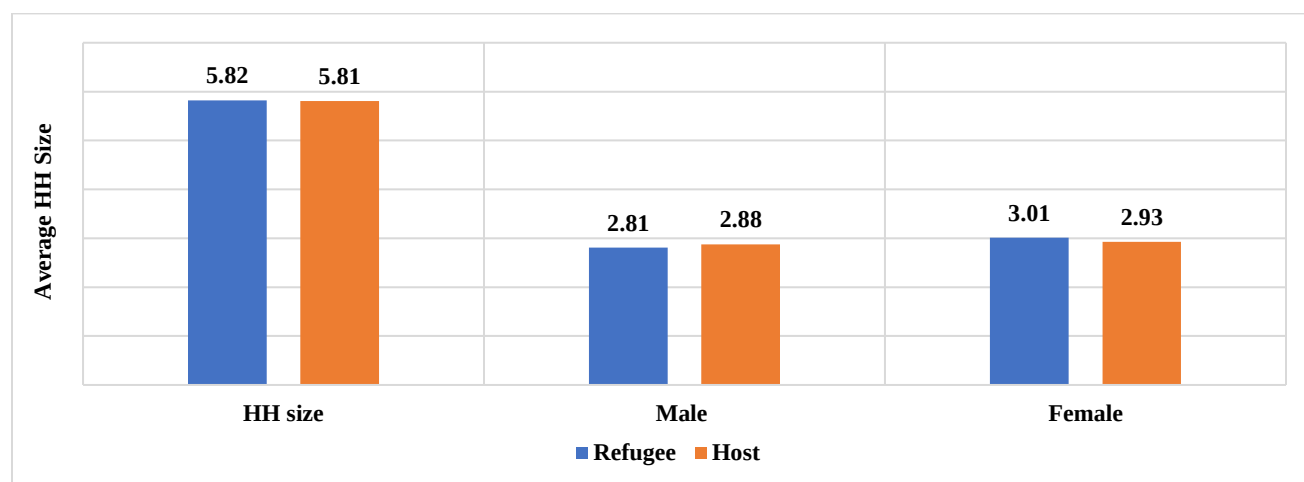
## 4.0 Socioeconomic and Demographic Characteristics from Baseline Survey

The following section presents a number of socioeconomic and demographic characteristic of both refugee and host community households.

### 4.1 Household Size

The Figure 2 illustrates the average household size by gender of the hosts and the refugees. Refugee household size is 5.82 while that of the hosts is 5.81; almost identical in nature. Refugee households, in addition to the above, also contain fewer average male members of the household (2.81 compared to hosts at 2.88), while the average of the females is slightly more in the case of the refugees (3.01 compared to hosts at 2.93).

**Figure 2: Household Size by Gender and by Communities**



Source: IUCN and Practical Action Baseline Survey, 2024

According to Table 2 refugee households have a higher percentage of young children and students but fewer earning members (75%) compared to host households (96%). With no surprise, the average number of earning members is also lower in refugee households (0.81) than in host households (1.36).

**Table 2: Other HH Demographic Composition by Communities**

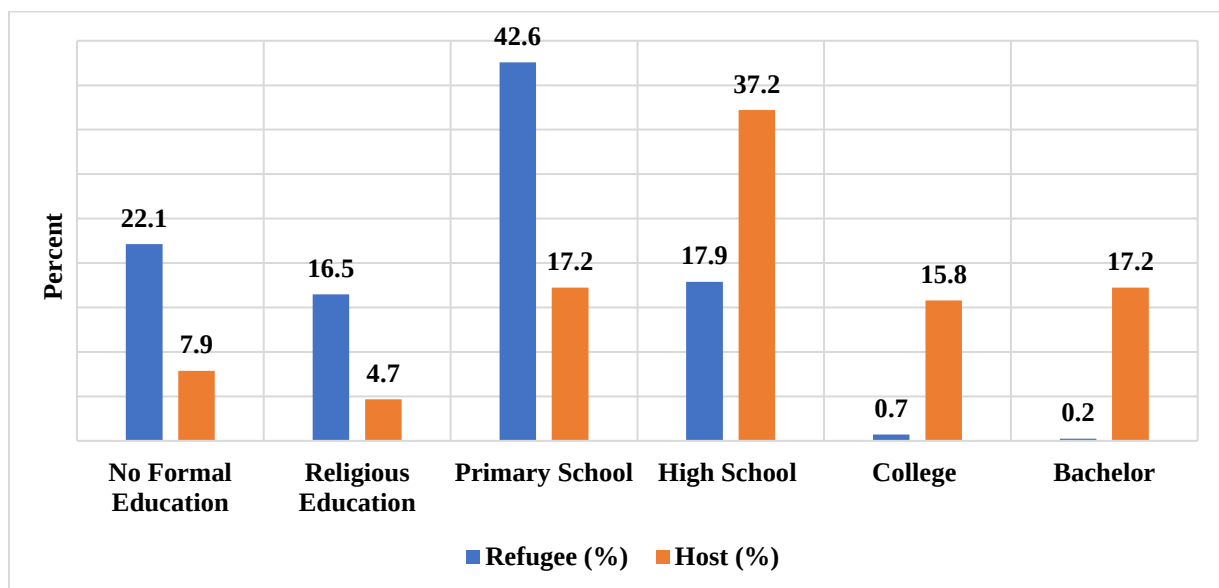
| Other HH Composition       | Refugee  |          |                        | Host     |          |                        |
|----------------------------|----------|----------|------------------------|----------|----------|------------------------|
|                            | # of HHs | % of HHs | Average Size (overall) | # of HHs | % of HHs | Average Size (overall) |
| Children (below 10 years)  | 331      | 78%      | 1.78                   | 422      | 68%      | 1.12                   |
| Children (below 5 years)   | 274      | 64%      | 0.99                   | 269      | 43%      | 0.58                   |
| HH member (above 60 years) | 84       | 20%      | 0.23                   | 215      | 35%      | 0.38                   |
| Student                    | 327      | 77%      | 1.80                   | 484      | 78%      | 1.67                   |
| Earning Member             | 320      | 75%      | 0.81                   | 597      | 96%      | 1.36                   |

Source: IUCN and Practical Action Baseline Survey, 2024

## 4.2 Highest Educational Attainment at HH

A comparison of highest educational attainment between refugee and host communities is presented in Figure 3. A significantly higher percentage of refugees (22.1%) have no formal education compared to hosts (7.9%). More refugees (16.5%) received religious education than hosts (4.7%). Most of the refugees (42.6%) possess primary school education, while fewer hosts (17.2%) fall in this category. In comparison, more hosts (37.2%) have high school compared to the refugees (17.9%). Additionally, while only 0.7% of the refugees have gone to college, as many as 15.8% of the hosts have, while holders of a bachelor's degree are 0.2% of the refugees while the respective figure is 17.2% of the hosts. This indicates a significant educational gap, with refugees having lower access to formal and higher education.

**Figure 3: Highest Educational Attainment by Communities**



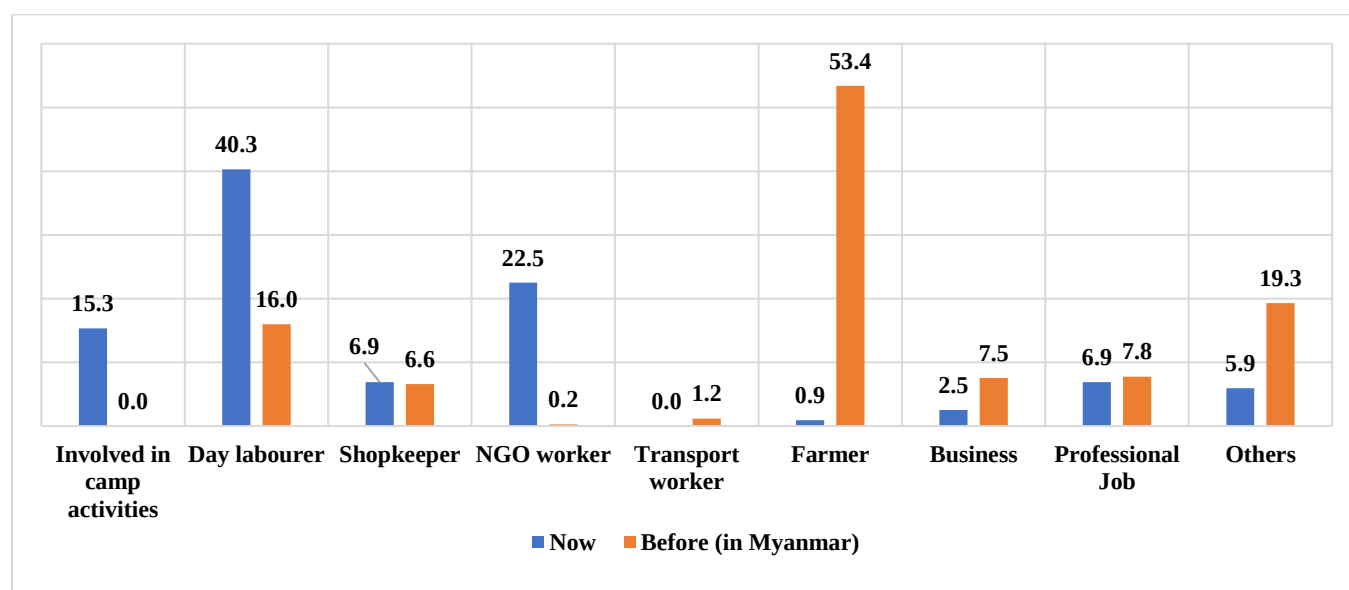
Source: IUCN and Practical Action Baseline Survey, 2024

## 4.3 Occupational Profile of HH Members

The Figure 4 provides a comparison of occupations of refugee household members before migration (in Myanmar) and their current employment status. Before migration, the majority (53.4%) were farmers, but now only 0.9% are involved in some form of farming after displacement. Nearly 15.3% of them are now involved in camp activities while additional 22.5% are working for NGOs operating within camps. There has been a significant rise in day laborers, increasing from 16.0% to 40.3%.



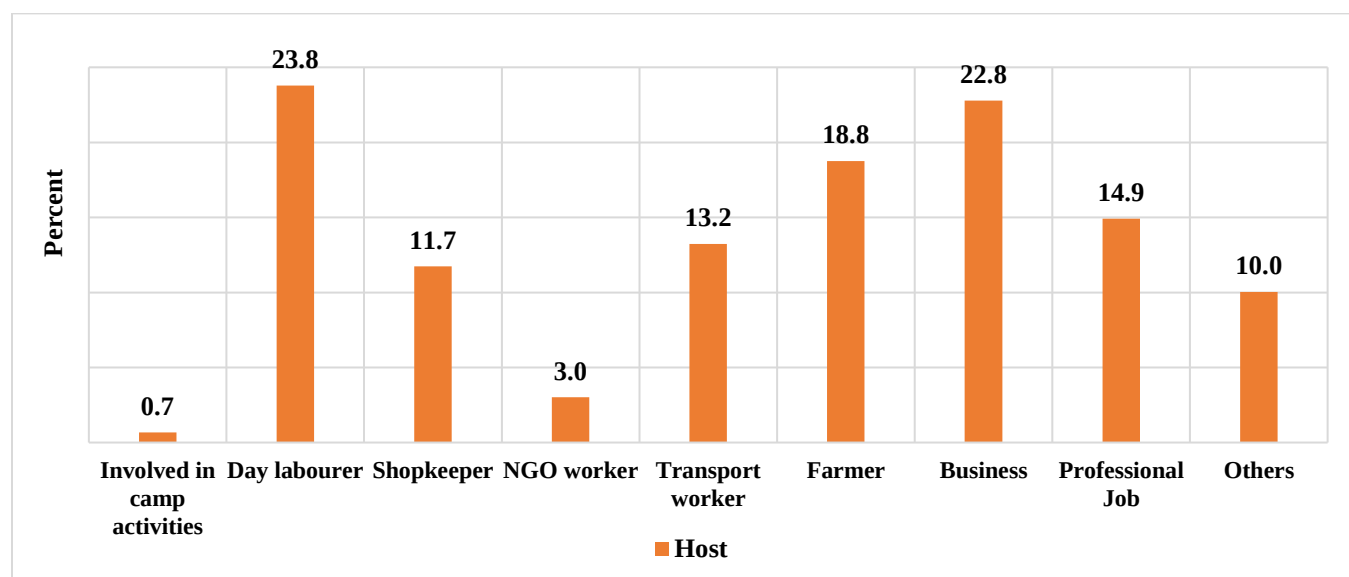
**Figure 4: Current Vs Pre-migration Occupation of Refugee Households (% of People)**



Source: IUCN and Practical Action Baseline Survey, 2024

On the other hand, among the host community households, a large portion of members works as day laborers (23.8%), farmers (18.8%), and in business (22.8%). Besides, 13.2% employed in transport sector while 11.7% in shopkeeping. Also, 14.9% are involved in professional jobs while 3.0% work in NGOs. A small percentage host community member is involved in camp activities (0.7%) too (Figure 5).

**Figure 5: Occupation of Host Community (% of people earning)**

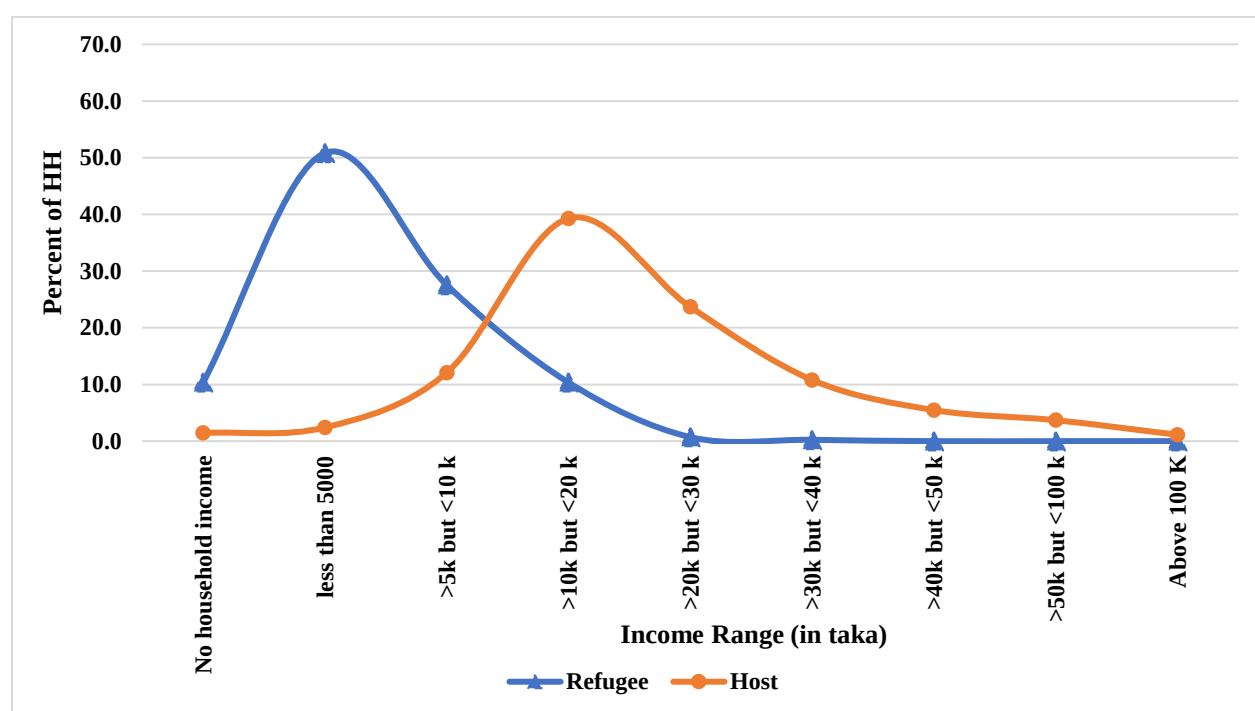


Source: IUCN and Practical Action Baseline Survey, 2024

#### 4.4 Household Income

With less opportunities to work outside the camps, it is no of a surprise that refugees have significantly lower household incomes compared to the host community. A large portion of refugees households (50.8%) earn less than BDT. 5000, with 10.4% HHs having no income at all (Figure 6). Only 27.5% HHs earn between BDT 5,000 and 10,000, while a small percentage (10.4%) earn between 10,000 and 20,000. In contrast, the host community has a higher income distribution, with 39.3% HHs earning between 10,000 and 20,000 while 23.7% HHs earning between 20,000 and 30,000. There are 10.8% HHs who reported earning between 30,000 and 40,000.

**Figure 6: HH Monthly Income Range (in BDT) by Communities**



Source: IUCN and Practical Action Baseline Survey, 2024

## 4.5 Household Expenditure

The Table 3 shows that refugees have an average monthly household expenditure of 8,596 taka, with 71.7% of this amount spent on food. In comparison, the host community has a higher average monthly household expenditure of 19,180 taka, with 59.2% allocated to food.

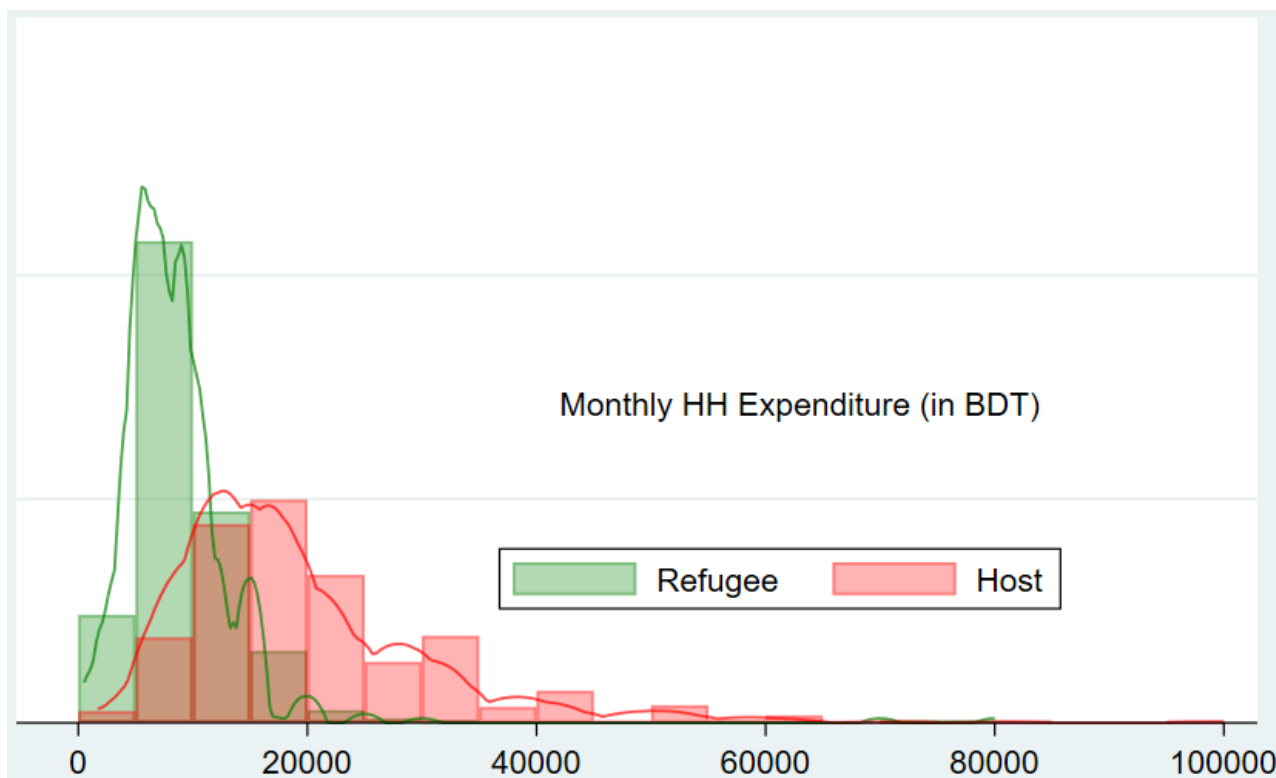
**Table 3: Average Monthly HH Expenditure (in taka) and Food expenditure (%)**

| Community | Number of HH | Average Monthly HH Expense<br>(in taka) | % of Food Expenditure |
|-----------|--------------|-----------------------------------------|-----------------------|
| Refugee   | 424          | 8,596                                   | 71.7                  |
| Host      | 618          | 19,180                                  | 59.2                  |

Source: IUCN and Practical Action Baseline Survey, 2024

Additionally, the distribution of monthly household expenditures in host communities is wider (Figure 7), which is expected since refugee households receive basic food rations, while host communities have greater access to market activities and income opportunities.

**Figure 7: Distribution of Monthly HH Expenditure by Communities**



Source: IUCN and Practical Action Baseline Survey, 2024

## 4.6 Household Asset Portfolio

According to Table 4 refugees have higher solar system usages (60.2%), indicating a greater readiness to adopt solar-based solutions, but own fewer assets overall, with limited livestock (28.9%), poultry (26.8%), and no access to motorized vehicles, computers, or refrigerators. Host communities, on the other hand, have more livestock (72.1%), poultry (65.5%), and cattle (65.5%), along with extensive land ownership (97.26%), and assets like cell phones (98.2%), fans (92.4%), and refrigerators (48.3%).

**Table 4: HH Asset Ownership by Communities**

| Assets                        | Refugee (% of HHs) | Host (% of HHs) |
|-------------------------------|--------------------|-----------------|
| <b>Agricultural Equipment</b> | 17.2               | 32.1            |
| <b>Fishing Equipment</b>      | 1.9                | 6.3             |
| <b>Livestock</b>              | 28.9               | 72.1            |
| <i>Poultry</i>                | 26.8               | 65.5            |
| <i>Cattle</i>                 | 1.2                | 65.5            |
| <i>Others</i>                 | 0.9                | 9.5             |
| <b>Solar System</b>           | 60.2               | 3.4             |
| <b>Cell phone</b>             | 84.7               | 98.2            |
| <b>Computer</b>               | 0.0                | 4.0             |
| <b>Cookers</b>                | 38.1               | 42.5            |
| <b>Fan</b>                    | 25.2               | 92.4            |
| <b>Refrigerators</b>          | 0.0                | 48.3            |
| <b>Sewing Machines</b>        | 3.1                | 10.3            |
| <b>Television</b>             | 0.0                | 13.5            |
| <b>Non-motorized vehicle</b>  | 1.6                | 4.2             |
| <b>Motorized vehicle</b>      | 0.0                | 16.6            |
| <b>Ownership Land</b>         | -                  | 97.26           |

Source: IUCN and Practical Action Baseline Survey, 2024

About 88.9% host community households have their own dwellings for living with an average size of 35.6 decimal area. Besides, 13.9% households have ownership of agricultural land, with an average size of 141.4 decimals (Table 5).

**Table 5: Land holding by Host Communities**

| Ownership of Land   | Number of HHs | % of HHs | Average size of land (in decimal) |
|---------------------|---------------|----------|-----------------------------------|
| <b>Dwellings</b>    | 552           | 88.89    | 35.6                              |
| <b>Agricultural</b> | 86            | 13.85    | 141.4                             |
| <b>Others</b>       | 45            | 7.25     | 22.1                              |

Source: IUCN and Practical Action Baseline Survey, 2024

## 5.0 Housing and Kitchen Structure and HH's Access to Electricity

This section presents information related housing and kitchen structure as well as provide facts on the HH's access to electricity.

### 5.1 Housing Structure

Refugee households have predominantly temporary house materials, with 99.5% of the walls constituting bamboo and polythene and the same materials being used for roofing by all the households. The structures are, however, more varied among host community households, with 45.6% of the walls being made of brick, 18.5% made of mud/clay, and 16.4% made of tin. Besides, 82.1% of host households use tin, and 12.7% use brick or cement to build the roof. In addition, a larger percentage of refugee households (94.8%) have cement floors compared to 55.9% in the host community (Table 6).

As regards sanitation structure, 91.8% of refugee households use pacca/kacha latrines, while host households have a more mixed setup, with 61.5% using pacca/kacha latrines, 32.4% using sanitary latrines, and 6.1% using other types. The structure of the dwelling is crucial because solar system installations require stable roofing and proper flooring to support the system and ensure its proper function.

**Table 6: Housing Structure by Communities**

| Housing Structure                   | Refugee (% of HHs) | Host (% of HHs) |
|-------------------------------------|--------------------|-----------------|
| <b>Dwelling Wall</b>                |                    |                 |
| <i>Brick</i>                        | 0.0                | 45.6            |
| <i>Tin</i>                          | 0.2                | 16.4            |
| <i>Mud/Clay</i>                     | 0.0                | 18.5            |
| <i>Brick + Bamboo</i>               | 0.2                | 5.5             |
| <i>Bamboo + Polythene</i>           | 99.5               | 13.5            |
| <i>Others</i>                       | 0.0                | 0.5             |
| <b>Roof</b>                         |                    |                 |
| <i>Bamboo + Polythene</i>           | 100.0              | 4.7             |
| <i>Tin</i>                          | 0.0                | 82.1            |
| <i>Brick/Cement</i>                 | 0.0                | 12.7            |
| <b>Floor</b>                        |                    |                 |
| <i>Cemented</i>                     | 94.8               | 55.9            |
| <b>Toilet Facility</b>              |                    |                 |
| <i>Pacca/Kacha latrine</i>          | 8.2                | 61.5            |
| <i>Pacca/Kacha latrine Sanitary</i> | 91.8               | 32.4            |
| <i>Others</i>                       | 0.0                | 6.1             |

Source: IUCN and Practical Action Baseline Survey, 2024

### 5.2 Kitchen-related Information

The differences in kitchen setups between refugee and host communities are highlighted in Table 7. Refugee households are less likely to have a separate kitchen (29.7% vs. 54.3%) or a separate door for their kitchen

(42.1% vs. 71.0%). Refugee households have a slightly improved system of ventilation, and 64.7% of the households have a separate window compared to the host households at 59.3%. Host households use more firewood, and of those households that do, they store 70.4% and 60.1% in piles of firewood. On the other hand, the households in the refugee population only store 39.8% of the firewood, and 43.8% in piles of firewood. These differences in settings of kitchen and firewood usage are critical from the perspective higher indoor air pollution during cooking.

**Table 7: Kitchen-related information by Communities**

| Kitchen-related Info       | Refugee (% of HHs) | Host (% of HHs) |
|----------------------------|--------------------|-----------------|
| Separate Kitchen           | 29.7               | 54.3            |
| Separate door in Kitchen   | 42.1               | 71.0            |
| Separate window in Kitchen | 64.7               | 59.3            |
| Observed Firewood Stack    | 39.8               | 70.4            |
| Observed Firewood          | 43.8               | 60.1            |

Source: IUCN and Practical Action Baseline Survey, 2024

### 5.3 Cooking Stoves in Use

The difference in cooking stove use between refugee and host communities is shown in Table 8. Most of the refugee households use LPG single-burner stoves (97.2%), while the hosts mainly use fixed mud stoves (79.7%). More transportable mud stoves and three-brick chulas are used by the refugees (24.2% and 16.2%, respectively), while the hosts use a mere 12.6% and 1.6%, respectively. Host households use LPG two-burner stoves (39.0%) and other items (14.8%) more, both of which the refugees use hardly at all. These differences perhaps underscore the different resources and cooking habits between the two groups

**Table 8: Usage of Cooking Stoves by Communities**

| Cooking Stoves                   | Refugee  | Host     |
|----------------------------------|----------|----------|
| Average Number of Cooking Stoves | 1.6      | 1.7      |
|                                  | % of HHs | % of HHs |
| Three bricks Chula               | 16.2     | 1.6      |
| Mud stove (portable)             | 24.2     | 12.6     |
| Mud stove (fixed)                | 19.5     | 79.7     |
| Kerosene Stove                   | 0.0      | 0.2      |
| LPG 1 stoves                     | 97.2     | 16.1     |
| LPG 2 stoves                     | 1.2      | 39.0     |
| Other Cooking stoves/appliances  | 0.0      | 14.8     |

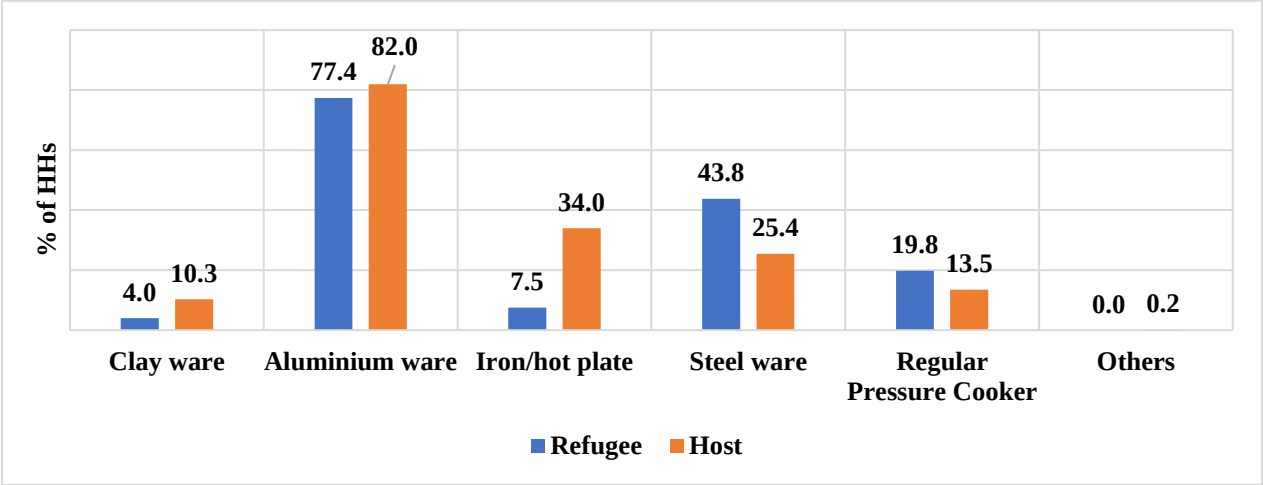
Source: IUCN and Practical Action Baseline Survey, 2024

### 5.4 Types of Utensils in Use

The use of utensils within the refugee and host households is presented in Figure 8. Aluminium ware is more prevalent in both groups (77.4% of the hosts, 82.0% of the refugees). Steel ware usage is more among the refugees (43.8%) than the hosts (25.4%). Iron/hot plates are being utilized by host families more (34.0%)

than the refugees (7.5%), and clay ware more by the hosts (10.3%). Pressure cookers are being utilized slightly more by the refugees (19.8%) than the hosts (13.5%); possibly because the households in the UNHCR managed settlements received the pressure cooker later for the purpose of saving LPG while cooking.

Figure 8: Usages of Utensils by Communities

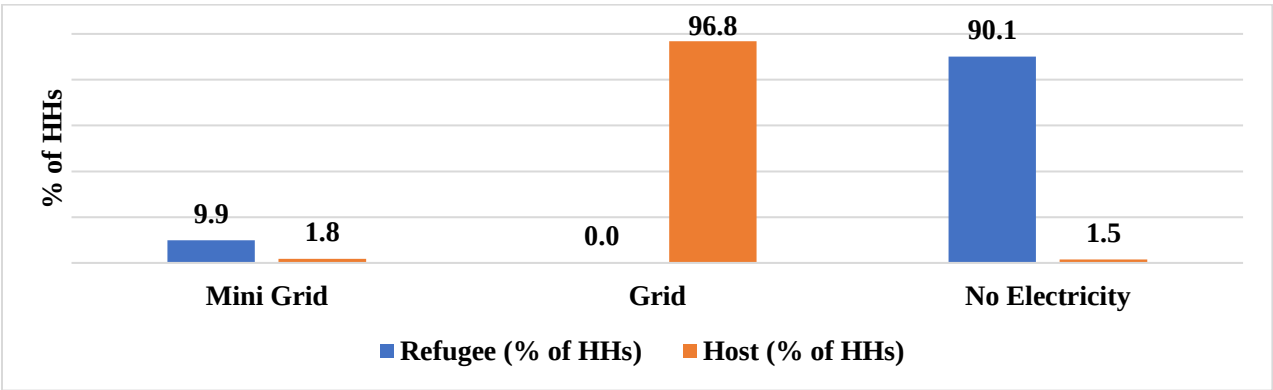


Source: IUCN and Practical Action Baseline Survey, 2024

5.5 Access to Electricity

The Figure 9 shows a clear difference in electricity access between refugee and host households. While 96.8% of host households have access to the national grid, none of the refugee households do (Figure 9). Refugees also rely more on mini-grids (9.9% as opposed to 1.8% for hosts), likely due to the limited infrastructure within the camps. In addition, 90.1% of refugee households do not have access to electricity at all, while just 1.5% of host households do not have access to electricity. Thus, limited access to electricity is the biggest challenge in refugee camps to deploy alternative solutions to cooking fuels to augment or replace the use of LPG.

Figure 9: Access to Electricity by Communities



## 5.6 Frequency of Load-shedding Faced by Host Community HHs

Most host families (96.3%) experience load shedding, with 47.3% experiencing power cuts more than three times a day and 38% three times a day (Table 9). Most affected times are evening (69% between 6:00–9:00 PM) and morning (45.3% between 6:00–9:00 AM), which coincide with peak cooking times for breakfast and dinner. Power disruptions are worst during summer (93.3%) and less frequent during winter (5.7%) and autumn (4.9%).

**Table 9: Experience of Load Shedding at HHs by Communities**

| Experiencing LS at HHs                               | Host (% of HHs) |
|------------------------------------------------------|-----------------|
| <b>Load Shedding (LS)</b>                            | 96.3            |
| <b>Frequency of LS (within HHs with Electricity)</b> |                 |
| <i>Daily once</i>                                    | 1.3             |
| <i>Daily twice</i>                                   | 9.7             |
| <i>Daily Thrice</i>                                  | 38.0            |
| <i>Daily more than 3 times</i>                       | 47.3            |
| <i>Once in two days</i>                              | 0.2             |
| <i>Once in three days</i>                            | 0.2             |
| <i>Sometimes</i>                                     | 3.3             |
| <i>Rarely</i>                                        | 0.0             |
| <b>Timing of LS</b>                                  |                 |
| <i>06:00 - 08:59 am</i>                              | 45.3            |
| <i>09:00 - 11:59 am</i>                              | 17.1            |
| <i>12:00-2:59 pm</i>                                 | 22.7            |
| <i>03:00-05:59 pm</i>                                | 33.0            |
| <i>06:00 - 08:59 pm</i>                              | 69.0            |
| <i>09:00 - 11:59 pm</i>                              | 34.6            |
| <i>12:00 - 05:59 am</i>                              | 14.4            |
| <b>Seasonal variation in LS</b>                      |                 |
| <i>Winter</i>                                        | 5.7             |
| <i>Spring</i>                                        | 13.6            |
| <i>Summer</i>                                        | 93.3            |
| <i>Rainy Season</i>                                  | 27.4            |
| <i>Autumn</i>                                        | 4.9             |

Source: IUCN and Practical Action Baseline Survey, 2024

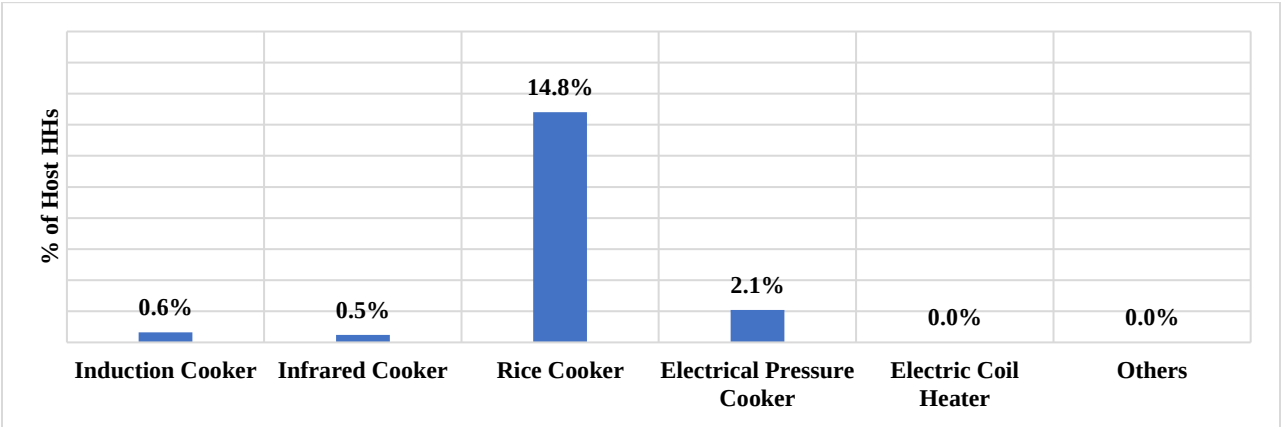
Such unstable power supply is a major setback to the promotion and use of e-cooking appliances. Since disruptions occur during peak times of meal preparation, the use of electric stoves becomes an issue, discouraging households from full adoption of e-cooking.



6.0 Use of E-cooking Appliances and Local Users Experiences

The survey found that e-cooking appliances were used only by the host community households because refugee camps lack electricity connection, and thus e-cooking adoption was unfeasible. Only 14.8% of the host community households have been using rice cooker now. Besides, 2.1% households have mentioned they are currently using an electric pressure cooker (Figure 10). In Ukhiya and Ramu, only slightly above 1% of the households have mentioned they are either using an induction or infrared cooker.

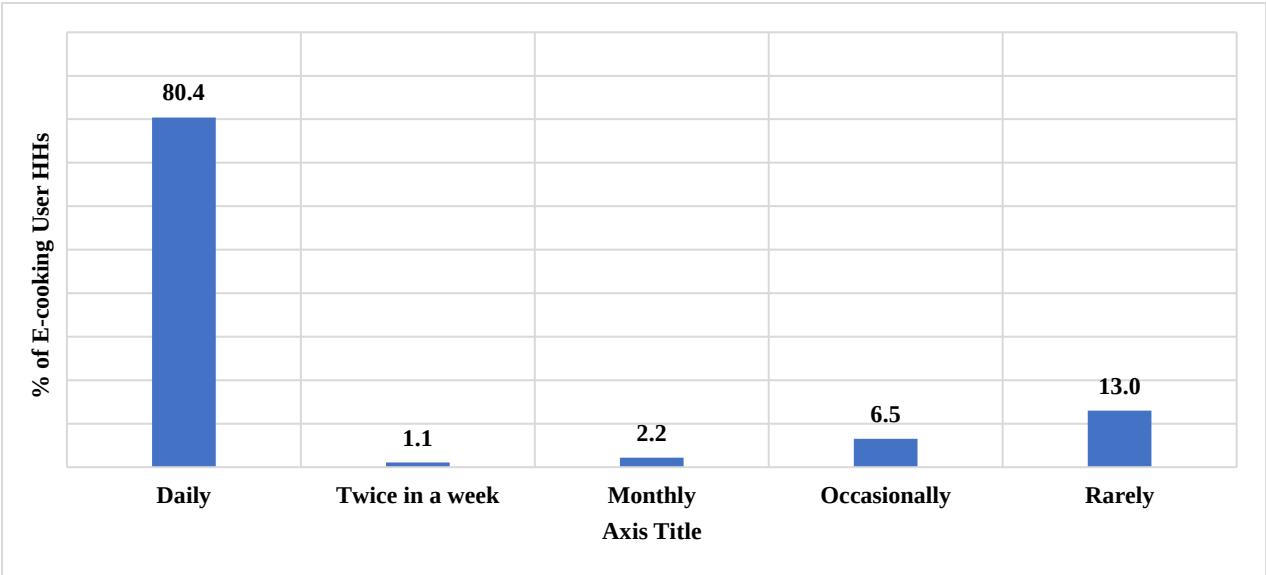
Figure 10: Usages of E-cooking appliances by Host Community HHs



Source: IUCN and Practical Action Baseline Survey, 2024

Despite only one-sixth of surveyed host households using e-cooking appliances, nearly 80% of them reported daily use (Figure 11). It means those who adopted e-cooking appliance for cooking, does use it regularly for cooking.

Figure 11: Frequency of Use of E-cooking Appliances by Host Community HHs



Source: IUCN and Practical Action Baseline Survey, 2024

Among the user of e-cooking at host communities 75% buy e-cooking appliances from local markets, while some get them from big cities (16.3%) or as gifts (9.8%). They mostly came to know about these appliances mostly from the internet (33.7%), TV ads (32.6%), neighbors (29.4%), and relatives (29.4%). Very few hear about them from billboards (1.1%) or immigrants (6.5%). In most homes, the household head (45%) or their partner (39%) decides to buy the appliance (Table 10).

**Table 10: E-cooking Appliance Purchase Related Statistics**

| <b>E-cooking Purchase among Users</b>          | <b>% of Using HHs</b> |
|------------------------------------------------|-----------------------|
| <b>Purchased from local market</b>             | 75.0                  |
| <b>Purchased from a big city</b>               | 16.3                  |
| <b>Received as a gift</b>                      | 9.8                   |
| <b>Came to know about e-cooking appliances</b> |                       |
| TV advertisement                               | 32.6                  |
| internet                                       | 33.7                  |
| Billboard                                      | 1.1                   |
| NGO campaign                                   | 0.0                   |
| From neighbors                                 | 29.4                  |
| From relatives                                 | 29.4                  |
| From an immigrant person                       | 6.5                   |
| Others                                         | 2.2                   |
| <b>Who decided to purchase</b>                 |                       |
| HHH                                            | 0.45                  |
| Partner of the HHH                             | 0.39                  |

Source: IUCN and Practical Action Baseline Survey, 2024

A 91.3% of households among the 92 host community households in our sample who are currently using e-cooking appliances; find it easy use. Additionally, 63% say that the appliances encourage even those who don't usually cook. About 44.6% have mentioned they would recommend others to use these electric appliances due to convenience of use. The majority (96.7%) believe that e-cooking saves electricity bills, but only 40.2% feel that the cost is worth paying. The main problem that users face is load-shedding (17.4%), while 5.4% mentioned about other issues (Table 11).

**Table 11: Users Experience of E-cooking Appliances from Host Community HHs**

| <b>Experience of E-cooking Appliances</b> | <b>% of E-cooking Users<br/>(n=92)</b> |
|-------------------------------------------|----------------------------------------|
| Easier to Use                             | 91.3%                                  |
| Encourage others to cook                  | 63.0%                                  |
| Will you recommend others                 | 44.6%                                  |
| Help to reduce electricity bill           | 96.7%                                  |
| Cost worth purchasing                     | 40.2%                                  |
| <b>Challenges for users</b>               |                                        |
| Load Shedding                             | 17.4%                                  |
| Others                                    | 5.4%                                   |

Source: IUCN and Practical Action Baseline Survey, 2024

## 7.0 Current Use of Cooking Fuel by Host and Refugee Households

This section provides insights into the cooking fuel currently used by the host and refugee households.

### 7.1 Current Use of Cooking Fuel by Host Communities

The following Table 12 highlights the cooking fuel preferences of host community households. It shows host households use a mix of multiple cooking fuels. There is still a strong reliance on firewood, used by 80% of households. The average household consumption of firewood among the users are 3.46 kg per day. In addition, LPG is also widely adopted; about 47.5% of host households now use it. The average household consumption of LPG is 0.385 kg per day among the users.

**Table 12: Current Fuel Use by Host Community HHs**

| Fuel type   | % of HHs | Consumption<br>(kg per day per hh) |
|-------------|----------|------------------------------------|
| LPG         | 47.5     | 0.385                              |
| Charcoal    | 7.9      | 0.435                              |
| Firewood    | 80.0     | 3.460                              |
| Electricity | 18.4     | -                                  |
| Others      | 0.5      | -                                  |

Source: IUCN and Practical Action Baseline Survey, 2024

Besides, charcoal is used by 7.9% of host households. Their per day use of charcoal as cooking fuel is 0.435 kg per day at the household level. In addition, 18.4% host community households use electricity as major fuel source for cooking.

Overall, the above statistics shows that host communities still significantly rely on firewood as their primary source of cooking fuel with a mix of LPG and other fuel types. In addition, nearly one-fifth of host community households have already adopted electricity-based cooking appliances which indicate a gradual shift toward alternative energy for cooking.

### 7.2 Current Usage of Cooking Fuel by Refugee HHs

According to the baseline survey, all refugee households receive an LPG support from the camp management and therefore, use it fully. However, Table 13 shows that apart from 3.5% of refugee households, the rest often ran out of LPG earlier than the schedule period. Of the refugee households sampled, a substantial portion, 49.2%, indicated that they ran out of LPG 12 times the previous year, considering an average household size of 6.25. This indicates that larger families, likely due to higher cooking demands prone to running out of LPG earlier than expected. On the other hand, respondents who reported running out of LPG once (1.4%) and twice (2.4%) before the scheduled time tended to have smaller

average household sizes, 4.50 and 4.75, respectively. This pattern suggests that the likelihood of LPG depletion increases with household size.

**Table 13: Number of times LPG finished earlier than the Stipulated Time in last 12 months**

| Frequency in last 12 months | % of Refugee HHs | HH Size (average) |
|-----------------------------|------------------|-------------------|
| Not at all                  | 3.5%             | 4.27              |
| Once                        | 1.4%             | 4.50              |
| Twice                       | 2.8%             | 4.75              |
| Thrice                      | 3.3%             | 5.57              |
| Four times                  | 5.0%             | 5.10              |
| Five times                  | 3.3%             | 4.50              |
| Six times                   | 4.7%             | 5.50              |
| Seven times                 | 3.8%             | 5.06              |
| Eight times                 | 6.1%             | 6.31              |
| Nine times                  | 2.6%             | 6.45              |
| Ten times                   | 10.2%            | 5.60              |
| Eleven times                | 4.0%             | 6.00              |
| In every month of the year  | 49.2%            | 6.25              |

Source: IUCN and Practical Action Baseline Survey, 2024

### 7.3 Use of Additional Cooking Fuels by Refugee HHs

The use of additional cooking fuels by refugee households are presented in Table 14. It shows what alternative fuels refugee households utilize when they deplete their supply of LPG for coping with the shortage. An overwhelming proportion of refugee households, amounting to 66.7%, remarked on their dependence on firewood usage when LPG is finished. Among these households, a majority of (53.4% of HHs) collect firewood from their neighborhood while 42.4% HHs buy it from the market. A smaller proportion, 9.9% of HHs, acquire firewood from the bushes and 33.4% of them collect from dismantled fences.

**Table 14: Alternative Sources of Fuel Use by Refugee Households**

| Fuel Source in Refugee Camps                | % of Refugee HHs |
|---------------------------------------------|------------------|
| LPG                                         | 98.9             |
| Bought LPG from local reseller              | 14.6             |
| Exchanged freely with relatives/friends     | 19.7             |
| Bought LPG from another family              | 5.8              |
| Others                                      | 6.2              |
| Used firewood                               | 66.7             |
| % of Firewood User HHs                      |                  |
| <i>Firewood Purchased</i>                   | 42.4             |
| <i>Firewood Collected from Neighborhood</i> | 53.4             |
| <i>Firewood collected from Forest</i>       | 9.9              |
| <i>Collected throw away fence</i>           | 33.4             |
| <i>Leaves/Twigs from neighborhood</i>       | 30.4             |
| <i>Others</i>                               | 4.5              |

|                                                   |     |
|---------------------------------------------------|-----|
| Firewood Use per day per refugee household in kg) | 2.1 |
|---------------------------------------------------|-----|

Source: IUCN and Practical Action Baseline Survey, 2024

On average, in addition to LPGs, refugee households in the camps use 2.1 kg of firewood per day. It reveals that there is still quite a heavy dependence on firewood as a primary cooking fuel during LPG shortages. Other sources, such as leaves and twigs from the neighborhood, contribute to 30.4% of firewood usage. However, when freely distributed LPG ran out of scheduled time, 14.6% refugee household purchase another cylinder of LPGs from local resellers while 19.7% exchanging with relatives or friends. Also, 5.8% refugee households buy LPG from another family once they finish their allocated amount earlier than schedule.

#### 7.4 Prevailing Problems Faced by Refugee HHs to Refill LPG

The following Table 15 highlights the challenges refugee households face when refilling their LPG cylinders. About 44.2% of refugee households have reported they do not face any problem during LPG refilling. However, the remaining 55.8% refugee households experience various challenges.

**Table 15: Problems faced during LPG Refilling by Refugee HHs**

| Problems faced during LPG Refilling             | % of Refugee HHs |
|-------------------------------------------------|------------------|
| None                                            | 44.2             |
| <b>Yes</b>                                      | 55.8             |
| <i>Distance of refilling centers</i>            | 12.5             |
| <i>Long queue for fetching gas</i>              | 20.9             |
| <i>Need a person to bring the cylinder home</i> | 25.9             |
| <i>Have to sacrifice a working day</i>          | 11.1             |
| <i>Transportation cost</i>                      | 29.7             |
| <i>Cylinder is too heavy to carry</i>           | 12.9             |
| <i>Others</i>                                   | 19.5             |

Source: IUCN and Practical Action Baseline Survey, 2024

The most common complaint is the cost of transport, experienced by 29.7% of the households, indicating transport of the cylinders to and from refilling points is a strain. In addition, 25.9% of the households require assistance to transport the cylinder to their home, most likely due to the cylinder's weight and the unavailability of an appropriate mode of transport. Also, 20.9% of the refugee households highlighted standing for a long queue in the refilling of gas as one of the major challenges.

#### 7.5 Challenges Faced by Refugee HHs to Cook with Current Fuel Types

The challenges faced by refugee households with their current cooking fuels and appliances are demonstrated in the Table 16. While 42.82% of refugee households report no issues, the remaining 57.18% experience various difficulties. Indoor air pollution is a major concern for 23.53% of households. Excessive

smoke is even a more widespread issue, as 35.53% of the households' face, which can lead to health issues such as difficulty in breathing and poor living standards. Inadequate safety for cooking, such as the potential for a fire or accident triggered by the handling of LPG or other fuels, is a worry of 13.18%. Irregular cooking temperature is an issue of concern to 16.47% of the refugee households, which can lead to inefficiency in food preparation.

**Table 16: Challenges with current cooking fuels and appliances by Refugee HHs**

| Challenges with current cooking fuels and appliances | % of Refugee HHs |
|------------------------------------------------------|------------------|
| <b>None</b>                                          | <b>42.82</b>     |
| <b>Yes</b>                                           | <b>57.18</b>     |
| <i>Creates Indoor Air Pollution*</i>                 | 23.53            |
| <i>Produces Excessive Smoke*</i>                     | 35.53            |
| <i>High Fuel Costs</i>                               | 13.65            |
| <i>Low Safety for Cooking</i>                        | 13.18            |
| <i>Inconsistent Cooking Temperature</i>              | 16.47            |
| <i>High Health Risks*</i>                            | 10.59            |
| <i>Inconvenient to Operate</i>                       | 8.94             |
| <i>Poor Food Taste Quality</i>                       | 4.71             |
| <i>Others</i>                                        | 6.35             |

Source: IUCN and Practical Action Baseline Survey, 2024; \* Health related concerns

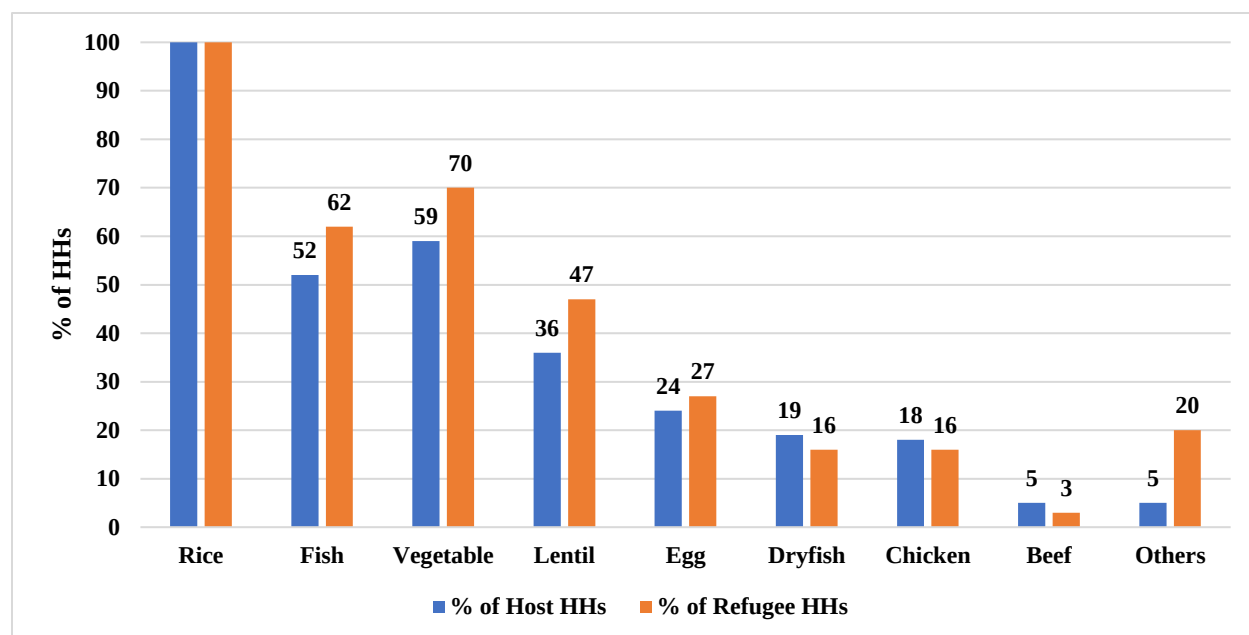
## 8.0 Regular Food Habits by Communities: Baseline Survey Findings

This section explores the regular food habits of both refugee and host community households based on the cooking data from the day before the baseline survey conducted by IUCN and PA.

### 8.1 Food Items Cooked Yesterday

The following Figure 12 informs about the food items cooked by host and refugee households on the previous day. Rice was a staple food for both groups and they cook it every day. Fish and vegetables are next two common items of daily cooking. In particular, 70% refugee and 59% host community households cooked vegetables yesterday. Besides, 62% refugee and 52% host community households cooked vegetable cooked fish items yesterday. Also, lentils and eggs were more commonly consumed by refugees than host communities.

**Figure 12: Percentage Distribution of HHs by Items Cooked Yesterday**



Source: IUCN and Practical Action Baseline Survey, 2024

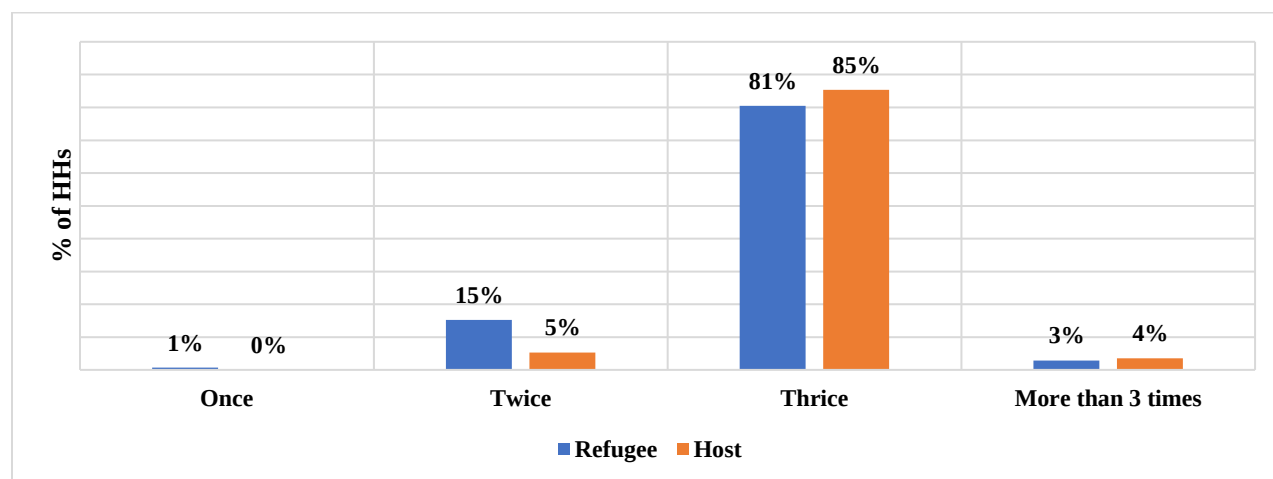
On the other hand, host households had a slightly higher consumption of dry fish (19% vs. 16%). Meat consumption was generally low among both groups. Chicken was cooked by 18% of host households and 16% of refugee households, while beef was the least consumed, with only 5% of host households and 3% of refugee households preparing it in their yesterday's meal. Also, refugee households prepared a higher number of additional food items (20%) compared to the host households (5%), indicating the food diversity of their diet. In general, while rice remained the food staple of both groups, refugee households consumed higher levels of fish, plant foods, and lentils. The host households had a greater preference for dry fish, chicken, and beef.



## 8.2 Frequency of Rice Cook in Yesterday's Meal

According to the baseline survey data analysis, it is found that 81% of refugee households and 85% of host households cook rice thrice in a day (Figure 13). In contrast, 15% of refugee households cook twice in a day while 5% of host households cook twice in a day. Besides, there are another 3% to 4% households from both host and refugee communities have cooked rice more than 3 times in a day.

**Figure 13: Number of Times Rice Cooked in Yesterday's Meal (% of HHs)**

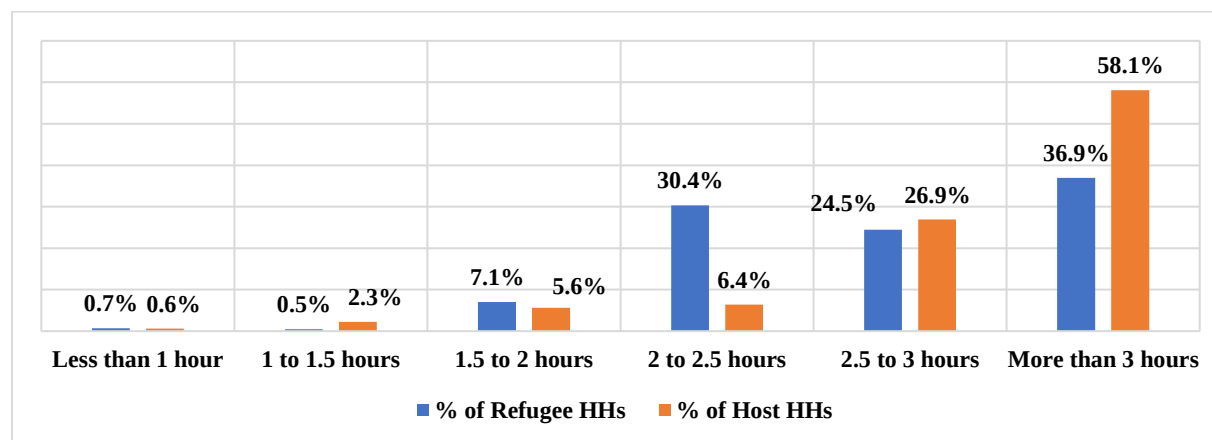


Source: IUCN and Practical Action Baseline Survey, 2024

## 8.3 Time use for cooking

Baseline survey data shows that 36.9% of refugee households and 58.1% of host households spent more than 3 hours cooking (Figure 14). In contrast, 30.4% of refugee households and 6.4% of host households took 2 to 2.5 hours. Overall, cooking time was notably longer for refugee households compared to host households probably due to the fact that host communities have more diverse access to food compared to refugee households.

**Figure 14: Time Required to Cook Items Yesterday**

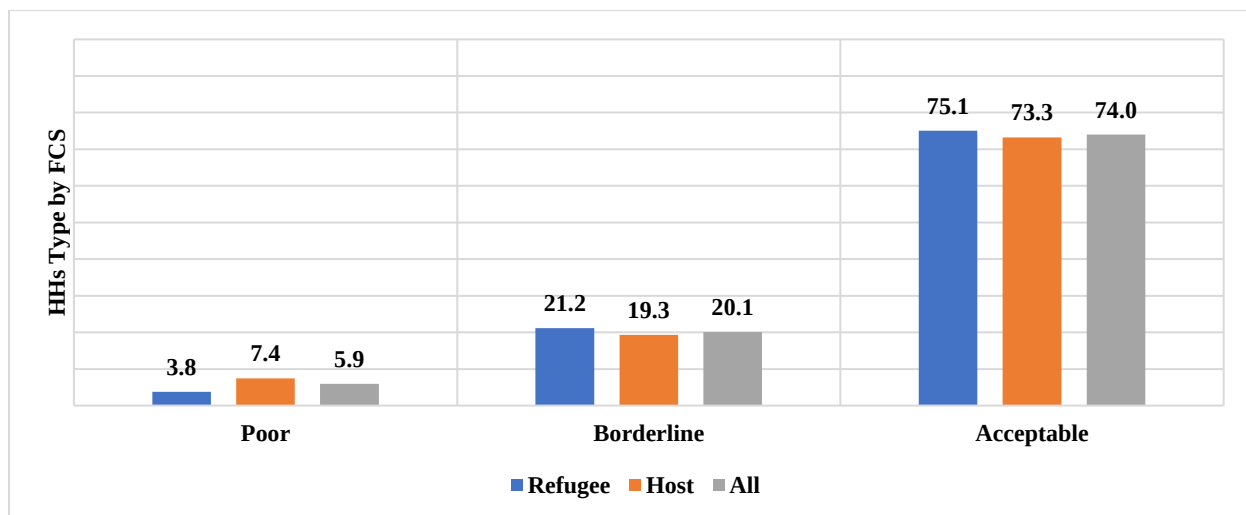


Source: IUCN and Practical Action Baseline Survey, 2024

## 8.4 Food Consumption Score by Communities

The Food Consumption Score (FCS) Index is an informal benchmark of food security that evaluates households' food security based on the dietary diversity and frequency along with the nutritional content of foods consumed within a week. The FCS is divided into three thresholds: “Poor” (0-28), “Borderline” (28.5-42), and “Acceptable” (>42). Based on the baseline data evaluation, approximately 75.1% of the refugee households and 73.3% of the host households are in the ‘acceptable’ category, which means that sufficient food security is present (Figure 15). Refugee households show a lower proportion of “poor” food consumption (3.8%) than host households (7.4%), while both groups show similar percentages of borderline food consumption, with refugees at 21.2% and hosts at 19.3%. It suggests that refugee households have slightly better food security compared to host households, though both groups have mostly acceptable food consumption levels.

**Figure 15: Household Type in reference to FCS**



Source: IUCN and Practical Action Baseline Survey, 2024

## 9.0 Willingness to Use E-Cooking Appliances

To assess aptitude towards e-cooking, households were also asked about their willingness to use or to switch to e-cooking using electricity. Questions also included about their current use of fuel for cooking including the quality of electricity they receive in host communities. This section presents the self-reported reasons by both refugee and host households on their willingness to use or switch to e-cooking appliances.

### 9.1 Reasons for Willingness to Use E-Cooking Appliances by Refugee HHs

The baseline survey data shows that 82.8% of refugee households are willing to switch to electric cooking (E-cooking), while 4.9% do not want to switch, and 12.2% are unsure (Table 17). The main reasons for willing to switch to e-cooking appliances include anticipated time savings (55.7% of HHs), reduced fuel costs (46.0% of HHs), lower indoor air pollution (29.0% of HHs), better health (23.3% of HHs), and enhanced safety (22.2% of HHs). Besides, 19.3% HHs feel it will cause better fuel efficiency in use while 9.7% HHs believe it will provide consistent cooking temperature. Overall, cost savings, convenience, and health improvements are the key motivations for adopting e-cooking appliances.

**Table 17: HHs willingness to Transit to E-cooking Appliances by Refugee HHs**

| Particulars                            | % of Refugee HHs                   |
|----------------------------------------|------------------------------------|
| No                                     | 4.9                                |
| Yes                                    | 82.8                               |
| Not Sure                               | 12.2                               |
| Reasons for Willingness to Switch      | % of Refugee HHs wanted to transit |
| Reduced Indoor Air Pollution           | 29.0                               |
| Lower Health Risks                     | 23.3                               |
| Increased Fuel Efficiency              | 19.3                               |
| Reduced Fuel Costs                     | 46.0                               |
| Time Savings                           | 55.7                               |
| Reduced Environmental Impact           | 4.8                                |
| Enhanced Safety                        | 22.2                               |
| Consistent Cooking Temperature         | 9.7                                |
| Reduced Deforestation                  | 6.0                                |
| Greater Accessibility for Remote Areas | 2.3                                |
| Others                                 | 10.2                               |

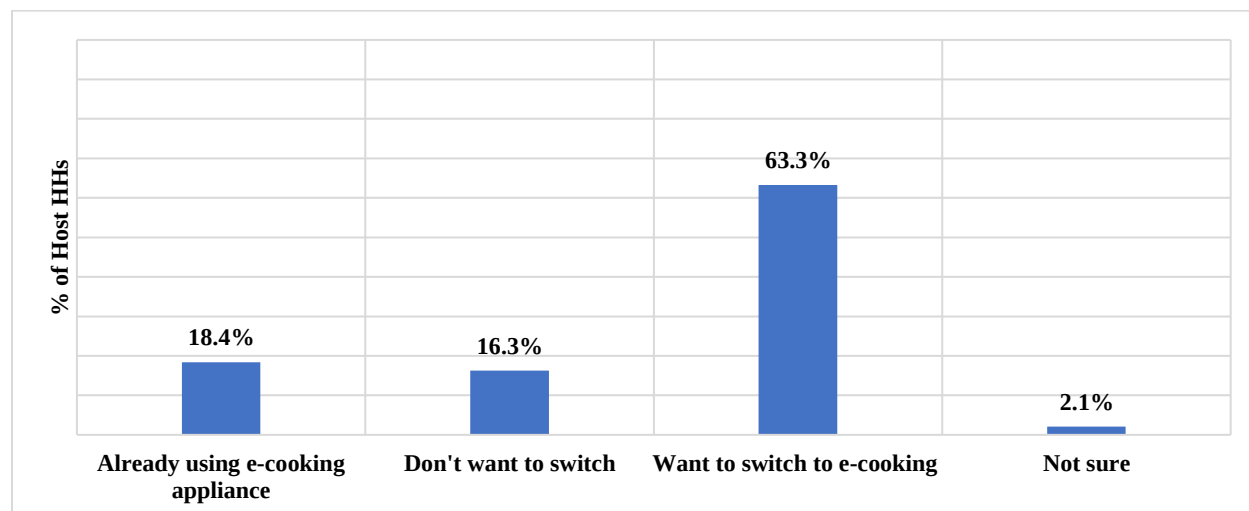
Source: IUCN and Practical Action Baseline Survey, 2024

### 9.2 Reasons for Willingness to Use E-Cooking Appliances by Host HHs

The data on willingness to use e-cooking appliances shows that a majority of host households (63.3%) are interested in switching, while 18.4% have already adopted e-cooking (Figure 16). However, 16.3% do not want to switch, citing reasons such as high product costs and unreliable electricity. A small portion (2.1%)

remains uncertain about their choice. This indicates a strong interest in e-cooking, but also highlights barriers that may need to be addressed to encourage wider adoption.

**Figure 16: HHs willingness to Transit to E-cooking Appliances by Host Community**



Source: IUCN and Practical Action Baseline Survey, 2024

The reasons why host households are willing to switch to e-cooking appliances are presented in Table 18. The most common reasons that the households mentioned are: lower health risks (58.3% of HHs), reduced indoor air pollution (50.4% of HHs), and time savings (57.0% of HHs). Among the other motivating factors 21.4% HHs have mentioned about reduced fuel costs while 25.5% mentioned about enhanced safety and 13.0% HHs mentioned about environmental benefits such as reduced deforestation (13.0%). However, fewer HHs cited fuel efficiency (9.9%) and consistent cooking temperature (5.6%) as key reasons for their willingness to switch.

**Table 18: Reasons for Willing to Switch to E-Cooking Appliance for Cooking by Host HHs**

| Reasons for willingness to switch | Within % of Host HHs<br>(want to switch) [n=393] |
|-----------------------------------|--------------------------------------------------|
| Reduced Indoor Air Pollution      | 50.4                                             |
| Lower Health Risks                | 58.3                                             |
| Increased Fuel Efficiency         | 9.9                                              |
| Reduced Fuel Costs                | 21.4                                             |
| Time Savings                      | 57.0                                             |
| Reduced Environmental Impact      | 14.0                                             |
| Enhanced Safety                   | 25.5                                             |
| Consistent Cooking Temperature    | 5.6                                              |
| Reduced Deforestation             | 13.0                                             |
| Others                            | 4.3                                              |
| Number of samples (n)             | 393                                              |

Source: IUCN and Practical Action Baseline Survey, 2024

The following Table 19 highlights the reasons why some host households are not willing to switch to e-cooking appliances. The most significant barriers that HHs mentioned are the high price of the product (78.2% of HHs) and unreliable electricity (71.3% of HHs). Additionally, 20.8% of HHs are concerned about the cost of use, while 12.9% anticipated use of e-cooking inconvenient. A small percentage (5.9%) believe that certain cooking items may not be suitable for e-cooking.

**Table 19: Reasons for ‘Not Willing’ to Switch to E-Cooking Appliance for Cooking by Host HHs**

| <b>Reasons for NOT willingness to switch</b> | <b>Within % of Host HHs<br/>(Who don't want to switch) [n=101]</b> |
|----------------------------------------------|--------------------------------------------------------------------|
| Price of the Product                         | 78.2                                                               |
| Cost of Use                                  | 20.8                                                               |
| Unreliable electricity                       | 71.3                                                               |
| Inconvenience of use                         | 12.9                                                               |
| of cooking items are not                     | 5.9                                                                |
| good                                         | 0.0                                                                |
| Others                                       | 2.0                                                                |

Source: IUCN and Practical Action Baseline Survey, 2024

## 10.0 Market Price/Cost: Cooking Fuels and E-Cooking Appliances

The IUCN and PA team have conducted 54 market surveys in 8 different market places. The market places include shops from Cox's Bazar Sadar, Ramu Sadar, Ukhiya Sadar Market, Palong Khali, Whykong, Shamlapur, Raja Palong and Kutupalong that sells either electric or traditional cooking fuels including firewood. The following section shows the current market prices of cooking fuels and e-cooking appliances available in the local market.

### 10.1 Costs of Cooking Fuels

Based on the market survey in thirty-two shops, the average value of current market price by different types of cooking fuel are presented in Table 20. It shows on average current market price of 12-liter equivalent LPG cylinders range from BDT 1,400 to 1,480. Also, it is found that the average charcoal costs between BDT 90 and 120 per kg, briquettes costs between BDT 12 to 14 per kg, firewood costs between BDT 11 and 17 per kg, and kerosene ranges from BDT 107 to 120 per liter.

**Table 20: Local Market Price (in taka) by Fuel Types**

| Fuel Type           | Minimum Market Price (in taka) | Maximum Market Price (in taka) |
|---------------------|--------------------------------|--------------------------------|
| LPG Cylinder (12 L) | 1,400                          | 1,480                          |
| Charcoal per kg     | 90                             | 120                            |
| Briquette per kg    | 12                             | 14                             |
| Firewood per kg     | 11                             | 17                             |
| Kerosene per liter  | 107                            | 120                            |

Source: IUCN and PA Market Survey, 2024

### 10.2 Current Market Price of E-cooking Appliances

The prices of e-cooking appliances are presented in Table 21. The price of rice cookers ranges from BDT 1,500 to 3,600 depending on size, with a 1 kg rice cooker averaging BDT 1,794, a 1.5 kg rice cooker averaging BDT 2,190, and a 2 kg cooker averaging BDT 2,740. Induction cooker price ranged between BDT 3,063 to 4,288 while infrared cooker ranges from BDT 3,060 to 3,980. Besides, average price of 6-litre electric pressure cookers cost nearly BDT 6,500 to 7,500. The price mostly varies due to feature of the appliances and for its quality and brand value.

**Table 21: Local Market Price (in taka) by Cooking Appliances**

| Cooking Appliances   | Average Price (in taka) | Min. Price (in taka) | Max. Price (in taka) |
|----------------------|-------------------------|----------------------|----------------------|
| Rice Cooker (1 kg)   | 1,794                   | 1,500                | 2,250                |
| Rice Cooker (1.5 kg) | 2,190                   | 1,800                | 2,500                |
| Rice Cooker (2 kg)   | 2,740                   | 2,100                | 3,600                |
| Induction Cooker     | 3,676                   | 3,063                | 4,288                |

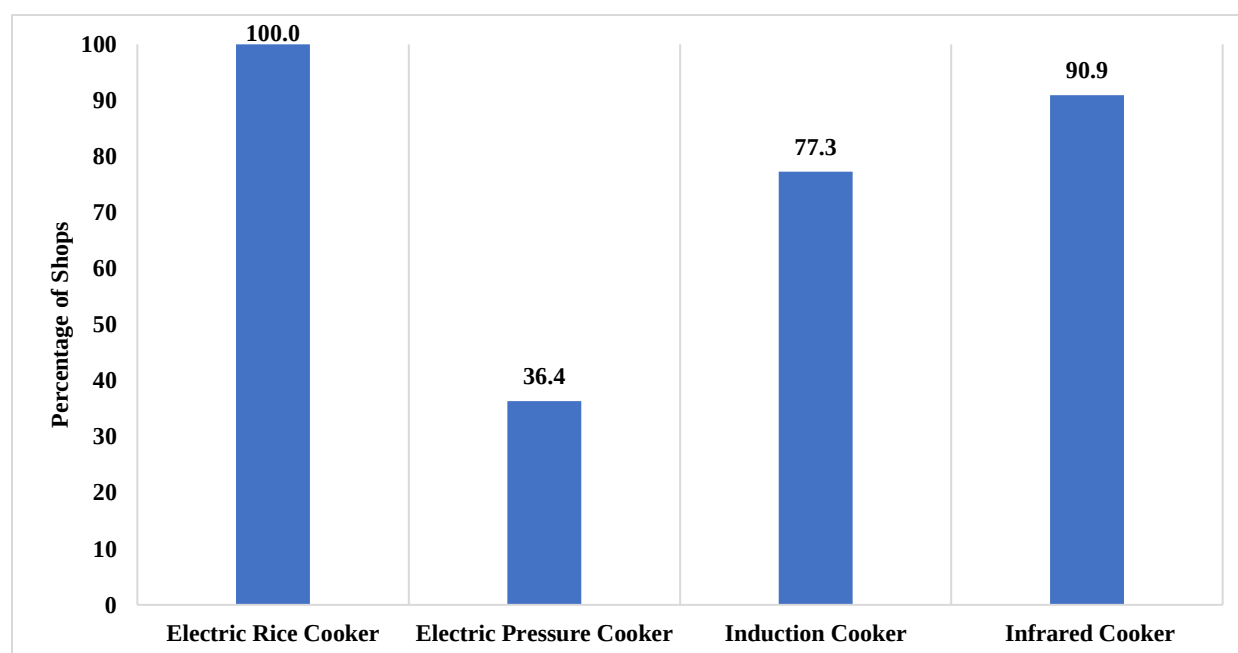
|                                 |       |       |       |
|---------------------------------|-------|-------|-------|
| Infrared Cooker                 | 3,520 | 3,060 | 3,980 |
| Electric Pressure Cooker (6 L)* | 6,500 | 7,500 | 7,000 |

Source: IUCN and PA Market Survey, 2024; \* Information Collected from Shops Outside of the Market Survey

### 10.3 Insights from Local Markets about E-Cooking Appliances

While surveying the market, the PA and IUCN team went through 22 retail outlets selling modern cooking appliances. Electric rice cookers were stocked in all shops surveyed, thus being the most accessible commodity. Infrared cookers were present in 90.9% of the outlets, and induction cookers in 77.3%. Electric pressure cookers were less accessible, being available in only 36.4% of the outlets (Figure 17).

**Figure 17: Availability of E-Cooking Appliances in the Local Shops**



Source: IUCN and PA Market Survey, 2024; \* Information Collected from Shops Outside of the Market Survey

Monthly sales figures also corroborate this trend. About 31.8% of the retailers indicated selling 10 to 20 rice cookers a month, and 27.3% indicated more than 20 units (Table 22). Electric pressure cookers, on the other hand, had the lowest level of sell, with 100% of the retailers selling less than five units per month. Infrared and induction cookers also had predominantly low-volume sales, with more than half of the retailers indicating fewer than five monthly sales for each.

**Table 22: Average Monthly Sales of Electric Cooking Appliances**

| <b>Average Monthly Sales (in piece)</b> | <b>Electric Rice Cooker</b> | <b>Electric Pressure Cooker</b> | <b>Induction Cooker</b> | <b>Infrared Cooker</b> |
|-----------------------------------------|-----------------------------|---------------------------------|-------------------------|------------------------|
| <b>Less than 5</b>                      | 13.6%                       | 100.0%                          | 58.8%                   | 75.0%                  |
| <b>5 to 10</b>                          | 27.3%                       | 0.0%                            | 29.4%                   | 10.0%                  |
| <b>10 to 20</b>                         | 31.8%                       | 0.0%                            | 5.9%                    | 5.0%                   |
| <b>More than 20</b>                     | 27.3%                       | 0.0%                            | 5.9%                    | 5.0%                   |

Source: IUCN and PA Market Survey, 2024; \* Information Collected from Shops Outside of the Market Survey

A notable observation is that locals are the primary users of electric rice cookers, and a perceived demand is visible on the part of women, as they are the majority users. But for induction, infrared, and electric pressure cookers, the primary users are not locals but those who are employed by NGOs and organizations working within the camps' areas. This is indicative of a segmented demand pattern, with less expensive appliances such as rice cookers being more embedded in local domestic consumption, and more portable and expensive appliances supplying a professional and non-local resident.

Seasonal demand is also found to influence appliance sales. Approximately 72.73% of the respondents noted that sales vary seasonally, which means that third-party influences, such as weather or power availability, can affect consumer behavior. Payment channels-wise, most consumers (62.5%) pay cash, followed by 20% who buy on credit. EMI or bundled payment modes are used by fewer consumers, indicating low penetration of flexible funding plans.

Barriers to adoption remain. Most frequently cited issues are product cost (29.17%) and unreliable electricity (22.92%), followed by operating costs (16.67%) and inconvenience (16.67%). Taste concerns were negligible, at 2.08% of the sample.

Overall, the market trends show that there is increasing demand for electric rice cookers among locals, particularly women, with constant availability and higher sales performance. Conversely, more recent technologies such as infrared, induction, and pressure cookers have minimal local adoption and are largely utilized by NGO personnel and camp workers. Seasonal volatility in sales and strong preference for cash payments indicate the necessity for more flexible financing schemes. Advances in affordability and electricity reliability will be most important in scaling up e-cooking appliance adoption beyond its present, niche consumer segment.



## 11.0 Political, social, environmental, and technological considerations for different fuel and appliance types

Communities often suffer from inertia against changes or to move away from the status quo. Such rigidity often are linked to the existing socio-political situation, availability of technology and the regulatory regime in which they live. As such, several group discussions were held with communities leaders and elders in the communities. This section, therefore, presents a comparative analysis of cooking fuel options in Bangladesh from the perspective of political, social, environmental and technological features (Table 23).

LPG continues to be a widely used cooking fuel in Cox's Bazar under the subsidy schemes facilitated by IOM and UNHCR. As LPG is highly import driven source of fuel, it is very susceptible to price. Firewood, although used extensively by poor and displaced people, is increasingly becoming scarcer because of deforestation. Although the legislation to limit excessive wood use is in place, its enforcement is poor. Charcoal, another of the biomasses, has poor burn rates and burn times but high pollution levels and unsustainable dependent production. Despite limited policy interventions, it remains a key cooking fuel in areas where firewood is scarce.

**Table 23: Comparative Analysis of Cooking Fuel Options in Bangladesh: Political, Social, Environmental, & Technological Aspect**

| Particulars                 | LPG                                                                                                                                       | Firewood                                                                                                                     | Electric Cooking using Solar                                                                                                 | Charcoal                                                                                                     |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <b>Government Policies</b>  | Regulated market price of LPG using Bangladesh Energy Regulatory Council (BERC).                                                          | Firewood collection is restricted and entry into the forest is monitored by the Forest Department.                           | In line with government's policy to promote sustainable energy use if it is solar-based.                                     | Limited policy interventions, though some regulations exist on charcoal production.                          |
| <b>Regulations</b>          | Strict safety regulations on storage and transport; enforcement varies.                                                                   | Firewood trading is under watch by the forest department and transporting large volume is prohibited.                        | Solar-based electricity is not taxed yet. Used batteries are subject to recycling by battery manufacturers.                  | Charcoal production is monitored in some areas due to environmental concerns.                                |
| <b>Incentives</b>           | Active support towards adoption of LPG by the government and donors in Cox's Bazar and at the same time rising firewood prices.           | Cooking stoves are easy to make. Does not require any specialized skill.                                                     | Once installed no further cost for power except battery replacement every 5 years.                                           | Little to none in place.                                                                                     |
| <b>Community Acceptance</b> | Urban communities are ready to accept it while rural communities view this as a snob item. Requires training to perfect cooking with LPG. | Widely used. Can be used for cooking diverse food items using clay-pot, aluminum pot, iron plate, etc. Requires no training. | Need to make people aware of it. While compatible utensils are available in the market, the solar panels are still imported. | Popular in some rural areas, especially where firewood is scarce. Ready market supply used to exist locally. |
| <b>Cultural Factors</b>     | For cooking some specific food, people often prefer earthen pot. Aesthetic product compared to firewood.                                  | Deeply rooted in cooking traditional food; often preferred for taste of food.                                                | Needs a change in cooking style.                                                                                             | Used in both rural and urban areas where other fuels are expensive or unavailable.                           |

|                             |                                                                                            |                                                                                                       |                                                                                                                                                     |                                                                                |
|-----------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| <b>User Experience</b>      | Easy to use but refilling and cost fluctuations create challenges.                         | Readily available but inefficient and produces heavy smoke.                                           | Efficient but requires changes in utensils. Solar power efficiency is low in the morning. Cooking at night is not possible without battery support. | Dirty fuel but locally available.                                              |
| <b>Carbon Emissions</b>     | Lower than biomass but still a fossil fuel; contributes to CO2 emissions.                  | Emits carbon.                                                                                         | Zero emissions at the point of use.                                                                                                                 | Significant emissions from production and use, including carbon monoxide.      |
| <b>Resource Consumption</b> | Relies on imported natural gas; availability fluctuates.                                   | Consumes large amounts of wood, leading to deforestation.                                             | Depends on grid energy; sustainability depends on power generation sources.                                                                         | Relies on unsustainable tree cutting and inefficient production methods.       |
| <b>Health Impact</b>        | Cleaner than other solid fuels; reduces indoor air pollution, and improves health.         | Prolonged exposure to smoke causes respiratory tract illness and contributes to indoor air pollution. | No indoor emissions; reduces respiratory illnesses.                                                                                                 | Produces harmful pollutants that contribute to respiratory diseases.           |
| <b>Feasibility</b>          | Existing well-developed supply chain.                                                      | Feasible and readily available in the market.                                                         | Feasible but requires changes to make repair and maintenance easy in local area.                                                                    | Commonly used but requires improved production and efficiency measures.        |
| <b>Efficiency</b>           | Highly efficient and easy cooking.                                                         | Low efficiency; high energy waste and requires more time to cook.                                     | Depends on cook stove and utensils.                                                                                                                 | Moderate efficiency; higher energy density than firewood but wasteful burning. |
| <b>Infrastructure Needs</b> | Require gas stove, and no changes in the utensils. Need local retail distribution outlets. | Minimal infrastructure needed; mostly manual collection.                                              | Stable electricity supply and durable appliances are essential.                                                                                     | Charcoal kilns and transport networks contribute to inefficiencies.            |

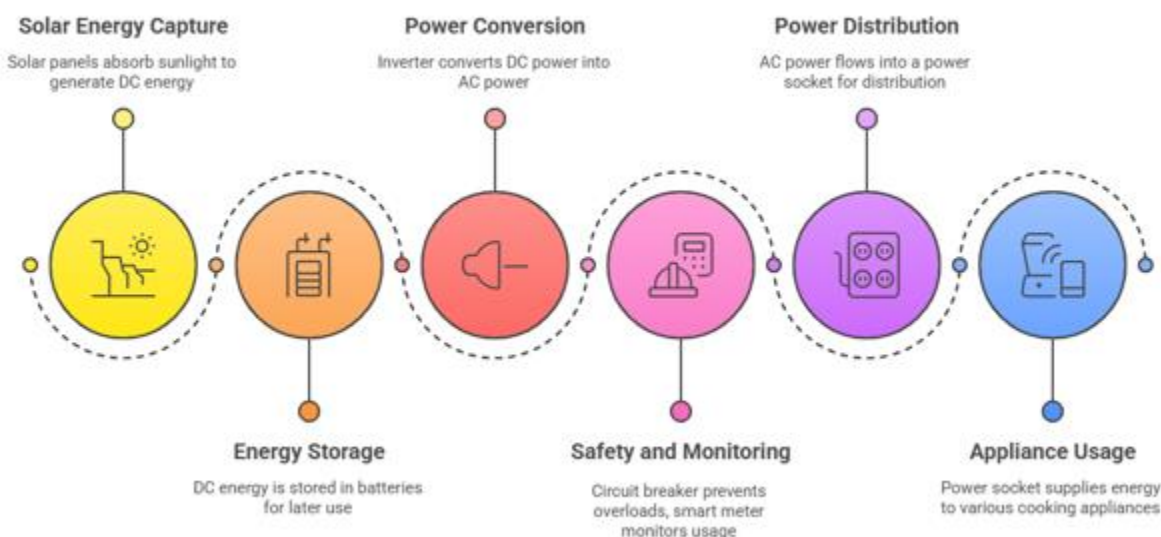
Source: Summarized by Authors from field observations, policy documents and secondary sources

Electric cooking provides a modern and efficient alternative with point-of-use zero emissions, accruing benefits to indoor health and air quality. The scope of large-scale adoption of electricity based modern cooking fuels limited are at current given instability in the grid electricity connection in the host communities while due to lack of access to electricity in refugee camps. The relatively higher price of solar system including batteries and price of these cookers are also impediments for large-scale adoption of the electricity based modern cooking fuels. While financial support for electric cookers remains minimal, adoption is growing where reliable electricity and solar-powered systems are available. In contrast, firewood and charcoal are widely used due to their availability and cultural acceptability, even if they are harmful to the environment and to health. Finally, cooking fuel choice in Cox's Bazar is driven by the availability of infrastructure, economic feasibility, as well as the viability of subsidization under the UNHCR and IOM operations.

## 12.0 Infrastructure Requirement for installation of e-cooking system

The following flowchart illustrates the process of generating solar power and utilizing solar energy for cooking appliances (Figure 18). The first step is to install solar panels that capture sunlight and stores into battery cells. During cooking it invert the electricity into AC power. The electricity then flows through a circuit breaker and a smart meter, ensuring safety and monitoring of usage into the cooking appliances.

**Figure 18: Flowchart of Solar-Powered Cooking System Requirements**



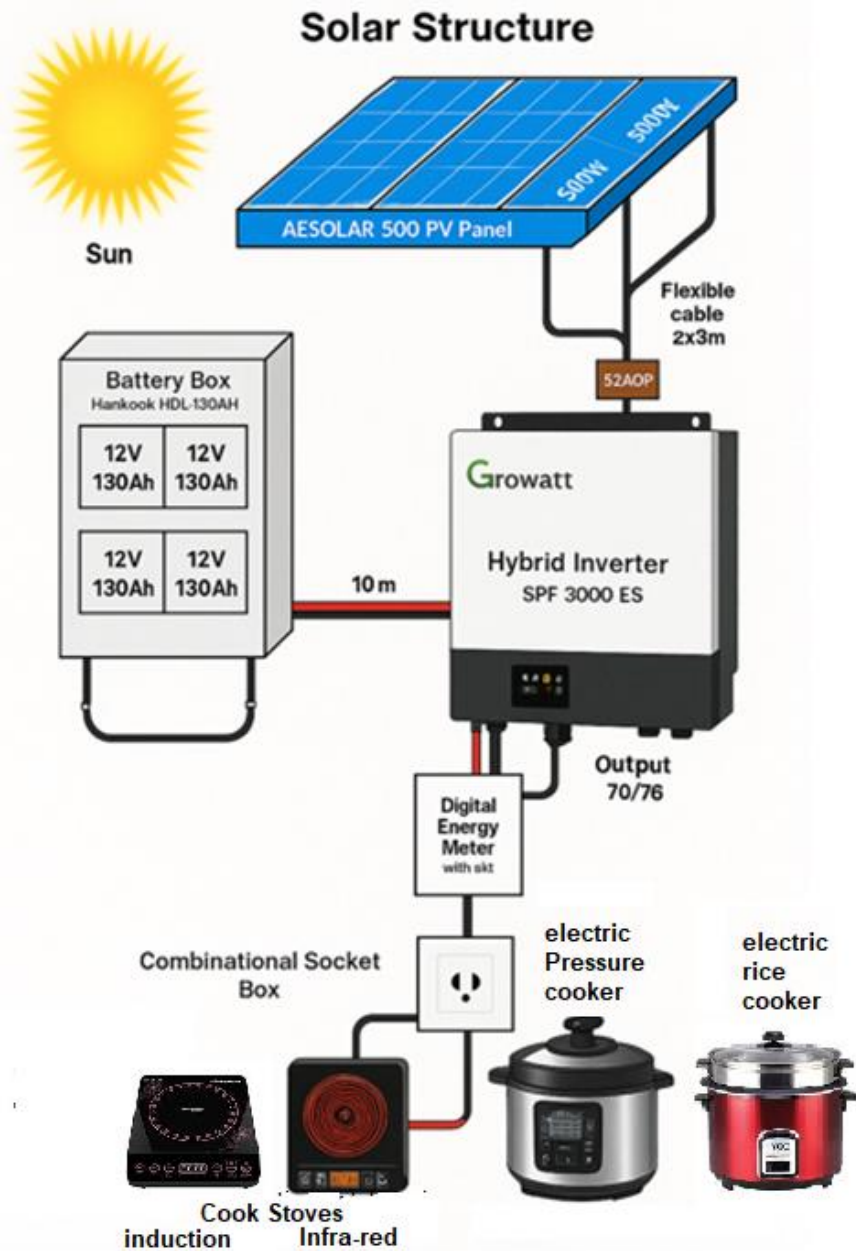
Source: Developed by Authors'

### Systems Installed During HH Experiment

As part of the Experiment, the selected households were provided with a full solar-powered electric cooking system to test the viability and feasibility of clean cooking technologies in off-grid areas. Each of the households was given a 3-kilowatt solar panel system (six 500W AESOLER PV panels) that was connected through flexible cables to a Growatt Hybrid Inverter (SPF 3000 ES model). For storing energy, a battery box of four 12V, 130Ah Hamko HPD batteries was mounted (Figure 19). A digital energy meter with an inbuilt circuit was provided for monitoring energy, interfaced to the system through a 32ADP output. The energy from the inverter is fed to a combinational socket box through which users were running different appliances. These comprised an induction cooker, an infrared cooker, and an electric pressure cooker of 6 liters, all designed to cater to varied cooking preferences. Two utensils were also provided with the cookers for convenience. One of the key limitations of the research was the deployment of the data logger, a valuable tool for recording energy use and consumption patterns, only could be installed in the fourth round of monitoring and on just a single household from each group. Restricted deployment of the data logger

restricted detailed energy use analysis. Nonetheless, the installed system offered valuable insight into the potential of off-grid solar technology for addressing cooking energy needs outlined above.

**Figure 19: Specification of Solar-Powered Cooking System Used in the Study**



Source: Developed by Authors

## 13.0 Findings from the Cooking Experiments

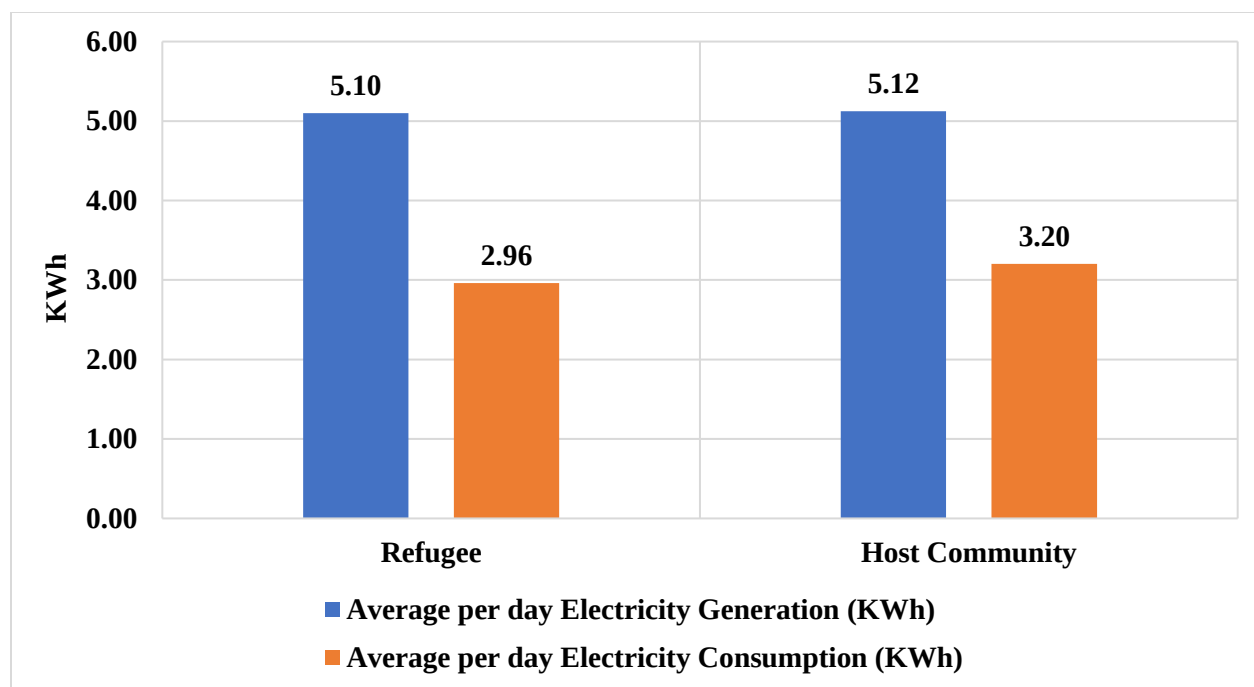
This section presents the findings from the experiments conducted in the refugee and host households.

### 13.1 Solar-based Electricity Generation and Consumption Statistics

The Figure 20 contrasts daily average electricity generated and consumed in host community and refugee households with installed solar systems. For refugee families, the average generation of electricity per day is 5.10 kWh, but the consumption level is just 2.96 kWh. The pattern is the same for host community families, with 5.12 kWh of generation and 3.20 kWh of consumption (Figure 20). In both settings, the installed systems are generating far more electricity than is being consumed.

This persistent generation-consumption imbalance indicates that installed solar system capacity is oversized compared to true demand. Hence, there is an evident opportunity to re-examine and re-analyze the households' energy requirements. By more directly matching system design to consumption patterns, fixed costs—especially in hardware such as battery storage and inverter sizing can be minimized without undermining the households' access to basic electricity services. This kind of optimization would make things more cost-effective and permit more effective allocation of resources, particularly in large or scaled-up implementations.

**Figure 20: Per Day Electricity Generation and Consumption by Communities**



Source: Author's estimation from IUCN and Practical Action E-cooking Demonstration Survey, 2024

## 13.2 Cooking Habits of HHs: Insights from Demonstration Survey Data

The demonstration survey at household-level captures cooking activities that are very comparable to what was observed during the baseline period for refugee and host community households. The comparability confirms that the provision of e-cooking facilities did not enforce a shift in their traditional cooking behavior. The findings validate the hypothesis that while cooking technologies may change, tastes in food are stable unless transformed by more prolonged exposure, changes in affordability, or social interventions.

Breakdown figures from the survey indicate that rice still reigns supreme in the meals of both groups, as refugee households prepare rice for dinner (94.9%), lunch (84.9%), and breakfast (69.0%). Percentages of host communities are also high, with rice cooking at lunch (97.4%), dinner (94.9%), and breakfast (72.5%).

**Table 24: % of Food Items Cooked during the Experiment by Meals and by Communities**

| Items Cooked                | % of Refugee HHs (n=20) |       |        | % of Host HHs (n=20) |       |        |
|-----------------------------|-------------------------|-------|--------|----------------------|-------|--------|
|                             | Breakfast               | Lunch | Dinner | Breakfast            | Lunch | Dinner |
| <b>Rice</b>                 | 69.0                    | 84.9  | 94.9   | 72.5                 | 97.4  | 94.9   |
| <b>Potato</b>               | 12.4                    | 15.1  | 11.0   | 21.1                 | 13.8  | 16.1   |
| <b>Vegetable</b>            | 43.4                    | 74.0  | 62.0   | 43.1                 | 41.4  | 32.2   |
| <b>Lentil (any variety)</b> | 27.4                    | 31.9  | 29.9   | 17.4                 | 24.1  | 20.3   |
| <b>Egg</b>                  | 18.6                    | 25.2  | 22.6   | 17.4                 | 17.2  | 19.5   |
| <b>Chicken</b>              | 11.5                    | 17.7  | 19.0   | 21.1                 | 27.6  | 24.6   |
| <b>Fish</b>                 | 33.6                    | 48.7  | 51.1   | 26.6                 | 41.4  | 35.6   |
| <b>Dry fish</b>             | 13.3                    | 16.0  | 16.8   | 7.3                  | 12.1  | 7.6    |
| <b>Beef/Goat Meat</b>       | 1.8                     | 5.9   | 3.7    | 8.3                  | 7.8   | 8.5    |
| <b>Wheat (roti/naan)</b>    | 20.4                    | 0.8   | 0.7    | 22.9                 | 0.9   | 0.0    |
| <b>Khichuri</b>             | 0.9                     | 0.0   | 0.0    | 0.0                  | 0.0   | 3.4    |
| <b>Others</b>               | 53.1                    | 10.9  | 9.5    | 18.4                 | 0.9   | 2.5    |

Source: IUCN and Practical Action E-cooking Experiment, 2024

The same applies to other foods like vegetables, fish, and lentils. Refugee families prepare more vegetables for lunch (74.0%) and dinner (62.0%) compared to host families (Table 24). Fish is a regular food item for both groups, though slightly more frequent among refugees. Chicken, however, is more frequently served in host families for all meals.

Most noteworthy is beef/goat meat that is still restricted in refugee households, probably on the basis of cost, while host households slightly increase its usage. Eggs, dry fish, and wheat-based foods like roti or naan are prepared with moderate frequency, primarily for breakfast.

Interestingly, a variety of 'other' foods are prepared by refugee families, particularly for breakfast (53.1%), reflecting a variety of food practices. Host families have more structured and less variety by meal time, but with some insertion of foods like khichuri for dinner.

In short, though the energy source and cooking technology might have been improved by the intervention, the food choices and eating habits underlying them have remained the same; highlighting the need to longer time of experiment to understand whether it causes any change in cultural food traditions when introducing new cooking technologies.

### **13.3 Time Required to Cook with Electric Appliances**

A key issue in fuel usage (whether electricity, LPG, or other fuels) is determining how much energy each household consumes for cooking with different types of fuel. Without a data-logger, this calculation becomes challenging. Additionally, solar electricity generation is most efficient between 7 AM and 4:30 PM, when solar radiation is at its peak. Understanding how much time households utilize during this period is crucial, as they can cook even without relying on battery storage.

The Table 25 presents data on cooking patterns for breakfast, lunch, and dinner, focusing on both the average number of people cooked for and the time spent preparing each meal. Here are the key takeaways:

#### **1. Average Household Size:**

The average number of people for whom meals are cooked is roughly consistent across the three meals, with breakfast at 5.84, lunch at 6.02, and dinner at 5.82. This suggests a stable household size or communal eating practice.

#### **2. Cooking Time Distribution:**

- Breakfast:
  - A significant majority (60.71%) of households cook breakfast in 30 minutes to 1 hour, indicating it is typically a quicker meal preparation.
  - Only 1.79% take less than half an hour, while a small percentage (3.57%) take between 1.5 and 2 hours, reflecting the generally fast-paced preparation associated with breakfast.
- Lunch:
  - Cooking times are more varied compared to breakfast, with almost 30% (29.63%) preparing lunch in 30 minutes to 1 hour.
  - A substantial portion (40.74%) takes between 1 to 1.5 hours, the highest among the three meals, indicating that lunch may involve more elaborate cooking.
  - There is also a notable 14.81% of households that spend 1.5 to 2 hours preparing lunch.
- Dinner:

- Dinner shows similar trends to lunch, with 40.30% of households cooking for 1 to 1.5 hours and 8.96% spending 1.5 to 2 hours.
- The proportion of households cooking dinner in the 30 minutes to 1 hour range (40.30%) is lower than for breakfast, indicating that dinner may often be more time-consuming.

3. Longer Cooking Times: The percentage of households preparing meals for extended periods (2 hours or more) is notably low across all meals—suggesting that long cooking durations are relatively uncommon.

Overall, the table clearly illustrates that breakfast is generally prepared more quickly than lunch or dinner, while lunch often takes the longest time to prepare. Additionally, despite variations, most households prefer to keep their cooking times within a manageable range, indicating an efficient approach to meal preparation.

**Table 25: Time Required to Cook by Meals at HH level**

|                                      | <b>Breakfast</b>       | <b>Lunch</b> | <b>Dinner</b> |
|--------------------------------------|------------------------|--------------|---------------|
| <b>Number of People - Cooked for</b> | 5.84                   | 6.02         | 5.82          |
|                                      | <b>% of Households</b> |              |               |
| <b>Less than half an hour</b>        | 1.79                   | 7.41         | 5.97          |
| <b>30 min to 1 hour</b>              | 60.71                  | 29.63        | 40.30         |
| <b>1 to 1.5 hours</b>                | 32.14                  | 40.74        | 40.30         |
| <b>1.5 to 2 hours</b>                | 3.57                   | 14.81        | 8.96          |
| <b>2 to 2.5 hours</b>                | 1.79                   | 5.56         | 4.48          |
| <b>2.5 to 3 hours</b>                | 0.00                   | 1.85         | 0.00          |

Source: IUCN and Practical Action E-cooking Demonstration Survey, 2024

### 13.4 Use of E-cooking Appliances

The Figure 21 shows the percentage distribution of items cooked using different cooking methods: Induction, EPC (Electric Pressure Cooker), Infrared, and Others for breakfast, lunch, dinner, and overall.

#### 1. Induction cooker usage:

- Used by 25% for breakfast.
- Higher usage for lunch (31%) and dinner (31%).
- Overall, accounts for 29% of items cooked.
- Infrared cooking stoves seem to be a better fit for the household's needs. This is primarily because induction cooking stoves require iron-based utensils that are heavy, making them harder to clean, especially for girls who often assist in cooking. Additionally, the family is more accustomed to using aluminum utensils.



## 2. EPC (Electric Pressure Cooker) used mostly to cook rice

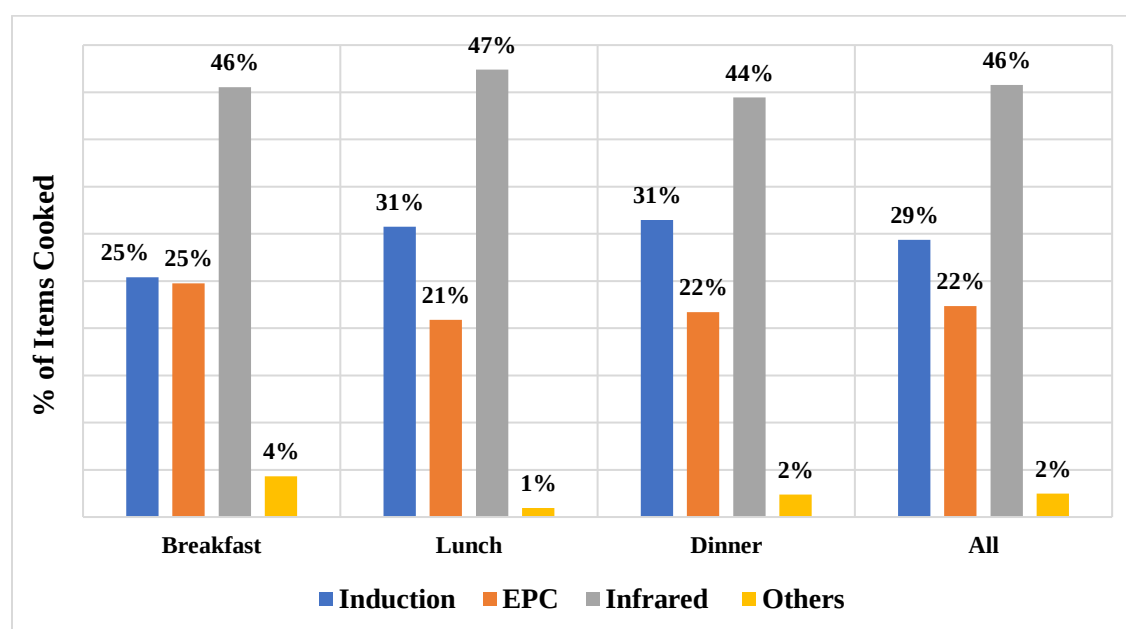
1. Utilized by 25% for breakfast.
2. Lower usage for lunch at 21%.
3. Similar usage for dinner at 22%.
4. Overall, represents 22% of cooking.
5. Users reported high satisfaction with the EPC, particularly for cooking rice, which could be done more affordably with a standard rice cooker. The advantage of the EPC or a rice cooker lies in its ability to maintain the rice's temperature for an extended period.

## 3. Infrared cooking stove usage:

- The most prominent method, particularly for breakfast (46%) and dinner (46%).
- Highest percentage at lunch (47%).
- Represents 46% of cooking overall.
- Infrared cooking stoves are the most popular option across all meals.

This suggests that traditional or other cooking methods are still prevalent, while modern methods like infrared cooking stove and EPC/rice cookers are popular for their efficiency and convenience.

**Figure 21: Percent of Items Cooked by Meals and by E-cooking Appliances**



Source: IUCN and Practical Action E-cooking Demonstration Survey, 2024

### 13.5 Cooking Time Patterns and Solar Utilization Potential

The Practical Action and IUCN 2024 e-cooking demonstration survey shows that, statistically, there are very clear differences between the cooking time preferences of refugee and host community households. When compared with solar radiation patterns, the differences provide valuable information on how to align solar e-cooking systems with actual usage patterns.

#### ***Breakfast Cooking: Early Start, Low Solar Yield***

Cooking in the morning is largely completed before 7:30 AM, particularly for the refugee families (Table 26). While about 35% of the refugee families begin cooking between 6:00–6:30 AM i.e. before the sunrise among the host families while it is only 2% among the refugee families. About 57% of the host families cook breakfast before 7am (before the sun reaches its optimal radiation) while it is only 21% for refugee households and is therefore the unfavorable time period for battery-free solar cooking.

**Table 26: Percentage of Breakfast Cooking Activities by Time Slot and by Communities**

| Time range (for Breakfast) | % of Cases Cooked |      |     |
|----------------------------|-------------------|------|-----|
|                            | Refugee           | Host | All |
| 6:00 to 6:30 AM            | 35%               | 2%   | 17% |
| Sunrise time               |                   |      |     |
| 6:30 to 7:00 AM            | 22%               | 19%  | 20% |
| 7:00 to 7:30 AM            | 27%               | 44%  | 36% |
| 7:30 to 8:00 AM            | 3%                | 16%  | 10% |
| 8:00 to 8:30 AM            | 5%                | 11%  | 9%  |
| 8:30 AM to 9:00 AM         | 3%                | 2%   | 2%  |
| 9:00 AM to 9:30 AM         | 3%                | 5%   | 4%  |
| 9:30 AM and later          | 2%                | 2%   | 2%  |

Source: IUCN and Practical Action E-cooking Demonstration Survey, 2024

In the absence of adequate early-morning solar radiation, breakfast will continue to be cooked using either stored solar energy or alternative sources like LPG. Solar breakfast cooking is technologically limited unless it is coupled with thermal storage or nighttime battery holdover.

#### ***Lunch Preparation: Midday Benefit and Solar Peak Match***

Based on Table 27, the most common cooking times for lunch across all groups occur between 12:00 PM and 12:30 PM, with 29% of all cases cooked during this time. This peak is particularly noticeable among the Host group, where 32% of people are cooking within this time frame.

Another significant time for cooking is from 12:30 PM to 01:00 PM, which accounts for 21% of all cooking cases. The Refugee group also shows consistent cooking activity during this period, contributing 10% of their cases.

Overall, the majority of cooking happens in the late morning to early afternoon, with the peak time being between 12:00 PM and 1:30 PM, indicating that this is when most people prepare their meals. Also, there is not much difference between host and refugee communities on this time range.

**Table 27: Percentage of Lunch Cooking Activities by Time Slot and by Communities**

| Time range (for Lunch)     | % of Cases Cooked |      |     |
|----------------------------|-------------------|------|-----|
|                            | Refugee           | Host | All |
| <b>11:00 AM or earlier</b> | 5%                | 3%   | 4%  |
| <b>11:00 to 11:30 AM</b>   | 18%               | 1%   | 9%  |
| <b>11:30 to 11:59 AM</b>   | 8%                | 5%   | 6%  |
| <b>12:00 to 12:30 PM</b>   | 25%               | 32%  | 29% |
| <b>12:30 to 01:00 PM</b>   | 10%               | 29%  | 21% |
| <b>01:00 to 01:30 PM</b>   | 10%               | 26%  | 18% |
| <b>01:30 to 02:00 PM</b>   | 11%               | 2%   | 6%  |
| <b>02:00 to 02:30 PM</b>   | 11%               | 2%   | 6%  |
| <b>02:30 PM and later</b>  | 2%                | 1%   | 1%  |

Source: IUCN and Practical Action E-cooking Demonstration Survey, 2024

### ***Preparing Dinner: Evening Load and Battery Demand***

Dinner cooking behavior shows the most significant timing disparity between the two groups. Approximately 67% of refugee households prepare their dinner before 5:30 PM, compared to only 16% of host households. This allows refugees to cook when solar radiation is effective, eliminating the need for battery support for solar cooking. Conversely, about 33% of refugees cook their dinner after 5:30 PM, while this figure rises to 84% among host communities (see Table 28). This suggests a strong demand for battery-supported solar systems, particularly in host communities where cooking typically occurs in the evening.

**Table 28: Percentage of Dinner Cooking Activities by Time Slot and by Communities**

| Time range (for dinner)     | % of Cases Cooked |            |            |
|-----------------------------|-------------------|------------|------------|
|                             | Refugee           | Host       | All        |
| <b>03:00 or earlier</b>     | 1%                | 14%        | 7%         |
| <b>03:00 to 3:30 PM</b>     | 8%                | 0%         | 4%         |
| <b>03:30 to 04:00 PM</b>    | 6%                | 0%         | 3%         |
| <b>04:00 to 04:30 PM</b>    | 15%               | 0%         | 7%         |
| <b>04:30 to 05:00 PM</b>    | 18%               | 1%         | 9%         |
| <b>05:00 to 05:30 PM</b>    | 19%               | 1%         | 10%        |
| <b>05:30 to 06:00 PM</b>    | 2%                | 1%         | 2%         |
| <b><i>Before Sunset</i></b> | <b>69%</b>        | <b>17%</b> | <b>42%</b> |

|                            |            |            |            |
|----------------------------|------------|------------|------------|
| <b>06:00 to 06:30 PM</b>   | 12%        | 4%         | 8%         |
| <b>06:30 to 07:00 PM</b>   | 2%         | 8%         | 5%         |
| <b>07:00 to 07:30 PM</b>   | 10%        | 4%         | 7%         |
| <b>07:30 to 08:00 PM</b>   | 2%         | 16%        | 9%         |
| <b>08:00 to 08:30 PM</b>   | 3%         | 20%        | 11%        |
| <b>08:30 to 09:00 PM</b>   | 1%         | 12%        | 6%         |
| <b>09:00 to 09:30 PM</b>   | 0%         | 14%        | 7%         |
| <b>09:30 and later</b>     | 1%         | 6%         | 4%         |
| <b><i>After sunset</i></b> | <b>31%</b> | <b>83%</b> | <b>58%</b> |

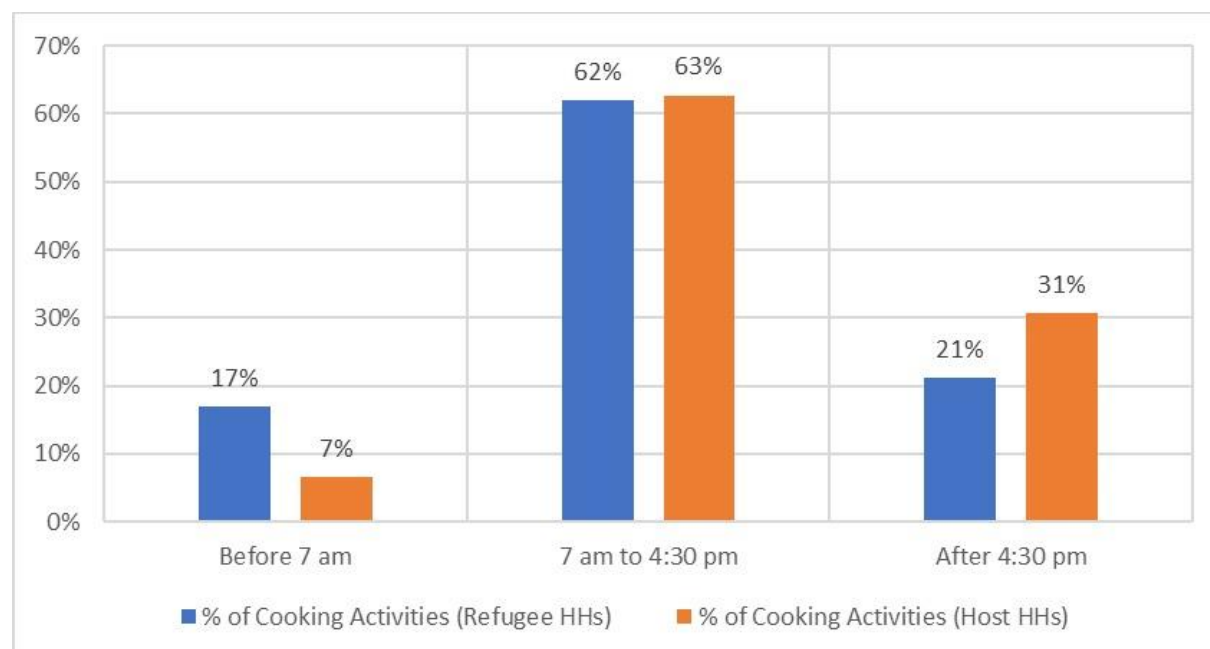
Source: IUCN and Practical Action E-cooking Demonstration Survey, 2024

Systems that are not built with adequate storage would be useless for these later hours, and this emphasizes the need to incorporate battery solutions or hybrid models including LPG for dinner preparation.

### ***Aggregated Cooking Time Slots: Synchronizing System Capacity with Solar Radiation Time***

A detail assessment of cooking time indicates that 29% of refugee cooking activities, as well as 34% of host cooking activities, is accomplished before 10 AM. In the time between 10 AM through 4 PM, when solar exposure is highest, 43% of refugee home cooking, as well as 38% of host home cooking activities take place (Figure 22). The remainder, 28% of each, takes place after 4 PM. Note that the 10 AM through 4 PM time is the most favorable for direct solar utilization. However, as approximately one-third of cooking is done outside productive solar hours, notably by host households, battery storage remains an important determinant of availability of energy in the evenings.

**Figure 22: Daily Aggregated Cooking Activates by Time Slots and by Communities**



Source: IUCN and Practical Action E-cooking Demonstration Survey, 2024

### **13.6 Implications for designing Solar E-Cooking Systems**

From a systems design perspective, we can draw the following conclusions:

First, not all households utilize optimal solar radiation hours for cooking, which span from 7 AM to 4:30 PM. While summer may extend this time due to increased solar radiation until 5:30 PM, winter months will see a reduction to 4:30 PM.

Second, by incorporating a battery option, refugee households could eliminate their reliance on LPG for cooking. In contrast, host families would need to adjust their cooking schedules for breakfast and dinner. This presents a challenge, particularly for agricultural workers who must leave for work early in the morning. It is also true for cooking dinner as they cook after sunset.

Third, most of the e-pressure cooker usage is primarily for cooking rice. In this case, using a more affordable e-rice cooker would be a more cost-effective option. This switch would not only lower electricity consumption but also reduce overall costs.

Fourth, field observation in the camps reveal that many households are privately using solar panels for light and also fan and the e-cooking system may not need to include option for light and fan.

Fifth, the electricity consumption associated with meal preparation has not been estimated because the team did not have data-logger installed. While we understand that nearly 62-63% of households can cook meals without battery support, we lack information on how much cooking they need to conduct after solar radiation is no longer available. This gap highlights the necessity for solutions that provide either battery support or LPG for cooking during those times.

Finally, the cooking timetables of refugee and host families differ, indicating that a one-size-fits-all policy may not be equally effective for both groups. Therefore, solutions should be tailored to accommodate the specific behavioral patterns of cooking for each group.

### **14.0 Cost-Benefit Analysis: Solar E-Cooking for Rohingya Households**

The discussion above indicates that there are multiple alternatives for implementing solar cooking solutions for both Rohingya and host communities. However, the current exercise is limited due to the small sample size of only 20 households in each group, representing a pre-pilot phase. During the pilot phase, a larger number of households should be tested to better understand adoption behavior across various household sizes, income levels (for host families), and educational backgrounds of the primary cook.

Although we recognize the need for further piloting, we have utilized the findings from the current pre-pilot phase to assess the feasibility of e-cooking using solar radiation. This is elaborated on in the following section.

We have evaluated two distinct packages for solar radiation-based e-cooking within the communities. Package 1 is a redesigned option that includes battery for power storage, while Package 2 consists of the same features but excludes the battery. In Package 2, we have also incorporated a limited provision for maintaining on-going LPG supply to accommodate cooking with LPG during early morning and late evening hours. A third alternative is to develop Package 3, which changes the current cooking timetable but includes additional interventions aimed at promoting behavioral changes among the users. This approach seeks to encourage adoption to solar cooking solutions without battery but with changes in cooking time. During the pilot phase, this can be tested also. However, in the current pre-pilot phase it was not tested among the households.

### ***Description of e-cooking options***

**Package 1 (With Battery):** This package consists of solar panels, a hybrid solar inverter, and a high-performance deep-cycle (HPD) battery. The battery stores energy for use during periods of insufficient sunlight and is anticipated to require replacement of battery in approximately every five years throughout the project's lifespan. Additionally, the package includes an infrared cooking stove and an electric rice cooker.

**Package 2 (Without Battery):** This system encompasses all components of Package 1 except for the storage cells (battery). It assumes the availability of a limited supplementary LPG supply to households to meet their cooking needs during periods of minimal solar radiation.

### ***Cost of the packages***

Based on the specifications and market survey data on e-cooking equipment, the costs of the packages are presented in Table 29. It indicates that the package with battery support will have an initial cost of 290,910 taka, along with a battery replacement cost of 85,200 taka every five years. In contrast, the package without battery support has an initial fixed cost of 205,710 taka. However, there is a need to supplement this package with limited LPG supply.

**Table 29: Cost of alternative solar e-cooking packages**

| Package 1             | In BDT  | Package 2               | In BDT  |
|-----------------------|---------|-------------------------|---------|
| Solar Panels          | 105,000 | Solar Panels            | 105,000 |
| Hybrid Solar Inverter | 85,000  | Hybrid Solar Inverter   | 85,000  |
| Battery HPD           | 85,200  | External Meter          | 10,000  |
| External Meter        | 10,000  | Infra-red cooking stove | 3,520   |

|                         |                |                    |                |
|-------------------------|----------------|--------------------|----------------|
| Infra-red cooking stove | 3,520          | Rice cooker 1.5 kg | 2,190          |
| Rice cooker 1.5 kg      | 2,190          |                    |                |
| <b>Package 1</b>        | <b>290,910</b> | <b>Package 2</b>   | <b>205,710</b> |

The cost-benefit analysis, along with a payback period analysis, has been conducted using the following data sources: a) cost of the package was estimated using market survey data, b) the observed usage behavior of e-cooking appliances during the experiment was used to capture changes in behavior at the household level, and c) a set of assumptions or parameters utilized for estimating the benefits.

Experimental data showed that daily LPG consumption is around 0.417 kg per day before the intervention while it is 0.097 kg per day after the intervention signifying a drop of LPG use by 76.6% in per-day while they practice using e-cooking appliances.

Assumptions or parameters used during economic and financial analysis (or payback analysis) are listed below.

In addition, the system's average daily electricity generation was recorded at 5.10 kWh, whereas the consumption was 2.95 kWh. The excess generation reflects a potential issue concerning the overcapacity of the installed systems. As such, the fixed costs have been adjusted by applying a 25% decrease in system capacity, which is more in line with the actual energy demands.

Every package was analyzed on the basis of two different financial conditions: one including the benefits of monetized carbon credits and the other ignoring them. In both instances, the prime performance indicators—Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR) and payback period were calculated for both packages.

**Table 30: Parameters used in the Analysis**

| Items and description                                 | amount | Unit                              |
|-------------------------------------------------------|--------|-----------------------------------|
| <b>Package 1</b>                                      | 290910 | in bDT                            |
| <b>Package 2</b>                                      | 205710 | in bDT                            |
| <b>Emission Reduction (ER)</b>                        |        |                                   |
| ER per household                                      | 0.99   | tCO <sub>2</sub> e per Refugee HH |
| ER per household                                      | 1.64   | tCO <sub>2</sub> e per Host HH    |
|                                                       |        |                                   |
| <b>Total Rohingya HH</b>                              | 204278 | UNHCR data                        |
| <b>Total Host HH</b>                                  | 121059 | Census 2022                       |
|                                                       |        |                                   |
| <b>E-cooking adoption rate</b>                        |        |                                   |
| for Rohingya HH                                       | 100%   | Assumption                        |
| for Host HH                                           | 100%   | Assumption                        |
|                                                       |        |                                   |
| <b>Life of battery</b>                                | 5      | years                             |
| <b>Price of Carbon in different compliant markets</b> |        |                                   |
| EU market                                             | 99.99  | USD per tCO <sub>2</sub> e        |
| Australian Market                                     | 21.9   | USD per tCO <sub>2</sub> e        |

| Items and description                      | amount | Unit                       |
|--------------------------------------------|--------|----------------------------|
| French market                              | 47.95  | USD per tCO <sub>2</sub> e |
| Canadian market                            | 58.95  | USD per tCO <sub>2</sub> e |
| Japanese market (used during the analysis) | 90.3   | USD per tCO <sub>2</sub> e |
| Exchange rate 1 USD =                      | 122    | BDT                        |
| Current use of LPG per day                 |        |                            |
| Rohingya HH                                | 0.417  | kg /day                    |
| Host HH                                    | 0.305  | kg /day                    |
| Price of LPG (per 12kg)                    | 1440   | BDT                        |
| Solar Panels                               | 105000 | BDT                        |
| Hybrid Solar Inverter                      | 85000  | BDT                        |
| Battery HPD                                | 85200  | BDT                        |
| External Meter                             | 10000  | BDT                        |
| infra-red cooker                           | 3520   | BDT                        |
| rice cooker 1.5 kg                         | 2190   | BDT                        |
| Percent reduction in LPG use               | 23.4%  | per day per hh             |
| Discount rate                              | 12%    |                            |
| Inflation rate                             | 8.00%  |                            |
| Real discount rate                         | 4.00%  |                            |

The cost-benefit analysis assumed that 100% of Rohingya families in the camps and 50% of host families would utilize solar-based cooking systems. For the implementation of solar e-cooking systems in refugee camps, the analysis included three scenarios: (i) a package with battery support, (ii) a package without battery, assuming 50% LPG usage, and (iii) a package without battery, assuming 23.5% LPG usage. Each model was evaluated both with and without carbon credit revenue to determine its financial viability.

**Table 31: Economic and Financial Analysis of Package 1 and Package 2**

| Economic analysis        | Package 1         | Package 2 |             |
|--------------------------|-------------------|-----------|-------------|
| Investment Cost          | 111,589.91        | 42,003.18 | million BDT |
| Present Value            |                   |           |             |
| PV of Costs              | 92,826.39         | 40,387.68 | million BDT |
| PV of carbon benefit     | 59,917.60         | 59,917.60 | million BDT |
| PV of LPG savings        | 68,142.11         | 52,176.31 | million BDT |
| Economic Analysis        |                   |           |             |
| NPV                      | 35,233.31         | 71,706.23 | million BDT |
| BCR                      | 1.38              | 2.78      |             |
| IRR                      | 19.51%            | 32.03%    |             |
| Benefits                 | 100,280           | 76,784    | million BDT |
| Investment Cost          | 59,400            | 42,003    | million BDT |
| Pay back period in years | 11.84             | 5.09      |             |
| Financial Analysis       |                   |           |             |
| NPV                      | <b>-51,009.95</b> | 11,654.32 | million BDT |
| BCR                      | 0.61              | 1.08      |             |
| IRR (nominal)            | ...               | 14.94%    |             |

Note: Estimated



Basic economic and financial analysis of investment in e-cooking systems using the assumptions and parameters listed in Table 30 indicates the following.

- a) Both Package 1 and Package 2 demonstrate economic efficiency, with an internal rate of return (IRR) of approximately 19.5% and 32%, respectively. This results in a benefit-cost ratio of about 1.38 for Package 1 and 2.78 for Package 2. Additionally, the net present value for both packages is positive.
- b) The income generated from carbon trading serves as a direct benefit to the project, while the associated costs does not include taxes and VAT incurred during the initial investment and ongoing operational and maintenance (O&M) expenses. In contrast, savings from LPG are not considered a direct benefit and are therefore excluded from the financial analysis.

As a result, the financial net present value (NPV) for Package 1 is negative, while Package 2 maintains a positive NPV. Additionally, the benefit-cost ratio (BCR) for Package 1 is less than 1, whereas for Package 2, it is greater than 1. This indicates that Package 2 is financially viable, provided that the carbon market remains active..

- c) The payback period for both Package 1 and Package 2 was evaluated. Package 1 has a payback period of approximately 12 years, while Package 2 enjoys a shorter payback period of around 5 years. This analysis takes into account the carbon pricing from the Japanese compliant market, which aligns with the Paris Agreement.

Additionally, Package 2 provides free LPG to refugee households for families that cook before sunrise and after sunset, enhancing its social impact.

- d) It has been concluded that Package 2 is both economically and financially viable and should be promoted for further analysis. This assessment is based on the assumption that the benefits from carbon trading will be received by the operator, who contributes to the reduction of carbon emissions by implementing e-cooking facilities.

Therefore, we recommend that UNHCR and IOM, the two organizations managing the Rohingya refugee camps in Bangladesh, should facilitate carbon trading and sell the credits in the compliant market. Compliant markets currently offer significantly higher prices compared to the voluntary market, which could enhance the financial returns of the project.

- e) In this analysis, it has been observed that approximately 50% of the total benefits come from the carbon market. For Package 2, however, this proportion is even higher, exceeding 50%.

- f) By integrating the compliant carbon market with introduction of e-cooking facilities, both UNHCR and IOM can stabilize their costs for supplying LPG. Since the project is financially viable, it means that the e-cooking facilities might be an independent option for even a commercial operator. However, we have used the Japanese market price to complete the primary analysis. To understand, other implications on economic and financial viability, we present the results of the sensitivity analysis in the following.

## **15.0 Sensitivity analysis**

The following section provides a sensitivity analysis on the assumptions and parameters utilized in the economic and financial evaluation of e-cooking facilities. This analysis focuses on a specific set of parameters, which is summarized in the table below, to assess whether any key assumptions exhibit significant sensitivity that could impact the financial or economic viability of the project.

It shows that a minimum of 37.2 USD per ton of CO<sub>2</sub>e will be required to make the project economically viable. It has been found that the rate of return is not sensitive to other assumptions.

**Table 32: Results of the Sensitivity analysis on key assumptions used during the economic and financial analysis and their implications**

| Item                           | Variables | Package 1        |      |        | Package 2        |      |        | payback for package 1 |            | payback for package 2 |            |
|--------------------------------|-----------|------------------|------|--------|------------------|------|--------|-----------------------|------------|-----------------------|------------|
|                                |           | NPV (in million) | BCR  | IRR    | NPV (in million) | BCR  | IRR    | with CC               | without CC | with CC               | without CC |
| Rohingya                       | 100%      | 35,233           | 1.38 | 19.51% | 71,706.23        | 2.78 | 32.03% | 11.84                 | 22.26      | 5.09                  | 10.94      |
|                                | 90%       | 33,290           | 1.38 | 19.57% | 67,583.63        | 2.79 | 32.14% | 11.82                 | 22.42      | 5.07                  | 11.02      |
|                                | 80%       | 31,346           | 1.39 | 19.64% | 63,461.02        | 2.80 | 32.27% | 11.79                 | 22.62      | 5.05                  | 11.12      |
|                                | 70%       | 29,402           | 1.39 | 19.71% | 59,338.42        | 2.81 | 32.43% | 11.75                 | 22.84      | 5.03                  | 11.23      |
| Host                           | 100%      | 35,233           | 1.38 | 19.51% | 71,706.23        | 2.78 | 32.03% | 11.84                 | 22.26      | 5.09                  | 10.94      |
|                                | 60%       | 28,915           | 1.37 | 19.25% | 59,514.15        | 2.73 | 31.52% | 11.96                 | 21.55      | 5.17                  | 10.59      |
|                                | 70%       | 30,495           | 1.37 | 19.32% | 62,562.17        | 2.74 | 31.66% | 11.93                 | 21.74      | 5.15                  | 10.69      |
|                                | 80%       | 32,074           | 1.37 | 19.39% | 65,610.19        | 2.76 | 31.79% | 11.90                 | 21.93      | 5.13                  | 10.78      |
| Carbon price in USD            |           |                  |      |        |                  |      |        |                       |            |                       |            |
| Carbon price @Japan Market     | 90.3      | 35,233           | 1.38 | 19.51% | 71,706.23        | 2.78 | 32.03% | 11.84                 | 22.26      | 5.09                  | 10.94      |
| Australia                      | 21.9      | (10,153)         | 0.89 | 9.66%  | 26,320.15        | 1.65 | 19.58% | 18.34                 | 22.26      | 8.56                  | 10.94      |
| price for package 2            | 0.00      | (24,684)         | 0.73 | 6.02%  | 11,788.64        | 1.29 | 15.53% | 22.26                 | 22.26      | 10.94                 | 10.94      |
| Price for package 1            | 37.20     | (0)              | 1.00 | 12.00% | 36,472.92        | 1.90 | 22.34% | 16.34                 | 22.26      | 7.43                  | 10.94      |
| France                         | 47.95     | 7,132            | 1.08 | 13.58% | 43,605.34        | 2.08 | 24.27% | 15.17                 | 22.26      | 6.80                  | 10.94      |
| Canada                         | 58.95     | 14,431           | 1.16 | 15.15% | 50,904.27        | 2.26 | 26.25% | 14.14                 | 22.26      | 6.25                  | 10.94      |
| max price                      | 167       | 86,127           | 1.93 | 30.23% | 122,599.69       | 4.04 | 47.89% | 8.47                  | 22.26      | 3.50                  | 10.94      |
| EU price                       | 99.99     | 41,663           | 1.45 | 20.84% | 78,135.93        | 2.93 | 33.87% | 11.28                 | 22.26      | 4.82                  | 10.94      |
| Savings on investment packages |           |                  |      |        |                  |      |        |                       |            |                       |            |
|                                | 25.00%    | 35,233           | 1.38 | 0.20   | 71,706.23        | 2.78 | 0.32   | 11.84                 | 22.26      | 5.09                  | 10.94      |
|                                | 15.00%    | 22,856           | 1.22 | 0.16   | 66,321.21        | 2.45 | 0.28   | 13.42                 | 25.22      | 5.77                  | 12.40      |
|                                | 20.00%    | 29,045           | 1.29 | 0.18   | 69,013.72        | 2.60 | 0.30   | 12.63                 | 23.74      | 5.43                  | 11.67      |
|                                | 25.00%    | 35,233           | 1.38 | 0.20   | 71,706.23        | 2.78 | 0.32   | 11.84                 | 22.26      | 5.09                  | 10.94      |
|                                | 30.00%    | 41,422           | 1.48 | 0.21   | 74,398.74        | 2.97 | 0.34   | 11.05                 | 20.77      | 4.75                  | 10.21      |

The sensitivity analysis shown in Table 32 yields intriguing findings. Firstly, as the adoption rate of the e-cooking system increases among the Rohingya communities, the Internal Rate of Return (IRR) also rises. However, this trend does not apply to the host communities. This discrepancy is attributed to the distinct cooking habits of these communities. Many members of the host community prepare their meals early in the morning, as they leave for agricultural work at dawn, and they also cook their dinner after sunset. This means that if the cooking behavior of host communities is not modified, adoption of e-cooking is not going to be an attractive option.

Second, as the price of carbon in the carbon market increases, the returns also rise. However, if the carbon price falls below \$37.20, Package 1 becomes infeasible. In contrast, Package 2 appears to be feasible even in the absence of carbon pricing.

Third, with carbon credits, the payback period is reduced both for package 1 and package 2. However, the payback period for package 2 can be as low as 3.5 years if carbon credit can be sold at the maximum price of 167 USD. This implies that the relevant carbon credit market is the compliant market for carbon credit where price is much higher than the voluntary carbon credit market.

## **15.0 Study Design Issues for Pilot Phase**

Considering all the options available and the sensitivity analysis, we suggest that during the pilot experiment, the study should concentrate on the following:

- Further research is needed on Package 2 to gain a deeper understanding of its implications, particularly regarding the carbon credit landscape. The present analysis used a standard IPCC methodology, specifically the "METHODOLOGY-SDG IQ Methodology for metered & measured energy cooking devices, Version 1.0," along with the ER calculation sheet developed by MECS (Modern Energy Cooking Services) and goldstandard.org whereas for using carbon market a more field level measurement of emission may be required.
- The pilot phase should focus on Rohingya communities only, with an emphasis on accommodating various household sizes.
- The selection of refugee households for the pilot phase must include a diverse range of characteristics, taking into account local geographical differences such as tree cover, the orientation of houses (east-west vs. north-south), and varying weather conditions (rainy vs. sunny days) to ensure that the design is adaptable for all weather scenarios.

- During the pilot phase, efforts should also focus on altering cooking behaviors to minimize the use of LPG. The pre-pilot phase, which occurred during dry weather, did not allow for insights into how household cooking practices might change during periods of cloudy or rainy weather.
- For cooking after sunset, Package 2 presumes a continuous but limited supply of LPG. The study team should examine this assumption during the pilot phase and consider redesigning the refill cycle to suit different household sizes.
- Host communities currently have access to grid electricity, although its supply is intermittent. It is anticipated that once the Rohingya communities start using e-cooking solutions, this will encourage the host communities to also adopt similar e-cooking technologies.
- The accumulation of dust on solar panels poses a significant challenge, as it reduces their effectiveness. While cleaning was carried out during each round of experiments in this phase, permanent installation of solar panels on rooftops may lead to persistent dust accumulation. It is important to study this issue further during the pilot phase to establish an effective solar panel management plan and develop a robust dust management strategy.

## **16.0 Limitations of the study**

This section highlights some of the key limitations of the study that should inform the stakeholders what to adopt, what to avoid and what may be further examined in the potential pilot phase of the study.

### **16.1 Sample Size and Sampling Technique of HH Demonstration Survey**

The study employed a small convenience sample of 40 households, of which 20 were from refugee camps while another 20 came from host communities in the household demonstration part of solar system-based e-cooking appliances. The small sample restricts the possibility of generalization of the findings. At the same time, a randomized sampling will allow to ensure that results are robust and replicable.

### **16.2 Data Logger issue**

During this phase, it was not possible to accurately measure the extent of energy use during each session of cooking. Data loggers were only installed during the fourth round, as well as only one house per community. This minimized the ability to capture changes over time, as well as among/between meals.

### **16.3 LPG use behavior**

Throughout this phase of the study, households were not actively discouraged from using LPG, as there was no changes to the refill cycle. Consequently, the behavior of households using LPG during periods of

low solar radiation was not examined. To facilitate a smoother transition from LPG to e-cooking solutions, it is essential to monitor this behavior, particularly in cases of limited LPG supply.

#### **16.4 Clustering-Based Electricity Distribution Remain Untested**

There has been a discussion to use community-based solar panels and distribute electricity among the neighborhood households to study whether it is a more effective and cheaper e-cooking solution in the Rohingya camps. This was not tested during the pre-pilot phase.