FEASIBILITY STUDY REPORT:

E-COOKING IN ROHINGYA REFUGEE CAMPS AND HOST COMMUNITIES, **COX'S BAZAR, BANGLADESH**

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MECS Modern Energy Cooking Services

Acknowledgment

This e-cooking feasibility research was delivered by the Global Platform for Action on Sustainable Energy in Displacement Settings – United Nations Institute for Training and Research (GPA-UNITAR) and partners (IUCN and Practical Action) as part of its work to identify sustainable and scalable energy delivery models in humanitarian settings. The study was funded by the UK Foreign, Commonwealth and Development Office (FCDO) through the Modern Energy Cooking Services (MECS) programme. We extend our sincere thanks to UNHCR and IOM Bangladesh for their valuable review of the reports and continuous support throughout implementation. The findings of this research have directly informed the design of an upcoming e-cooking pilot, which will be implemented by Mercy Corps in the Rohingya refugee camps and host communities in Cox's Bazar, Bangladesh, under the Transforming Humanitarian Energy Access (THEA) programme, also funded by FCDO via the Transforming Energy Access (TEA) Platform managed by the Carbon Trust. Further updates on its implementation will be shared in due course.

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Acronyms

BBS	Bangladesh Bureau of Statistics
BCR	Benefit-Cost Ratio
BDT	Bangladeshi Taka
BERC	Bangladesh Energy Regulatory Council
EMI	Equated Monthly Instalment
EPCs	Electric Pressure Cookers
ER	Emission Reduction
EU	European Union
FAO	Food and Agriculture Organisation
FCS	Food Consumption Score
FDMNs	Forcibly Displaced Myanmar Nationals
FGDs	Focus Group Discussions
GoB	Government of Bangladesh
GPA	Global Platform for Action on Sustainable Energy in Displacement Settings
HH	Household
HPD	High-Performance Deep cycle
IOM	International Organisation for Migration
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
KW	Kilowatt
LPG	Liquefied Petroleum Gas
LS	Load Shedding
MECS	Modern Energy Cooking Services
NBR	National Board of Revenue
NGOs	Non-Governmental Organisations
NPV	Net Present Value
O&M	Operational and Maintenance
PA	Practical Action
PV	Photovoltaic
RRRC	Refugee Relief and Repatriation Commissioner
SPF	Sun Protection Factor
SREDA	Sustainable and Renewable Energy Development Authority
SS	Sample Size
UNHCR	United Nations High Commissioner for Refugees
UNITAR	United Nations Institute for Training and Research
USD	United States Dollar
VAT	Value Added Tax
WFP	World Food Programme

Executive summary

The district of Cox's Bazar in Bangladesh hosts over one million Rohingya refugees across 33 camps. The Rohingya crisis remains one of the world's most complex and protracted humanitarian emergencies. Large-scale forced displacements from Myanmar's Rakhine State occurred in 1978, 1992, 2012, and 2016, culminating in the mass exodus of August 2017, which brought over 700,000 Rohingyas into Bangladesh. More recently, renewed inter-communal violence in Myanmar since late 2023 has displaced hundreds of thousands internally, with thousands more crossing into Bangladesh throughout 2024 and even 2025. Since their mass influx in 2017, the reliance on firewood for cooking placed immense pressure on surrounding forests, with as much as three to five football fields cleared daily (UNHCR, 2017). To curb deforestation and improve safety, UNHCR and IOM launched one of the world's largest clean cooking interventions, providing free LPG cylinders and stoves to more than 200,000 refugee households. By 2019, this transition reduced forest dependence by 80%. However, rising LPG import costs, declining humanitarian funding, and restrictive policies limiting refugees' ability to earn an income have since placed this approach at risk.

In response, UNITAR's GPA Coordination Unit, with IUCN and Practical Action, assessed the feasibility of solar-powered electric cooking (e-cooking) for both refugees and host communities. The study combined a baseline survey of 1,046 households (425 refugee and 621 host), a market assessment across eight marketplaces, and a household-level pilot with 40 families (20 refugee, 20 host community). Each pilot household received a 3 kWp solar PV system with four batteries, a hybrid inverter, as well as three appliances: an induction stove, infrared stove, and 6-litre electric pressure cooker (EPC) for a 7–10-day period.

The baseline survey from this feasibility study confirmed stark inequalities. Refugee households earned on average less than BDT 5,000 (USD 42) per month, with 10% reporting no income, compared to host households averaging BDT 19,180 (USD 160). Nearly all refugees (98.9%) depended on LPG, though 49% reported monthly shortages that forced them to turn to firewood, averaging 2.1 kg/day during those periods. Hosts relied on firewood (80% at 3.5 kg/day), LPG (48% at 0.4 kg/day), and charcoal (8% at 0.4 kg/day), with 18% already using small e-cooking appliances such as rice cookers.

Willingness to adopt solar e-cooking was striking: 82.8% of refugee households and 63.3% of host households expressed interest, citing time savings (56%), reduced fuel costs (46%), and health benefits (up to 58%). Demonstrations reinforced this demand, with over 90% of participants reporting satisfaction. Cooking patterns however appeared to diverge with 69% completing dinner before 5:30 PM, while 83% of host families cooked later, preparing dinner after sunset. This pattern highlights differing technology needs: battery-free systems for refugees versus battery-backed or hybrid LPG-solar systems for hosts.

Pilot data showed that systems consistently generated more electricity than they used - 5.1 kWh/day produced versus 3.0–3.2 kWh/day consumed - underscoring opportunities to downsize and reduce costs. Appliance use revealed clear preferences: infrared stoves accounted for 46% of cooking, EPCs for 22%, and induction stoves for 29%. While EPCs were valued for convenience and speed, their cost and energy intensity suggested rice cookers could be a cheaper, more efficient alternative for households on primarily rice-based diets.

Yet affordability remains the largest barrier. Each household PV system consisting of the PV panels, inverter, batteries and the three appliances (EPC, induction and infrared stove), cost approximately USD 2,600—far beyond the means of refugees and most host families. Concerns about theft of panels, fragile shelter structures, limited repair services, unreliable grid electricity, and fears of losing LPG distributions were also consistently raised.

Overall, the study found that that solar e-cooking is technically viable, socially acceptable, and environmentally beneficial, but scaling it requires a phased, community-centred approach. The next step is an economic and financial modelling exercise to identify affordable configurations—smaller PV systems, hybrid designs, and appliance-only options—and to evaluate carbon finance potential. Early sensitivity analysis suggests that revenues from carbon credits, combined with subsidies or instalment-based financing, could make solar e-cooking feasible at scale. With the right design, solar e-cooking can move beyond a pilot to become a catalyst for safer, healthier, and more dignified lives for refugees and host communities in Cox's Bazar.

1.0 Introduction and background


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Bangladesh hosts one of the world's largest refugee populations, with over 1 million Rohingya refugees currently residing in 33 IOM and UNHCR managed camps across Ukhiya and Teknaf in Cox's Bazar, as well as Bhasan Char Island. The majority arrived during the 2017 crisis, when military crackdowns in Myanmar's Rakhine State forced approximately 740,000 people to flee within a few months. This mass and rapid displacement placed immense pressure on the environmentally fragile Cox's Bazar region, which is highly vulnerable to flooding, landslides, and other climate risks. Despite significant humanitarian assistance from the Government of Bangladesh, UNHCR, IOM, and partners, refugees have remained in protracted displacement, reliant on humanitarian support for shelter, food, and energy access.

From the onset of the 2017 influx, energy access for cooking emerged as a critical humanitarian and environmental challenge. Refugees depended heavily on firewood, mainly collected from surrounding forests, leading to severe deforestation (estimated at three to five football fields per day) and heightened tensions with host communities (UNHCR, 2017). The use of firewood for cooking also generated dangerous indoor air pollution, causing respiratory illnesses, while women and children faced heightened protection risks during fuel collection. In response, UNHCR conducted research and cost-benefit analyses (across multiple fuel options) that identified Liquefied Petroleum Gas (LPG) as the most viable solution. Beginning in 2018, a large-scale LPG transition programme was launched, distributing single-burner stoves and cylinders to refugee households. Over 200,000 Rohingya refugee households have been receiving free LPG asset and refills from IOM and UNHCR to reduce deforestation and improve social cohesion with host communities in Cox's Bazar. Some surrounding host community households also received a free LPG assets and refills for about 6 months during the first phase of the LPG roll out programme in 2018. Multiple studies have documented the environmental, social, and health benefits of LPG provision, including a study carried out in 2019 by the International Union for Conservation of Nature (IUCN), which revealed that the LPG rollout contributed to an 80% decrease on forest reliance by refugees (IUCN, 2019). 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 biomass stoves, further reducing the pressure on forest resources (Bari et al, 2022).

Despite these positive outcomes, the rising cost of import-dependent LPG, declining funding availability, and policies that prevent refugees from earning income and contributing to cooking fuel costs have undermined the sustainability of maintaining a stable LPG supply. This has increased the risk of reverting to environmentally harmful practices, such as collecting firewood from surrounding forests. These challenges highlight the need to explore alternative clean and sustainable cooking technologies that can reduce the financial burden of LPG provision and strengthen the long-term resilience of both host and refugee communities. In addition, transitioning to cleaner technologies could unlock access to climate mitigation funds and other innovative financing opportunities.

Against this backdrop, UNITAR, through the Global Platform for Action (GPA) on Sustainable Energy in Displacement Settings, in collaboration with IUCN and Practical Action (PA), conducted a study to assess the feasibility of introducing e-cooking solutions to the Rohingya refugee and host community households. The study examines the technical, operational, economic, and financial viability of using solar PV-powered appliances such as electric pressure cookers (EPCs), induction cookers, and infrared cookers in these communities. It also analyses existing market supply chains and user behaviour. The key research questions addressed are as follows:

a) Are solar PV powered modern cooking solutions feasible for adoption in the Rohingya refugee camps and host communities?

b) What are the enablers, opportunities, and barriers for introducing solar PV powered e-cooking solutions in the refugee camps and the surrounding host communities?

To meet the objectives of the study, the study was structured as follows:

- First, a baseline household survey was conducted between November and December 2024, in both refugee and host communities to understand the demographic characteristics, cooking practices, and energy sources used for cooking. The survey also captured information on income levels, electricity access, and willingness to transition to e-cooking solutions. A market survey was also conducted alongside the household survey, to assess the availability and pricing of various cooking fuels and technologies in the local markets.
- Following the baseline survey, a small-scale solar PV-powered e-cooking demonstration was conducted from January to March 2025 in both refugee and host communities (20 households each). A complete system (PV panels, battery, inverter, EPC, infrared, and induction stove) was installed in each household for seven to ten days, during which users received training and daily in-person data collection was carried out. In addition, public e-cooking demonstrations were held to gather feedback from individuals who could not participate in the household-level demonstrations.
- Finally, the baseline survey and household demonstration findings informed a cost–benefit analysis and high-level carbon finance modelling to assess both the environmental and financial benefits of introducing e-cooking in the camps, as well as the potential to generate carbon credits to support scaled roll-out. The cost–benefit analysis will be published in the coming months, once additional work is completed to align with partner analyses and incorporate data from the forthcoming larger e-cooking pilot, ensuring a more robust and comprehensive assessment.

Accordingly, this report is structured to present the findings in a logical sequence. It begins with the baseline survey results, followed by insights from the household and public e-cooking demonstrations. It then outlines the preliminary cost–benefit and carbon finance assessments, noting that further work is underway.

2. Household baseline survey: Approach and findings

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The baseline survey was conducted between November and December 2024 across eight areas in Cox's Bazar district: four in refugee camps (led by IUCN) and four in host communities (led by Practical Action) within Ukhiya and Ramu upazilas (or sub-districts). Refugee households were selected from Camps 1W and 21 (both camps managed by UNHCR), and camps 20 Extension, and 21 (managed by IOM), which together housed 20,085 households as of December 2024 (UNHCR). Host community sites included Raja Palong and Holodia Palong in Ukhiya Upazila, and Rajarkul and South Mithachhari in Ramu upazila. According to the 2022 Population and Housing Census provided by Bangladesh Bureau of Statistics (BBS), Ukhiya upazila has an estimated 55,982 households while Ramu upazila has an estimated 69,125 households (BBS, 2023a). Following the sample size determination process outlined in Annex A, a total of 425 refugee households and 621 host community households were selected for the baseline survey as per the breakdown presented in **Table 1.**

Table 1: Sample size selected per community

Refugee Camps				**Host Community**			
Location	**Population (# of hhs)**	**Sample size**	**% of total sample**	**Location**	**Population (# of hhs)**	**Sample size**	**% of total sample**
Camp_21	3,696	107	25.2	Raja Palong (Ukhiya)	55,982	152	24.5
Camp_1W	8,364	105	24.7	Holodia Palong (Ukhiya)		166	26.7
Camp_19	5,488	108	25.4	Rajarkul (Ramu)	69,125	156	25.1
Camp_20Ext	2,537	105	24.7	South Mithachhari (Ramu)		147	23.7
Total	**20,085**	**425**	**100.0**	Total	**125,107**	**621**	**100.0**

Enumerators received two days of in-person training on administering the household surveys using Kobo Toolbox, followed by a community-based pilot test before the full rollout.

Photo 1: Enumerator training for baseline data collection in host and refugee community, jointly organized by IUCN and Practical Action ©IUCN/Sarwar

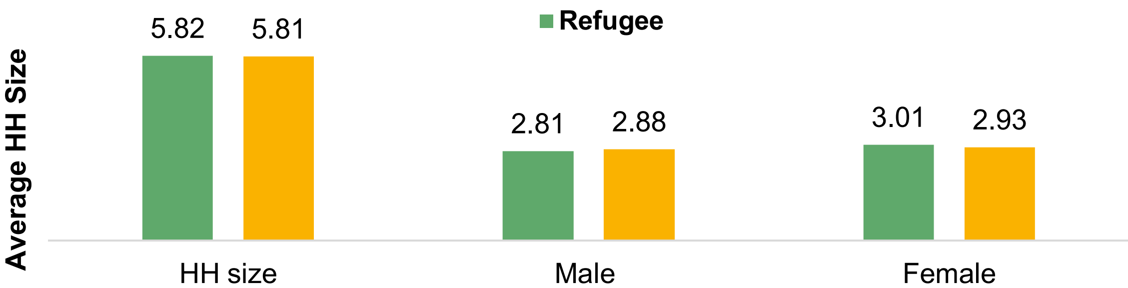
2.1. Household socioeconomic and demographic characteristics

The following section presents the socioeconomic and demographic characteristics of both refugee and host community households.

2.1.1. Household Size.

Figure 1 shows that average household size is almost identical between refugees (5.82 members) and hosts (5.81 members). Gender composition varies slightly, with refugee households having fewer males (2.81 vs. 2.88) but more females (3.01 vs. 2.93). These subtle differences may reflect demographic patterns linked to displacement, family structure, or registration status within the camps.

Figure 1: Household size by gender and by communities



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%). As expected, the average number of members per household earning is also lower in refugee households (0.81) than in host households (1.36).

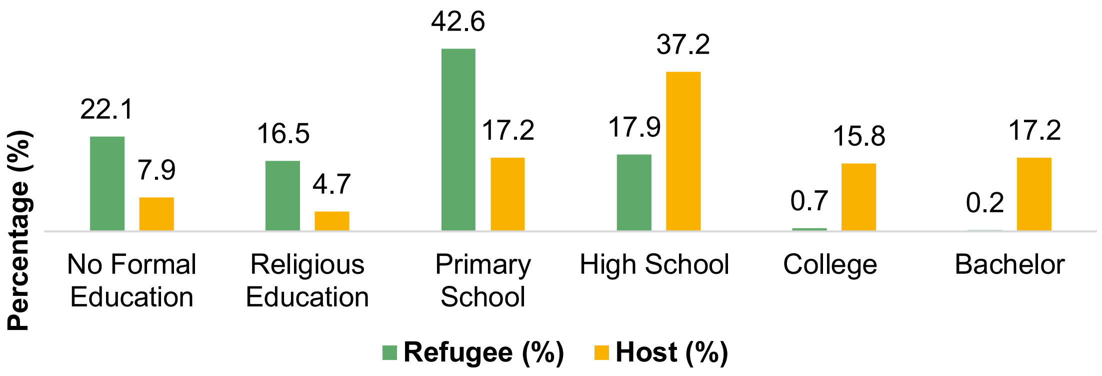
Table 2: Other household demographic characteristics

	Refugee			Host		
Parameter	**No of HHs**	**% of HHs**	**Av. no of people per HH (overall)**	**# of HHs**	**% of HHs**	**Av. no of people per HH (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**
Elderly members (above 60 years)	**84**	**20%**	**0.23**	**215**	**35%**	**0.38**
Student	**327**	**77%**	**1.80**	**484**	**78%**	**1.67**
Earning members	**320**	**75%**	**0.81**	**597**	**96%**	**1.36**

2.1.2. Educational profile

Figure 2 highlights marked differences in educational attainment between refugee and host communities. Among refugees, 22.1% have no formal education (vs. 7.9% of hosts), 16.5% rely on religious education (vs. 4.7%), and 42.6% have only primary education (vs. 17.2%). Hosts appear to show higher attainment: 37.2% completed high school (vs. 17.9% of refugees), 15.8% attended college (vs. 0.7%), and 17.2% hold a bachelor's degree (vs. 0.2%).

Figure 2: Highest educational level attained



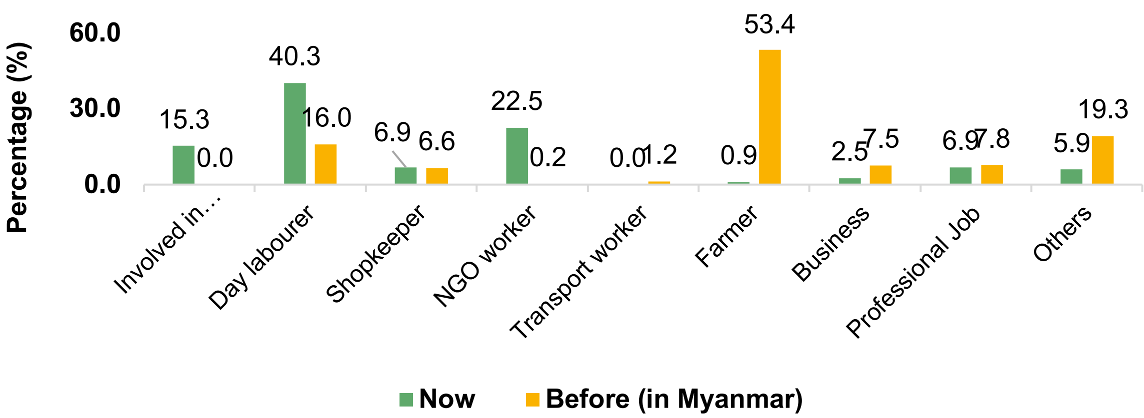
This data reflects a substantial educational gap between the two communities, with refugees having significantly lower access to formal and higher education opportunities. The gap is likely to widen further, as current educational provisions in refugee camps are largely limited to primary schooling (mainly focused on the Myanmar curriculum) and religious instruction. Formal pathways to secondary education, college, or vocational training remain largely absent, which restricts long-term development and integration prospects for the refugee population.

Photo 2: Baseline survey data collection at refugee camps ©IUCN

2.1.3. Occupational profile of household members

Figure 3 compares refugee occupations before and after displacement. Farming, once the main livelihood for 53.4% in Myanmar, has dropped to just 0.9% under current land and work restrictions in Bangladesh. Post-displacement, refugee livelihoods shifted as well with 15.3% working in camp-based activities (distribution, community mobilisation, hygiene promotion, and basic education support), while 22.5% are engaged by NGOs in support roles, mainly as volunteers or part-time within income and geographical restrictions.

Figure 3: Current vs pre-migration occupation of refugee households (% of People)



One notable shift is the rise in the proportion of day labourers, which increased from 16.0% before migration to 40.3% at present. This category includes informal, irregular, and often undocumented work arrangements, such as construction work, small-scale loading and unloading tasks, agricultural support in nearby villages, and other forms of manual labour within or just outside the camp periphery. While official policies prohibit formal employment for FDMNs, enforcement gaps and economic necessity have led to informal labour markets where refugees find short-term, low-paid opportunities. The rise in day labour among refugees can be understood as a coping mechanism in response to the lack of formal livelihood options, rather than as a formal employment trend. It reflects both the precarious economic reality of refugee life and the limited livelihood alternatives available under the current policy landscape.

In contrast, the occupational distribution among host community households remains more diversified due to the absence of legal restrictions. A significant portion are day labourers (23.8%), followed by those engaged in business (22.8%) and farming (18.8%). Other notable occupations include work in the transport sector (13.2%), shopkeeping (11.7%), professional jobs (14.9%), and NGO employment (3.0%). A small share (0.7%) of host community members also participates in camp-related activities, such as logistics, water distribution, site management, construction, latrine installation, maintenance services, and serving as local contractors or service providers in coordination with humanitarian agencies (Figure 4).

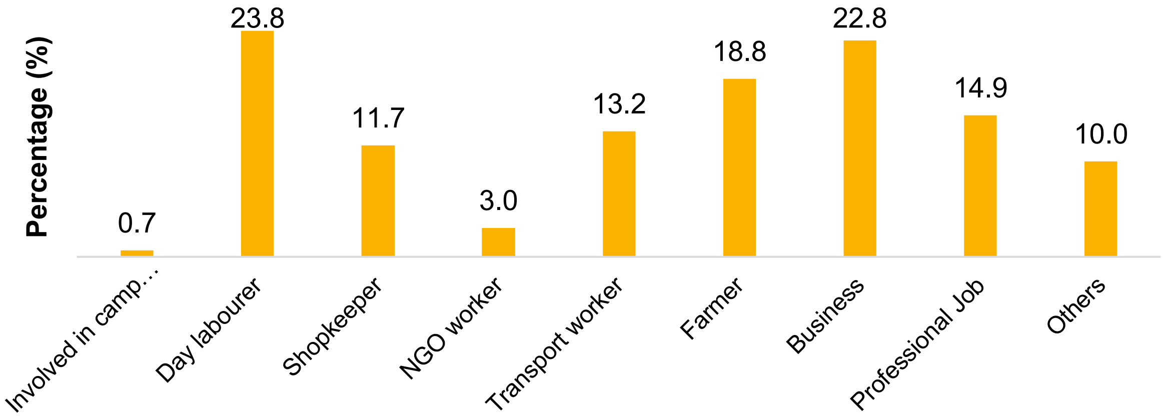


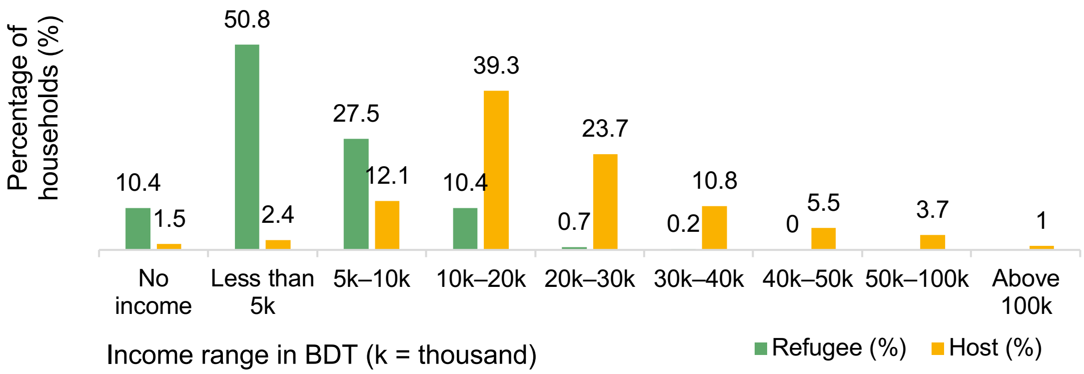
Figure 4: Occupation of host community (% of people earning)

2.1.4. *Household income and expenditure*

Refugee households face severe economic challenges, with 50.8% earning under BDT 5,000 (USD 42) per month and 10.4% reporting no income (Figure 5). Another 27.5% earn BDT 5,000–10,000 (USD 42–83) and 10.4% fall within BDT 10,000–20,000 (USD 83–167). In contrast, host households show higher incomes: 39.3% earn BDT 10,000–20,000 (USD 83–167), 23.7% earn BDT 20,000–30,000 (USD 167–250), and 10.8% earn BDT 30,000–40,000 (USD 250–333), reflecting broader livelihood opportunities and mobility.

For context, the national average monthly household income in Bangladesh in 2022 was BDT 32,422 (USD 270) (BBS, 2023b). Refugee households earn well below this - most less than one-sixth - while host households are closer to the average but still largely below it, reflecting challenges such as underemployment, inflation, and limited rural economic diversification.

Figure 5: Household monthly income distribution per community



Expenditure data further underscores this disparity. Refugee households report an average monthly expenditure of BDT 8,596 (USD 72), with a striking 71.7% spent on food (Table 3). This is despite receiving food assistance from the World Food Programme (WFP), which provides vouchers for essential staples like rice, lentils, and oil. The continued high share of food expenditure suggests that refugees must supplement these provisions to address nutritional adequacy and household dietary preferences, highlighting both the limitations of current assistance models and the constrained economic environment.

In comparison, host households report a significantly higher monthly expenditure of BDT 19,180 (USD 160), with 59.2% directed toward food (**Table 3**). It is of note that host households rely entirely on market purchases. Their broader participation in income-generating activities allows for more diversified consumption, although their expenditure patterns still reflect economic stress.

Table 3: Average monthly household expenditure and percentage spent on food

Community	Average monthly HH expenses		% spent on food
	BDT	**USD**	
Refugee	8,596	72	71.7%
Host	19,180	160	59.2%

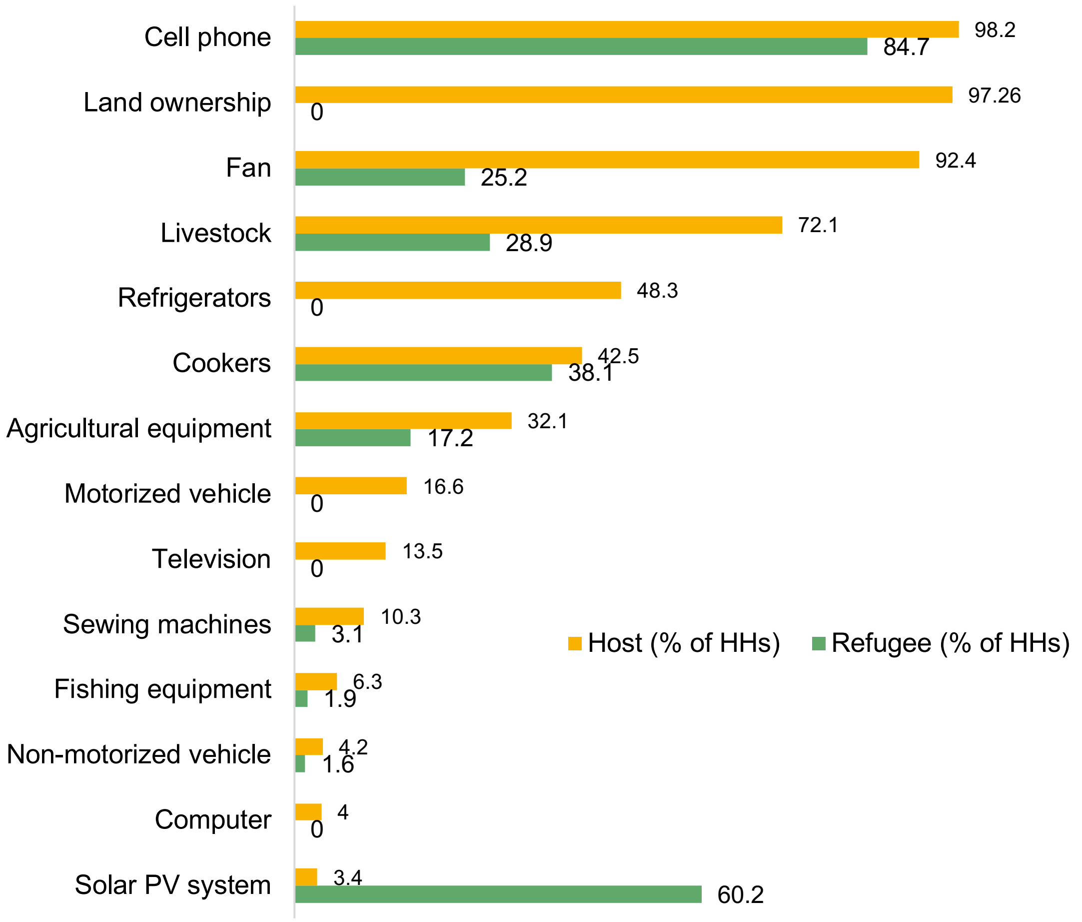
These findings underscore a multidimensional economic gap between refugee and host communities. Refugees face compounded constraints (legal, economic, and humanitarian) that suppress their earning potential while host communities, though more economically integrated, remain vulnerable in comparison to national averages.

2.1.5. Household asset ownership

About 60.2% of refugee households report owning solar home systems compared to just 3.4% of host households

Figure 6). While this appears significant, it should be interpreted in context. Refugee camps lack access to grid electricity, and the solar systems in use are typically low-capacity, donor-supplied kits intended for basic functions such as lighting, phone charging, and in a few cases, operating small fans for limited hours. These systems cannot support high-energy intensive appliances, which is further reflected in the absence of refrigerators, computers, or television sets among refugee households.

Figure 6: Asset ownership among households



Generally, asset ownership among refugee households is also limited. Only 28.9% of refugee households own livestock (26% poultry, 1.2% cattle and 0.9% others) compared to 72.1% livestock ownership in the host community (65.5% poultry, 65.5% cattle and 9.5% others). Refugees in Bangladesh are not permitted to own land and lack formal access to employment or credit, which severely limits their ability to invest in productive or durable assets. The relatively high rate of mobile phone ownership (84.7%) reflects practical necessity for communication and access to humanitarian services and should not be mistaken as an indicator of household wealth.

In contrast, host community households display far higher asset ownership, enabled by legal land rights and greater economic mobility. Almost all (97.3%) own residential or agricultural land, providing a foundation for livelihoods and long-term wealth. Of these, 88.9% hold residential plots averaging 35.6 decimals (~1,448 m²), while 13.9% possess agricultural land averaging 141.4 decimals (~5,745 m²) (Table 4). Such assets underpin resilience and intergenerational wealth - opportunities legally denied to refugees.

Table 4: Land ownership in host communities

Land type	Nº of HHs	% of HHs	Average size of land	
			in decimal	m^2
Dwellings	552	88.89	35.6	1,448
Agricultural land	86	13.85	141.4	5,745
Others	45	7.25	22.1	894

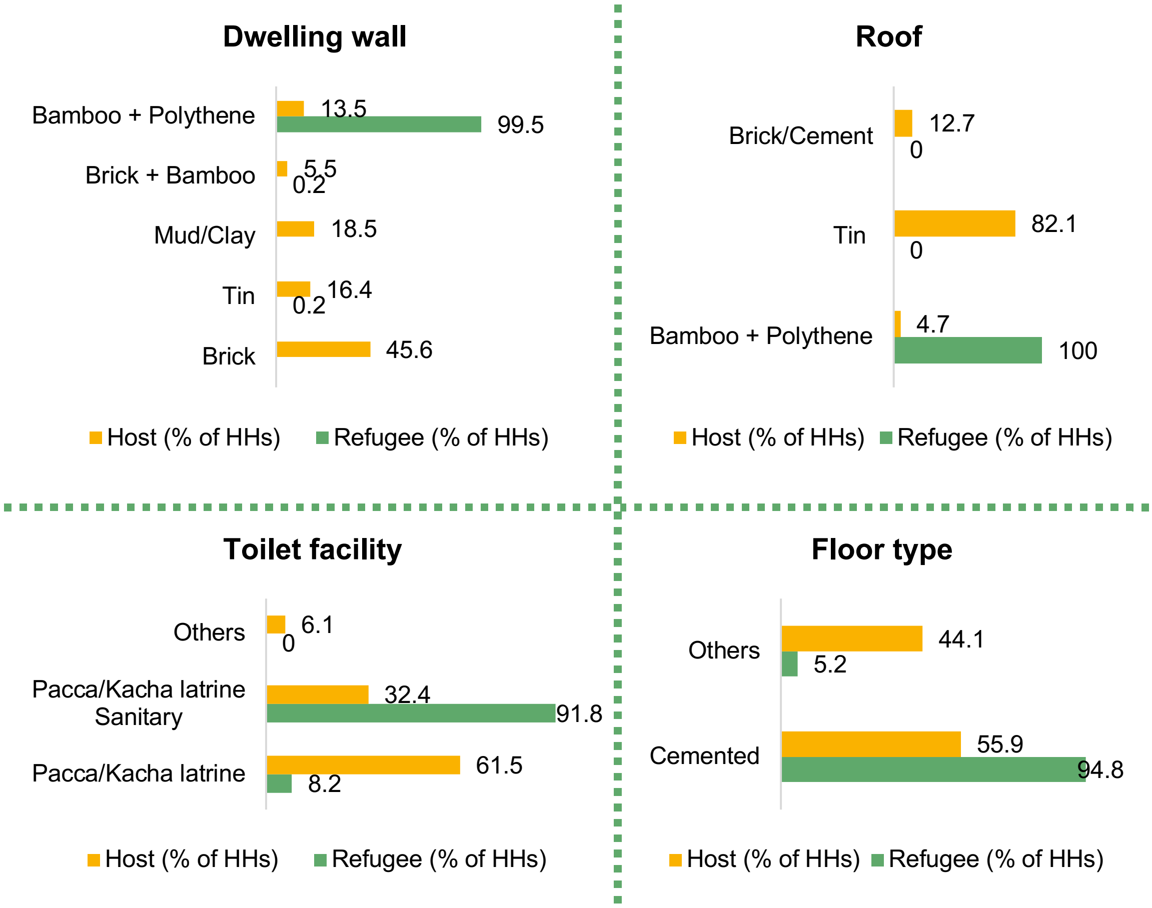
2.1.6. Housing structure

Table 4 presents data on housing characteristics among refugee and host community households, but the stark contrast in living conditions is not fully conveyed through statistical comparison alone. Refugee households almost exclusively reside in temporary shelters constructed from bamboo and polythene sheeting (99.5%), with similar materials used for roofing (100%). These shelters, typically limited to a single small room per family, are built on camp-assigned plots without legal tenure. They offer minimal structural integrity, lack sufficient insulation, and are highly vulnerable to extreme weather. Lightweight doors and thin walls provide minimal insulation, soundproofing, and security. Due to weather exposure and material deterioration, they usually require repairs or partial rebuilding each year.

Despite 94.8% of refugee households reporting cemented floors, overall shelter conditions remain basic and fragile in terms of durability. Inadequate drainage and ventilation make it difficult to maintain indoor dryness and air quality, especially during the monsoon season. Sanitation is primarily communal, with 91.8% of households relying on shared ‘pacca/kacha’ (permanent/semi-permanent) sanitary latrines.

In contrast, host community households display more varied and durable housing structures. Nearly half (45.6%) live in brick-walled houses, and an additional 16.4% in tin-walled dwellings, with roofs made predominantly of tin (82.1%) or brick and cement (12.7%). While only 55.9% have cemented floors, many homes offer better protection, space, and privacy. Toilet facilities are usually private and located on the premises, with 61.5% of households using ‘pacca/kacha’ (permanent/semi-permanent) latrines and 32.4% reporting sanitary latrines (Figure 7).

Figure 7: Housing structures and sanitation facilities among refugee and host households



2.1.7. Observable kitchen-related information

The differences in kitchen setups between refugee and host communities are highlighted in **Table 5**. These notable differences can be understood within the broader context of their housing environments. Refugee shelters, often small and built with bamboo and polythene, typically lack defined spaces for cooking. As a result, only 29.7% of refugee households report having a separate kitchen, compared to 54.3% among host households, who typically live in larger, more permanent structures. Similarly, fewer refugee kitchens have separate doors (42.1% vs. 71.0%), although a slightly higher share report having windows (64.7% vs. 59.3%); in refugee shelters, these often refer to basic ventilation openings rather than standard windows.

Table 5: Kitchen-related information

Observable kitchen-related characteristics	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 use	43.8	60.1

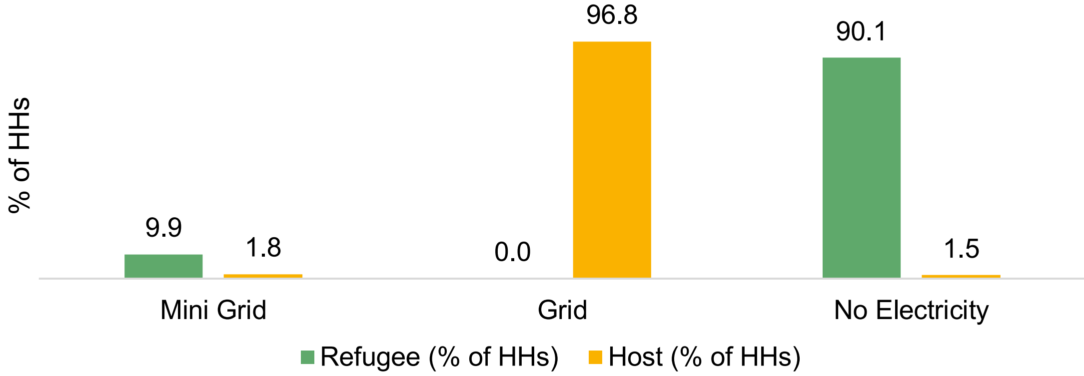
Firewood use and storage also differ, influenced by availability of space and safety considerations. Among host households using firewood, 70.4% had visible firewood stacks, compared to only 39.8% in refugee settings. Observed firewood use was also higher among host households (60.1%) than refugees (43.8%). These differences in kitchen structure and fuel handling reflect broader disparities in housing size, layout, and permanence. They are particularly relevant when assessing indoor air pollution risks, as cooking in small, poorly ventilated shelters increases exposure to smoke and related health hazards.

Photo 3: Typical kitchen in a refugee shelter © IUCN

2.2. Access to electricity

Figure 8 highlights stark disparities in electricity access between refugee and host households. Nearly all host households (96.8%) are connected to the national grid, compared to none of the refugees. Instead, 90.1% of refugee households have no electricity access, with just 9.9% relying on small camp mini grids (compared to 1.8% of hosts). While humanitarian agencies and NGOs are working to expand mini-grid installations for basic needs such as lighting, phone charging, and small devices, coverage remains limited. Solar-powered streetlights have been deployed to improve safety and mobility at night, though many are reported as non-functional.

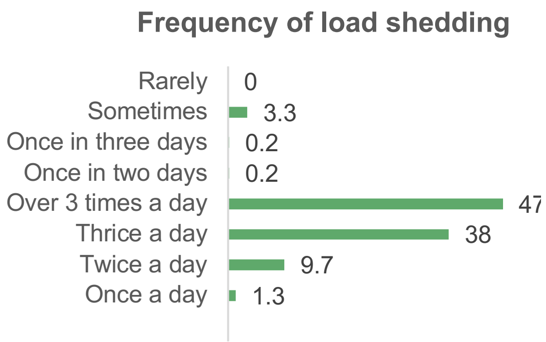
Figure 8: Access to electricity among refugee and host households

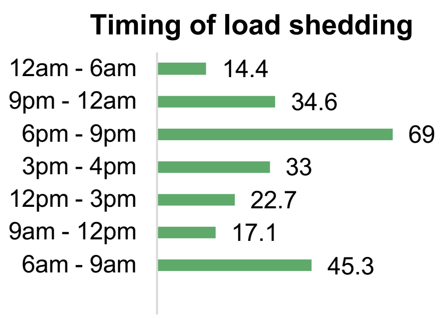


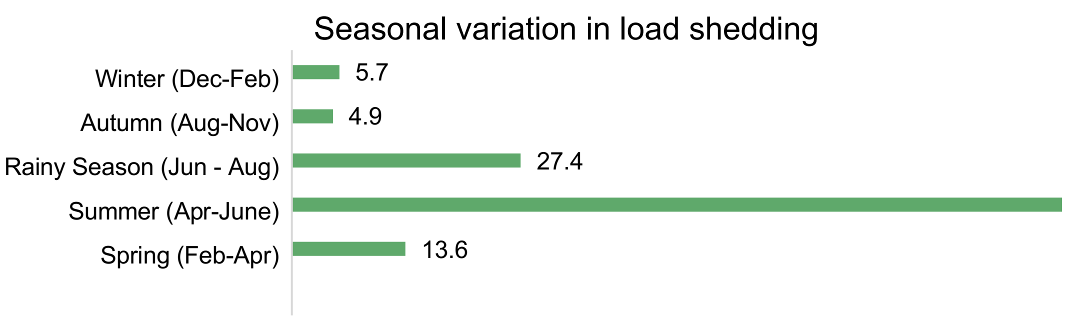
2.2.1. Frequency of load-shedding among host community households

Most host households (96.3%) experience load shedding, with about 85.3% facing power cuts three or more times a day. Outages mainly occur during peak cooking hours; 69% in the evening (6 - 9 PM) and 45.3% in the morning (6 - 9 AM). Disruptions are most severe in summer (93.3%), when demand for cooling with fans and air conditioners exceeds grid capacity, and much lower in winter (5.7%) and autumn (4.9%) (Figure 9).

Figure 9: Load shedding (LS) in host community households with electricity access







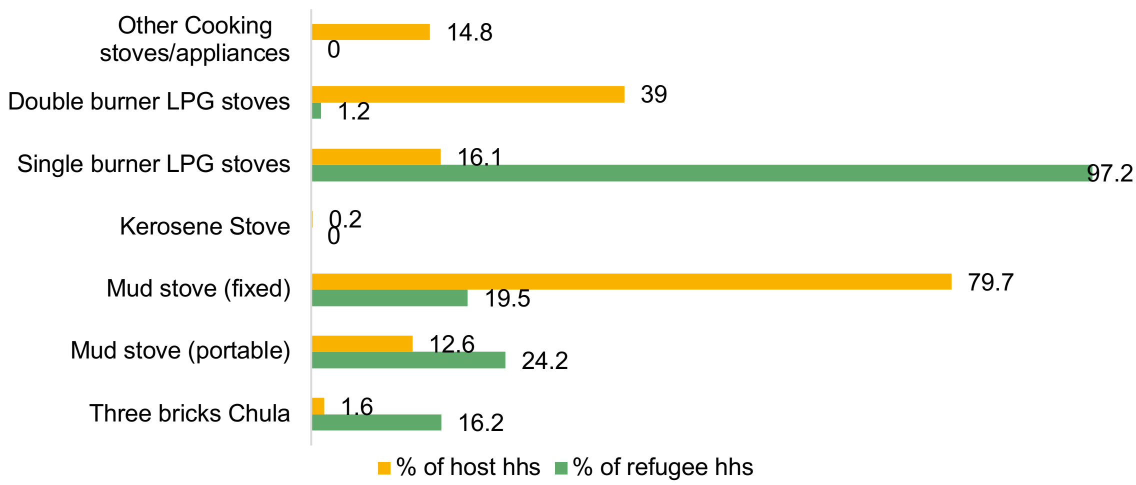
Such unstable power supply is a major setback to the promotion and use of e-cooking appliances. Since disruptions occur during peak times of meal preparation, the use of electric stoves becomes an issue, discouraging households from full adoption of e-cooking.

2.3. Access to clean cooking

2.3.1. Cooking Stoves in Use

The difference in cooking stove use between refugee and host communities is shown in Figure 10. Most refugee households rely on single-burner LPG stoves (97.2%), which are distributed by humanitarian agencies operating in the camps (UNHCR and IOM). In contrast, host households primarily use fixed mud firewood stoves (79.7%). When LPG is insufficient to meet cooking needs, traditional cooking methods such as transportable mud stoves and three-brick *chulas* are also more common among refugees (24.2% and 16.2%, respectively), compared to just 12.6% and 1.6% among hosts. Conversely, host households make greater use of two-burner LPG stoves (39.0%) and other devices (14.8%), both of which are rarely used by the refugees. These differences are reflective of the varying levels of access to resources, infrastructure and cooking habits across the two groups.

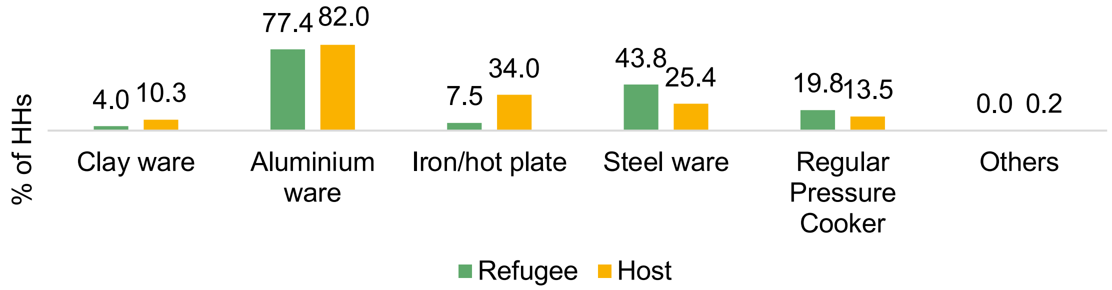
Figure 10: Stoves used for cooking



2.3.2. Types of utensils used for cooking

As illustrated in Figure 11, Aluminium ware is prevalent across both groups (77.4% of hosts, 82.0% of refugees). The use of steel ware is however more common among refugees (43.8%) than to the hosts (25.4%).

Figure 11: Usage of utensils by communities



Iron/hot plates are more commonly used by host households (34.0%) than refugees (7.5%), alongside clay ware (10.3%). In contrast, pressure cooker use is higher among refugees (19.8%) than hosts (13.5%), largely because humanitarian agencies (IOM and UNHCR) distributed pressure cookers to refugee households to help reduce LPG consumption.

Photo 4: Mud stoves typically used in refugee shelters when LPG runs out ©IUCN

2.3.3. Fuel used for cooking in the host and refugee households

2.3.3.1. Fuels used by host community households for cooking

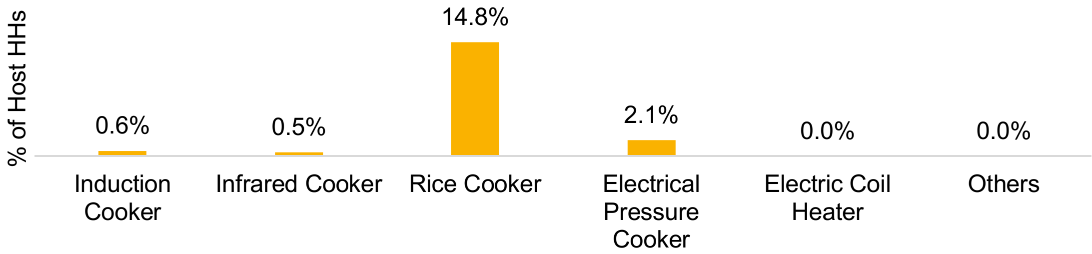
Table 6 shows that host households rely on a mix of cooking fuels, though firewood remains dominant, used by 80% of households at an average of 3.46 kg/day. LPG is also common, used by 47.5% of households with an average consumption of 0.385 kg/day, while 7.9% use charcoal, averaging 0.435 kg/day.

Table 6: Fuels used for cooking in host community households

Fuel type	% of HHs	Average consumption (kg per HH per day)
LPG	47.5	0.385
Charcoal	7.9	0.435
Firewood	80.0	3.460
Electricity	18.4	-
Others	0.5	-

Electricity is used for cooking by 18.4% of host households, mainly through rice cookers (14.8%) and, to a lesser extent, electric pressure cookers (2.1%), as well as induction, or infrared cookers (~1%) (Figure 12). Most appliances were purchased locally in Cox's Bazar (75%), with others sourced from other cities (16.3%) or received as gifts (9.8%). Although only one in six host households use e-cooking appliances, nearly 80% of these users report daily use, showing that the use of above-mentioned appliances has become a regular part of their cooking routine. Baseline data also confirms that these users from the host communities learned about e-cooking predominantly via the internet (33.7%), TV ads (32.6%), neighbours (29.4%), and relatives (29.4%).

Figure 12: Use of e-cooking appliances in the host community



These findings show that while firewood is common in host communities, it is often not the main fuel. Many households use LPG, electricity, and charcoal, indicating fuel stacking based on availability, cost, and needs. Nearly one-fifth now cook with electricity, signalling a shift toward cleaner options.

2.3.3.2. Fuels used by refugee households for cooking

According to the baseline survey, all refugee households received LPG canisters, single burner stoves and regular refills from IOM and UNHCR and therefore rely on it almost exclusively. 98.9% of surveyed refugee households use LPG for cooking. However, **Table 7** shows that only 3.5% of households reported never running out of LPG before the scheduled refill period, the rest frequently experienced early depletion. Of the refugee households sampled, a substantial portion, 49.2%, mostly HHs with an average HH size of 6.25, indicated that they ran out of LPG 12 times in the previous year. This indicates that larger families, are more likely to deplete LPG earlier than scheduled, likely due to higher cooking demands. On the other hand, respondents who reported running out of LPG once (1.4%) and twice (2.4%) a year before the scheduled time have smaller average household sizes of 4.50 and 4.75, respectively.

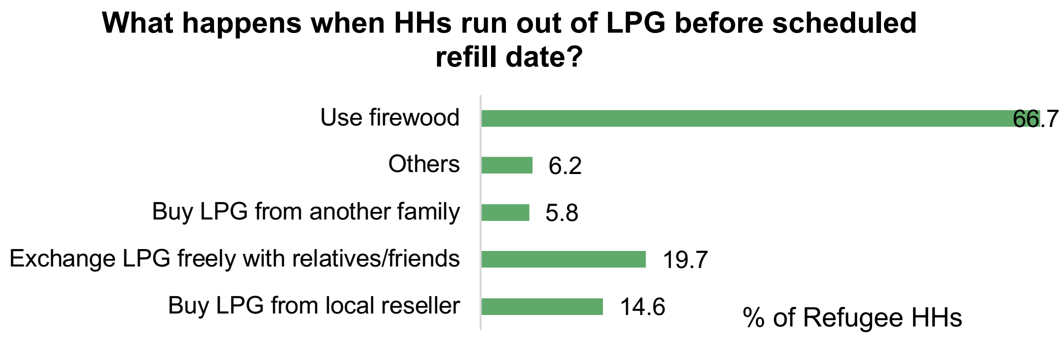
Table 7: Number of times LPG finished earlier than the stipulated time in last 12 months

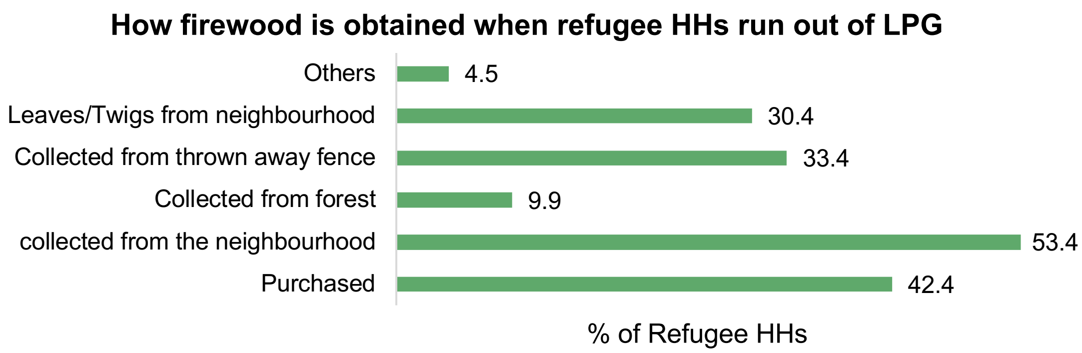
Frequency of early LPG depletion in the last 12 months	% of Refugee HHs	HH Size (average)
Not at all	3.5%	4.27
Once	1.4%	4.50
Twice	2.8%	4.75
Thrice	3.3%	5.57
Four times	5.0%	5.10
Five times	3.3%	4.50
Six times	4.7%	5.50
Seven times	3.8%	5.06
Eight times	6.1%	6.31
Nine times	2.6%	6.45
Ten times	10.2%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

2.3.3.3. Fuels used by refugee households when LPG runs out

Figure 13 shows the fuels refugees turn to when LPG runs out. Two-thirds (66.7%) rely on firewood, sourced locally (53.4%), from markets (42.4%), bushes (9.9%), or dismantled fences (33.4%). On average, each refugee household uses 2.1 kg of firewood daily during LPG outage, underscoring continued dependence on biomass. Leaves and twigs supplement this, accounting for 30.4%. When LPG depletes early, 14.6% buy an extra cylinder from resellers, 19.7% exchange with relatives or friends, and 5.8% purchase from other households.

Figure 13: Other cooking fuels used by refugee households





2.3.4. Challenges faced by refugee and host community households in fuels used for cooking

2.3.4.1. Challenges faced by refugee households in refilling LPG

Table 8 shows 55.8% of refugee households face challenges refilling LPG cylinders, while 44.2% report no issues. The main difficulties include transport costs (29.7%), the need for assistance carrying heavy cylinders (25.9%), and long queues at refill points (20.9%).

Table 8: Problems faced during LPG refilling by refugee HHs

Problems faced during LPG Refilling	% of refugee HHs
Percentage of HHs who reported facing no problems	44.2
Percentage of HHs who reported facing problems	55.8
Types of problems faced	
Transportation cost	29.7
Require assistance transporting the cylinder home	25.9
Long queues at refill centres	20.9
Others	19.5
Cylinder is too heavy to carry	12.9
Long distance to refilling centres	12.5
Have to sacrifice a working day	11.1

2.3.4.2. Challenges faced by refugee HHs to cook with current fuel and appliance types

The challenges faced by refugee households with their current cooking fuels and appliances are summarised in **Table 9**. While 42.82% of refugee households report no issues, the remaining 57.18% experience various difficulties. Indoor air pollution is a major concern, reported by 23.5% of households.

Table 9: Challenges with current cooking fuels and appliances by Refugee HHs

Challenges with current cooking fuels and appliances	% of Refugee HHs
Percentage of HHs who have faced no challenges	42.8
Percentage of HHs who have faced challenges	57.2
Challenges faced	
Poor food taste quality	4.7
Inconvenient to operate	8.0
High health risks*	10.6
Low safety for cooking	13.2
High fuel costs	13.7
Inconsistent cooking temperature	16.5
Creates indoor air pollution*	23.5
Produces excessive smoke*	35.5
Others	6.4

* Health related concerns

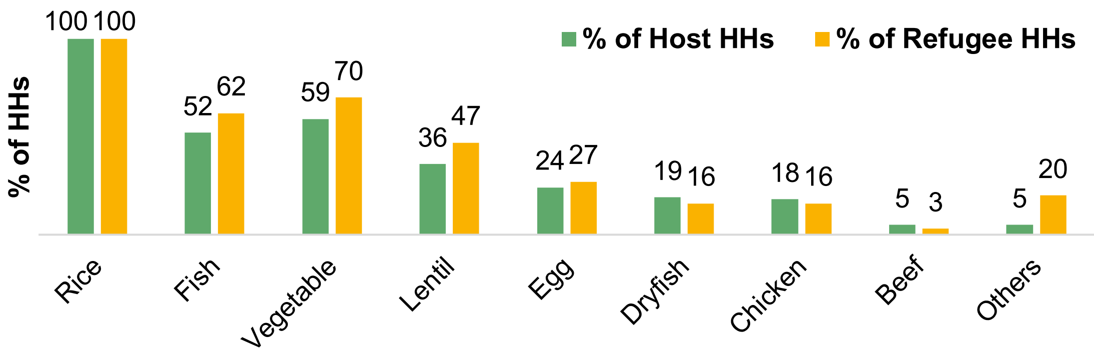
Excessive smoke is the most frequently reported issue (35.5%), contributing to respiratory problems and poor living conditions. Inadequate cooking safety, including fire risks from mishandling LPG or other fuels, is a concern for 13.2%. Irregular cooking temperatures affect 16.5% of households, reducing efficiency in food preparation.

2.3.5. Food habits by host communities

This section examines the foods most commonly prepared by refugee and host households, based on cooking data from the day preceding the IUCN and PA baseline survey. Figure 14 shows the food items cooked by host and refugee households on the day before the survey. Rice was the staple for both groups and was prepared daily. Fish and vegetables were the next most common items, with 70% of refugee households and 59% of host households cooking vegetables, as well as 62% of refugees and 52% of hosts preparing fish. Refugee households also consumed lentils and eggs more frequently than host households.

Host households reported a slightly higher consumption of dry fish (19% vs. 16%). Meat consumption was generally low for both groups: chicken was cooked by 18% of host households and 16% of refugees, while beef was consumed the least, (being prepared by only 5% of host households and 3% of refugees). Refugee households also prepared more additional food items (20%) compared to host households (5%), indicating greater dietary diversity. Overall, while rice remained the staple for both groups, refugee households consumed more fish, plant-based foods, and lentils, whereas host households showed a greater preference for dry fish, chicken, and beef.

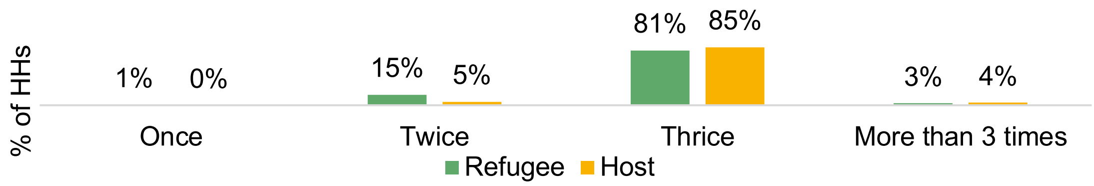
Figure 14: Percentage distribution of households by food items cooked the previous day



2.3.5.1. Frequency of cooking rice

Baseline survey data shows that 81% of refugee households and 85% of host households cook rice three times a day (Figure 15). About 15% of refugee households and 5% of host households cook it twice a day, while 3–4% in both groups cook it more than three times daily.

Figure 15: Number of times rice was cooked the previous day (% of HHs)

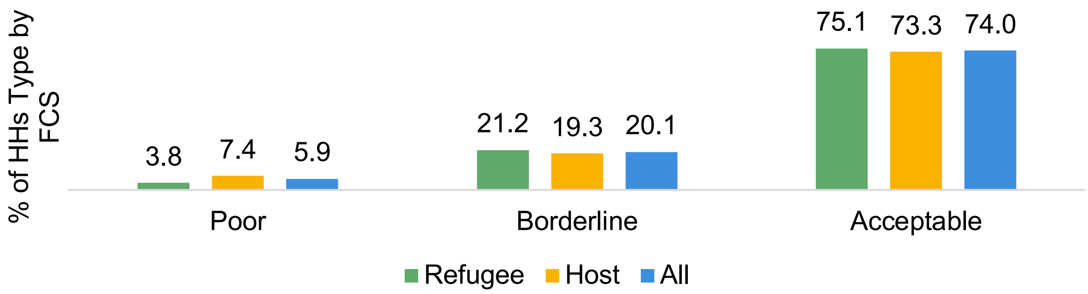


2.3.6. Food Consumption Score by Communities

The Food Consumption Score (FCS) Index is an informal benchmark of food security that evaluates households' food security based on the dietary diversity. 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 for the majority of households in both groups (

Figure 16). 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%. This suggests that refugee households experience slightly better food security compared to host households — likely due to the regular provision of food rations by the World Food Programme within the camps.

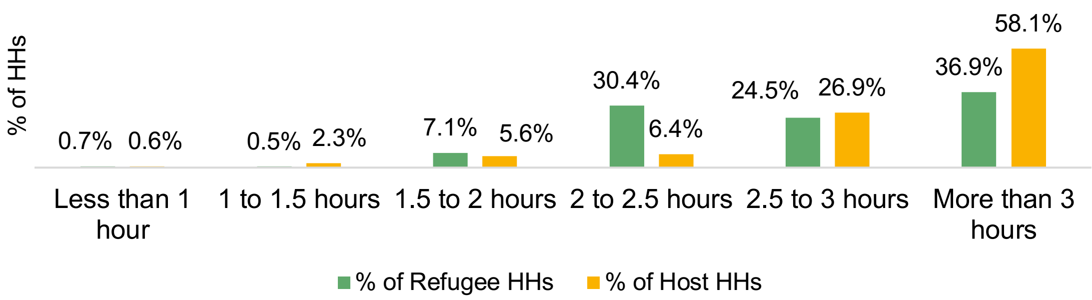
Figure 16: Household FCS per community



2.3.7. Time spent cooking

Baseline survey data shows that 36.9% of refugee and 58.1% of host households spent more than three hours cooking each day (Figure 17).

Figure 17: Time spent cooking items in the previous day's meals



2.3.8. Willingness to use e-cooking appliances

During the baseline survey and prior to the team rolling out the e-cooking appliances, households were asked about their willingness to use or to switch to e-cooking.

2.3.8.1. Willingness to use e-cooking appliances amongst refugee households

The baseline survey data indicates that 82.8% of refugee households are willing to switch to electric cooking (e-cooking), while 4.9%are unwilling , and 12.2% are unsure (**Table 10**). The main reasons for willing to switch to e-cooking appliances include anticipations around 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). Also, 19.3% of the refugee HHs cite 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 willingness to adopt e-cooking appliances among refugee households.

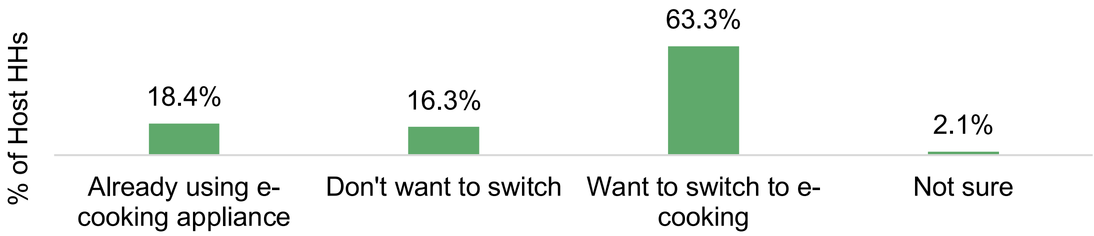
Table 10: HHs willingness to Transit to E-cooking Appliances by Refugee HHs

Particulars	**% of Refugee HHs**
Percentage of HHs not willing to adopt e-cooking	4.9
Percentage of HHs willing to adopt e-cooking	82.8
Percentage of HHs who not sure are	12.2
Reasons for refugee households willing to switch to e-cooking	
Time savings	55.7
Reduced fuel costs	46.0
Reduced indoor air pollution	29.0
Lower health risks	23.3
Enhanced safety	22.2
Increased fuel efficiency	19.3
Others	10.2
Consistent cooking temperature	9.7
Reduced deforestation	6.0
Reduced environmental impact	4.8
Greater Accessibility for Remote Areas	2.3

2.3.8.2. Willingness to use e-cooking appliances amongst host community households

The majority of host households (63.3%) are interested in switching, while 18.4% have already adopted e-cooking (Figure 18). However, 16.3% do not want to switch, citing reasons such as high product costs and unreliable electricity supply. A small portion (2.1%) are undecided. This indicates a strong interest in e-cooking adoption but also highlights barriers that may need to be addressed to encourage wider adoption.

Figure 18:Willingness to transition to e-cooking by host community



The reasons why host households are willing to switch to e-cooking solutions are presented in **Table 11.** The most common reasons mentioned include 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% of HHs mentioned reduced fuel costs while 25.5% mentioned enhanced safety and 13.0% mentioned 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 11: Reasons for Willing to Switch to E-Cooking Appliance for Cooking by Host HHs

Reasons for willingness to switch	Within % of Host HHs willing to switch [n=393]
Lower health risks	58.3
Time savings	57
Reduced indoor air pollution	50.4
Enhanced Safety	25.5
Reduced fuel costs	21.4
Reduced environmental impact	14
Reduced deforestation	13
Increased fuel efficiency	9.9
Consistent cooking temperature	5.6
Others	4.3

Table 12 outlines the reasons some host households are unwilling to adopt e-cooking. The main barriers are high product cost (78.2%) and unreliable electricity supply (71.3%). Other concerns include cost of use (20.8%), inconvenience (12.9%), and perceptions that certain foods cannot be cooked with e-cooking (5.9%).

Table 12: Reasons for 'Not Willing' to Switch to E-Cooking Appliance by Host HHs

Reasons for NOT willing to switch	% of Host HHs not willing to switch [n=101]
Price of the product	78.2
Unreliable electricity	71.3
Cost of Use	20.8
Inconvenience of use	12.9
Taste of cooked items are not good	5.9
Others	2

Photo 5: Household level cooking data collection in Rohingya Camps ©IUCN

2.4. Market Survey: Approach and findings

To assess the availability, pricing, and distribution of cooking fuels and e-cooking appliances in the Cox's Bazar market, IUCN and PA conducted 54 market surveys across the following eight marketplaces: Cox's Bazar Sadar, Ramu Sadar, Ukhiya Sadar Market, Palong Khali, Whykong, Shamlapur, Raja Palong, and Kutupalong. All markets surveyed were located outside the refugee camps, reflecting local commercial environments accessible to both host and refugee communities, directly or indirectly.

Of the 54 outlets visited, 22 provided information on e-cooking appliances, while the remainder focused on traditional fuels such as firewood, LPG, briquettes, charcoal, or kerosene. This diversity of market settings revealed how product availability, sales volumes, and prices vary by geography, demand, and supply chain conditions. The survey approach also enabled a better understanding of vendor perspectives, supply conditions, and market readiness for cleaner cooking technologies. For example, prices in remote areas may be higher due to transport costs, while urban markets may show more diversity in appliances and fuels and offer lower prices. In addition, the staggered timing of the surveys conducted in late November by the IUCN team, and in mid-December by the PA team allowed for cross-validation of findings and consideration of short-term price or stock fluctuations.

Overall, this comprehensive and geographically diverse market survey offers a strong foundation for understanding the local market for cooking energy in Cox's Bazar. It provides critical insights to guide targeted, area-specific interventions aimed at expanding access to cleaner, more sustainable cooking solutions. The following sub-sections show the market prices of cooking fuels and technologies available in the local market.

2.4.1. Selling price for cooking fuels in the Cox's Bazar market

As per **Table 13**, the market survey found that 12kg LPG cylinder refills cost BDT 1,400 -- 1,480, charcoal BDT 90 – 120/kg, briquettes BDT 12 – 14/kg, firewood BDT 11 – 17/kg, and kerosene BDT 107 – 120/litre.

Table 13: Local market prices of fuel types

Fuel type	Minimum market price		Maximum market price	
	BDT	USD	BDT	USD
12 LPG Cylinder refill	1,400	11.7	1,480	12.3
Kerosene per liter	107	0.9	120	1.0
Charcoal per kg	90	0.8	120	1.0
Briquette per kg	12	0.1	14	0.1
Firewood per kg	11	0.1	17	0.1

2.4.2. Selling price for e-cooking appliances in the Cox's Bazar market

As per **Table 14**, e-cooking appliance prices vary by type, size, features, and brand. Rice cookers range from BDT 1,500 – 3,600, averaging BDT 1,794 for 1 kg, BDT 2,190 for 1.5 kg, and BDT 2,740 for 2 kg models. Induction cookers cost BDT 3,063 – 4,288, infrared cookers BDT 3,060 – 3,980, and 6 litre electric pressure cookers BDT 6,500 – 7,500.

Table 14: Local market price for e-cooking appliances

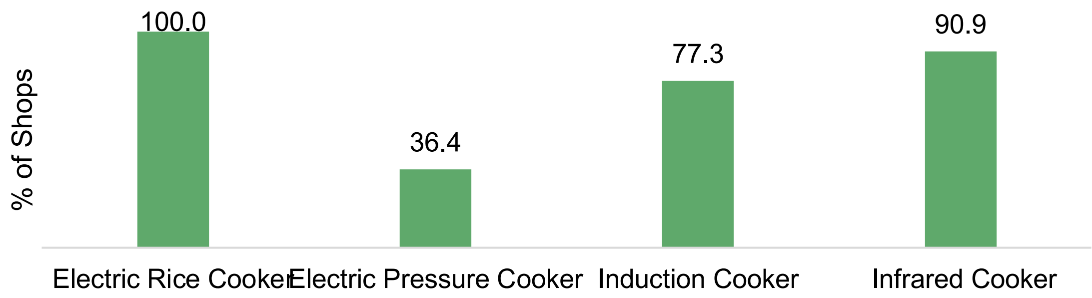
Cooking Appliances	Average Price		Min. Price		Max. Price	
	BDT	(USD)	BDT	(USD)	BDT	(USD)
Rice Cooker (1 kg)	1,794	(15.0)	1,500	(12.5)	2,250	(18.6)
Rice Cooker (1.5 kg)	2,190	(18.3)	1,800	(15.0)	2,500	(20.8)
Rice Cooker (2 kg)	2,740	(22.8)	2,100	(17.5)	3,600	(30.0)
Induction Cooker	3,676	(30.6)	3,063	(25.5)	4,288	(35.7)
Infrared Cooker	3,520	(29.3)	3,060	(25.5)	3,980	(33.2)
Electric Pressure Cooker (6 L)*	6,500	(54.2)	7,500	(62.5)	7,000	(58.3)

Source: IUCN and PA Market Survey, 2024; * Information collected from shops outside of the market survey area

2.4.3. Insights from local markets about e-cooking appliances

The market survey found that all 22 surveyed outlets stocked electric rice cookers, making them the most widely available e-cooking appliance. Infrared cookers were available in 90.9% of outlets, induction cookers in 77.3%, while electric pressure cookers were the least common, stocked by only 36.4% of retailers. (Figure 19).

Figure 19: Availability of e-cooking appliances in the local shops (%)



* 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 electric rice cookers a month, and 27.3% indicated more than 20 sold units (Table 15). EPCs, in contrast, had the lowest level of sales, 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 15: Average monthly sales of electric cooking appliances (%)

Average monthly sales (units)	Electric rice cooker	Electric pressure cooker	Induction cooker	Infrared cooker
Less than 5	13.6	100.0	58.8	75.0
5 to 10	27.3	0.0	29.4	10.0
10 to 20	31.8	0.0	5.9	5.0
More than 20	27.3	0.0	5.9	5.0

* Information collected from shops outside of the market survey

The analysis shows a segmented demand pattern for e-cooking appliances in Cox's Bazar. Local residents, particularly women, are the main users of electric rice cookers, reflecting their affordability and suitability for domestic use. In contrast, higher-cost appliances such as induction cookers, infrared cookers, and electric pressure cookers are primarily used by NGO and organisation staff working in the camps, rather than the locals.

Appliance sales in Cox's Bazar are influenced by seasonality, with 72.7% of sellers reporting fluctuations linked to factors such as weather and electricity availability. Most consumers (62.5%) pay in cash, 20% buy on credit, and only a small share use instalment plans, indicating limited access to flexible financing. Key barriers to adoption include high product costs (29.2%), unreliable electricity (22.9%), operating costs (16.7%), and inconvenience (16.7%), while taste concerns are negligible (2.1%).

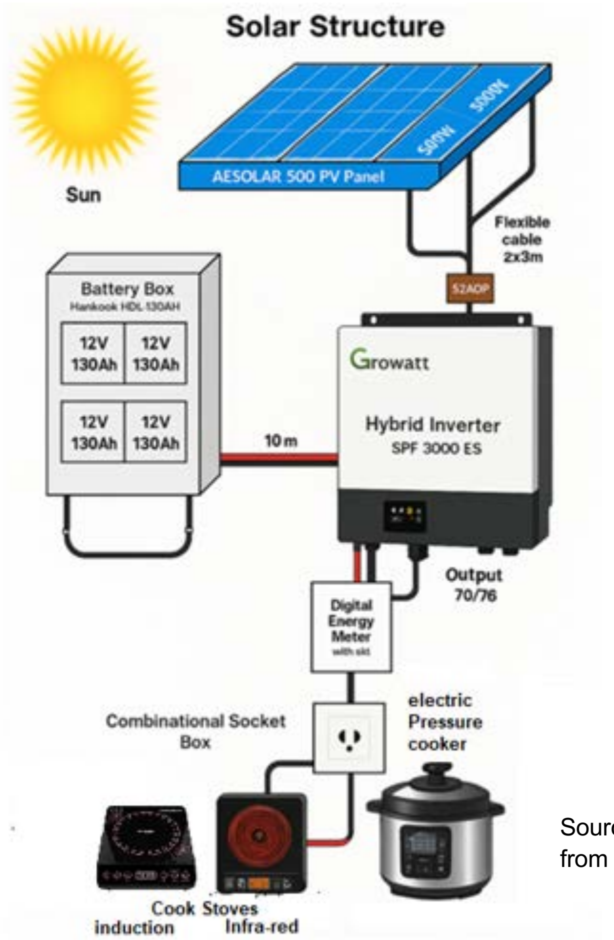
Photo 6: Market Survey of cooking fuels and e-cooking appliances ©Practical Action

3. E-cooking Pilot: Design, implementation and findings

© GPA-UNITAR

Following the baseline household and market assessment, a small e-cooking pilot was implemented between January and March 2025 to test the technical, operational, and cultural feasibility of using solar PV-powered e-cooking appliances in both refugee and host community households. Given the limited number of systems (ten solar PV e-cooking systems) and project period, the pilot engaged 40 households in total: 20 from refugee camps and 20 from host communities. The pilot was carried out in four rounds of 10 days each, with five households from each group participating at a time. Each household received a complete solar PV e-cooking setup comprising a 3 kWp solar PV array (six 500 W AESOLER panels), a Growatt SPF 3000 ES hybrid inverter, four 12 V 130 Ah Hamko HPD batteries, and a digital energy meter with a 32A DP output for electricity monitoring. To accommodate different cooking practices and assess user's preference for the different e-cooking appliances, participating households were provided with an induction cooker (plus two compatible utensils), an infrared cooker, and a 6-litre electric pressure cooker (Figure 20).

Figure 20: Specification of solar-powered cooking system used in the study



Source: Author's Illustration from the design of the pilot

3.1. Pilot implementation approach

Each household's participation began with a two-day installation and training phase. Field teams installed the solar PV systems and appliances, confirmed proper functionality, and provided hands-on training on appliance use, daily maintenance, and safety procedures.

Live cooking demonstrations with the end-users emphasised energy efficiency, temperature control, and safe operation, with participants practising under trainer supervision and receiving real-time troubleshooting support.

From days 3 to 10, households operated the systems independently. Energy use was tracked with digital meters, while field teams made routine visits to observe use, collect data, troubleshoot issues, and verify equipment performance. Participants also maintained daily logs on meals, appliances, cooking times, and any arising issues, which were cross-checked during visits.

Feedback was collected twice: on Day 3 to capture initial impressions (ease of use, technical issues, and comparisons with traditional cooking), and on Day 7 for final reflections on cooking habits, time savings, energy efficiency, and willingness to continue e-cooking. Combined with usage data, this feedback offered valuable insights into the acceptance and practical viability of solar e-cooking among refugee and host households. The systems were then uninstalled and re-installed in the next set of households.

Photo 7: E-Cooking appliances used for cooking demonstration in a refugee household ©IUCN/Sarwar

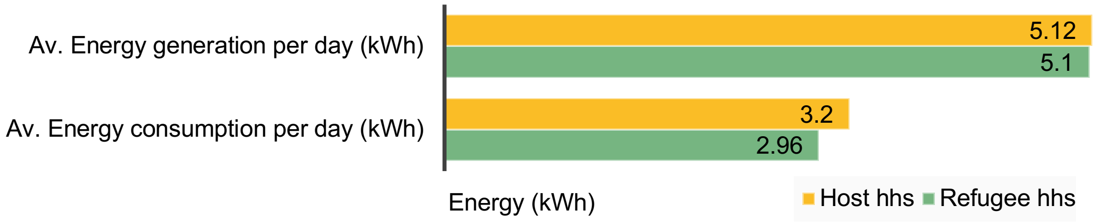
3.2. Findings from the e-cooking pilot

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

3.2.1. Energy generation and consumption

Figure 21 contrasts daily average electricity generated and consumed in host communities and refugee households. For refugee families, average daily electricity generation is 5.10 kWh, while the consumption 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 21). In both cases, the systems generated significantly more electricity than was used. It is important to note that this consumption data reflects only the energy used for cooking as the systems were not designed to support other household electricity needs such as lighting, fan use, or phone charging. Therefore, the energy consumption figures presented here represent only the demand of electricity for cooking and do not capture broader household energy use.

Figure 21: Daily energy generation and consumption



The persistent gap between generation and consumption suggests that the installed solar systems were oversized relative to actual cooking demand. This highlights the need to reassess household energy requirements and align system design with real consumption patterns. Optimising hardware components, including PV panels, batteries, and inverters, would lower system costs, improve cost efficiency, and enable more effective resource allocation, particularly in larger-scale rollouts.

Table 16: Average per day energy generation and consumption by timeframe and location

	Refugee households			Host community households		
Timeframe	**Camp name**	**Energy generated (KWh)**	**Energy consumed (KWh)**	**Host HH locations**	**Energy generated (KWh)**	**Energy consumed (KWh)**
20 – 26 January	Camp_20 Ext	5.25	3.46	Raja Palong	5.09	3.29
31 January - 6 February	Camp_19	5.49	3.26	Holodia Palong	5.42	3.17
11- 16 February	Camp_21	6.30	4.28	South Mithachhari	5.05	2.51
23 February – 01 March	Camp_1W	3.45	1.80	Rajarkul	4.83	2.87
Average		**5.10**	**2.96**	**Average**	**5.12**	**3.20**

The data suggest that average electricity generation and consumption are broadly similar across refugee camps and host communities (**Table 16**). However, certain locations in Ramu upazila, particularly South Mithachhari and Rajarkul, consistently show lower consumption levels despite moderate generation levels. A decline in both generation and consumption was also observed across all sites during the last week of February, likely due to weather conditions. Camp 21 recorded the highest solar generation (6.30 kWh) and consumption (4.28 kWh) among refugee camps, possibly due to better weather conditions or higher demand. However, the small, non-random sample limits confidence in this finding. Future assessments should use a randomized, geographically stratified design to account for variations in behaviour, system performance, and weather.

Photo 8: Installed 3kWp solar PV panels on a shelter roof in the Refugee camp ©IUCN

Dust accumulation on solar panels just two days after installation ©IUCN

3.2.2. Meal composition and cooking patterns in refugee and host households

Refugee households rely on donor-provided food rations that include rice, lentils, and oil, shaping a diet centred on staple foods supplemented by affordable items like vegetables and fish. The weekly consumption data collected during the pilot show that rice remains the staple food for both groups (**Table 17**), aligning with the findings of the baseline survey. Among refugee households, 94.9% cook rice for dinner, 84.9% for lunch, and 69.0% for breakfast. Host households report similar figures: 97.4% at lunch, 94.9% at dinner, and 72.5% at breakfast. Beyond rice, refugee households report more frequent preparation of vegetables (74.0% at lunch, 62.0% at dinner), lentils (31.9% at lunch, 29.9% at dinner), and fish (48.7% at lunch, 51.1% at dinner), indicating a broader use of affordable non-rice items. Breakfast data also shows wider diversity in refugee diets, with 53.1% reporting "other" food items compared to 18.4% among host households.

Table 17: Food items cooked by meal and community

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

Source: IUCN and PA E-cooking household demonstration, 2025

Cooking activities recorded during the household-level pilot for a week were broadly consistent with those observed in the baseline survey for both communities. This indicates that the introduction of e-cooking appliances did not lead to immediate changes in the types of meals prepared or general cooking practices. However, it is important to note that the intervention was not intended to influence food habits or reshape cooking behaviour. The short trial period is insufficient to assess changes in food preferences or routines, which typically shift over longer timeframes and under broader social and economic influences. Therefore, any interpretation regarding stability or transformation in dietary practices falls beyond the scope of this study.

Photo 9: E-cooking demonstration training at Camp 20 Extension for HHs selected for the pilot ©IUCN/Sarwar

Photo 10: Usage of e-cooking appliances by the host community during cooking demonstration ©Practical Action

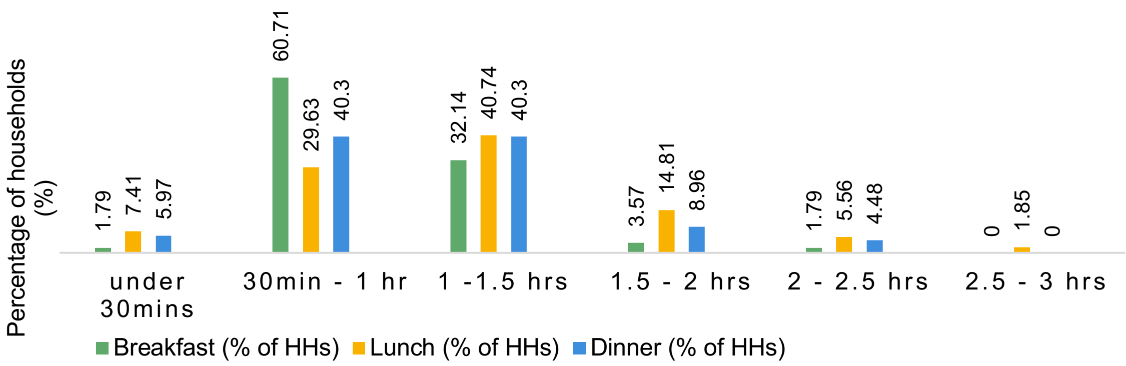
3.2.3. Meal preparation times

Understanding cooking duration is important for estimating household energy consumption across different fuels. For solar systems, this is especially relevant since generation is most efficient between 7:00 AM and 4:30 PM. Cooking during these hours allows households to rely directly on solar energy, minimising dependence on battery storage. In this pilot, the information on cooking duration and timeframes were obtained during in-person visits to the households as data loggers were only installed during the last round of the e-cooking demonstrations and were not completely configured to log the required data. This limited setup did not allow for detailed analysis of energy use across meals and times of day. Data loggers are ideal for such analysis, as they record minute-level generation and consumption data and can also estimate environmental indicators (e.g., CO_2 reductions, avoided deforestation) and track climate variables such as temperature, precipitation, and solar radiation.

Figure 22 presents recall-based information on meal preparation times and related household size. The results show that the number of people cooked for is consistent across the day - 5.84 at breakfast, 6.02 at lunch, and 5.82 at dinner - suggesting that meals are generally prepared for the entire household.

Breakfast emerges as the quickest meal, with most households (60.7%) spending 30 minutes to an hour and very few exceeding 1.5 hours. Lunch is the most time-intensive, with 40.7% of households cooking for 1–1.5 hours and a further 14.8% for 1.5–2 hours, reflecting its cultural and nutritional importance. Dinner follows a similar pattern, though fewer households spend more than 1.5 hours. Across all meals, very few households cook for more than two hours, likely due to time, fuel, and efficiency constraints. No significant differences were observed between host and refugee households. Overall, breakfast is the quickest and most routine meal, lunch the longest, and dinner falls in between.

Figure 22: Average time spent cooking meals at households



3.2.4. Use of e-cooking appliances

Figure 23 presents the distribution of food items cooked with different appliances (induction, EPC, and infrared) across breakfast, lunch, and dinner. No major differences were observed between refugee and host communities in their preference for electric cooking devices. The findings are therefore aggregated to highlight overall usage patterns and trends.

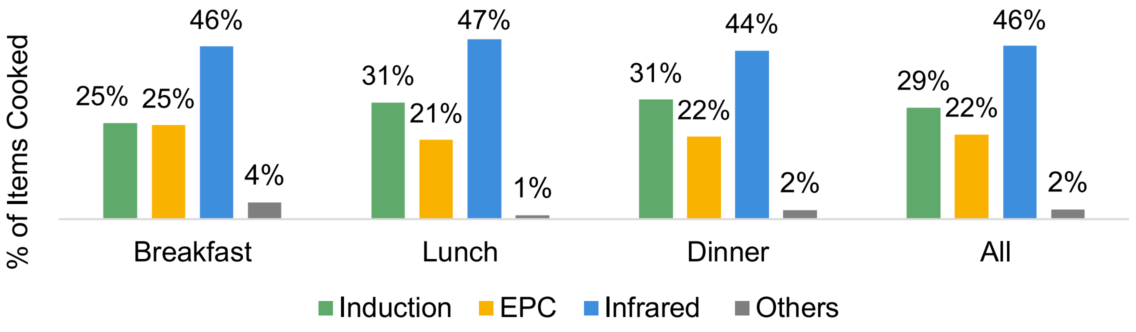
Infrared stoves are the most widely used, accounting for 46% of all cooking. Their popularity stems from compatibility with common aluminium (round bottom) utensils, ease of reheating, and a visible flame-like glow that resembles traditional LPG or biomass stoves. Unlike induction stoves, they can be used with regular pots, making them more convenient and familiar for most households. "*I don't need to buy new pots for this, my old ones work fine*" one participant said.

Induction cookers accounted for 29% of cooking, used by 25% of households at breakfast and 31% at lunch and dinner. Their limited uptake was linked to the requirement for specific iron-based cookware. The heavy induction pots supplied (weighing approximately 8 kg with lid) were difficult for many users, particularly women and girls. Additionally, the black coating on the pots wore off during use, reducing appeal and usage. Most households are more familiar with aluminium utensils, which are incompatible with induction stoves, it should be noted that lighter and better-quality induction compatible pots are available in the market. Hence, lower usage in this pilot therefore reflects user habits and preferences rather than technical limitations as some households still appreciated their speed and lower power consumption.

EPCs were mainly used for cooking rice, representing 22% of total cooking activities. Usage was consistent across meals: 25% of households at breakfast, 21% at lunch, and

22% at dinner. Participants valued their speed, programmability, and convenience, noting that EPCs cooked faster than LPG, required minimal supervision, and could keep food warm for several hours thereafter. This allowed users to multitask and save time. Some households also highlighted their versatility, including the ability to bake and even added that their children were now more excited to assist in the kitchen and to cook using the EPC. However, EPCs were considered less suitable for fried or roasted dishes, limiting their use. As a result, while highly regarded for rice and time-saving benefits, EPCs were often paired with other appliances to meet diverse cooking needs.

Figure 23: Share of items cooked by meal type and appliance used



3.2.5. Cooking time patterns

The e-cooking pilot reveals clear statistical differences in cooking time preferences between refugee and host households. When compared with solar radiation patterns, these differences offer important insights and opportunities for aligning solar e-cooking systems with real usage behaviours.

Breakfast cooking

Breakfast preparation times differ significantly between refugee and host households, with most cooking completed before 7:30 AM. Refugee households start much earlier, with 35% starting between 6:00–6:30 AM (versus 2% of host households). A further 49% of refugees and 63% of host households start between 6:30–7:30 AM. Overall, 84% of refugee households and 65% of host households finish breakfast by 7:30 AM, which has important implications for the feasibility of solar-based cooking as the sun is often not producing much power within this time (Figure 24).

When focusing specifically on cooking completed before 7:00 AM, prior to sunrise, 57% of refugee households fall into this category, compared to just 21% of host households. This highlights early-morning cooking as a major limitation for battery-free solar cooking systems, particularly in refugee contexts. Without sufficient solar radiation at this time, breakfast preparation would rely on stored battery energy or alternative fuels such as LPG or biomass.

Figure 24: Percentage of breakfast cooking activities by time slot and by communities

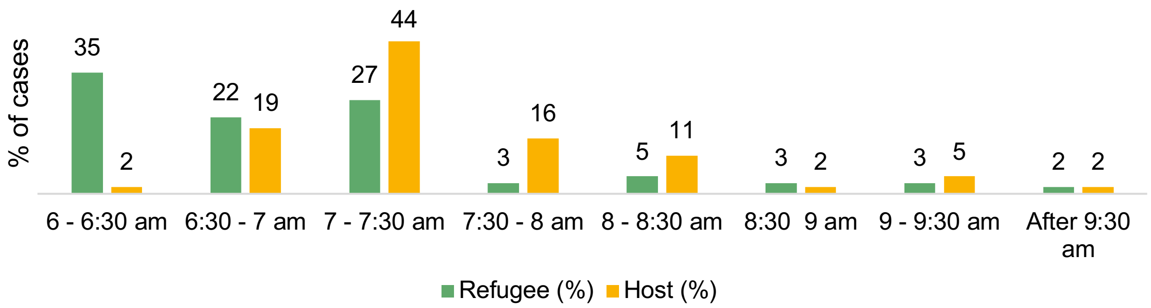
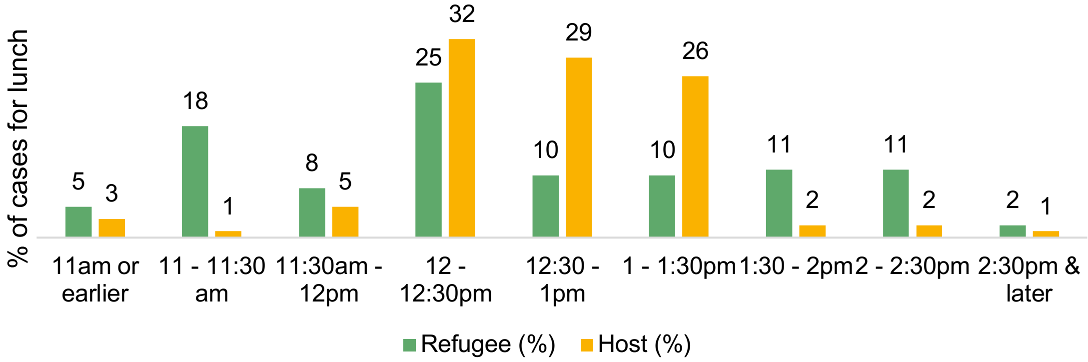


Photo 11: Public demonstration of e-cooking appliances from host (left) and refugee community (right). ©Practical Action; IUCN/Easin

Lunch preparation

Figure 25 shows that most lunch preparation in both refugee and host households takes place between 12:00 PM and 1:30 PM, aligning with peak solar radiation hours. During this window, 68% of host households and 45% of refugee households cook lunch. The busiest period is 12:00–12:30 PM, when an average of 29% of all households prepare lunch across both groups.

Figure 25: Percentage of lunch cooking activities by time slot and by communities



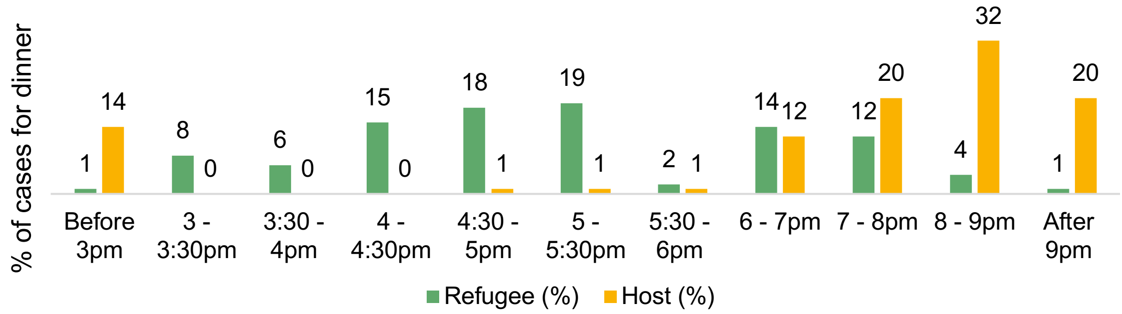
Refugee households display slightly more variation in lunch preparation times, but most cooking still occurs in the solar peak hours window. The similarity in timing between refugee and host households reflects shared cultural habits and practical factors like daylight availability. This midday peak offers an optimal period for solar-powered cooking, especially for systems without battery backup on sunny days.

Dinner Preparation

Dinner cooking behaviour shows the most significant timing disparity between both groups. Approximately 69% of refugee households prepare their dinner before 5:30 PM, compared to just 17% of host households (Figure 26). This allows refugees to cook when solar radiation is still present, thereby reducing dependence on battery support for solar PV powered cooking. As per Figure 26, approximately 31% of refugee households cook dinner after 5:30 PM, compared to 83% in host communities, indicating stronger reliance on battery-supported solar systems among hosts. Refugee households, with little or no reliable electricity, typically finish cooking before dark to avoid working without light. As one refugee participant explained, *"We always try to finish cooking before dark; there is no light, and cooking after sunset is risky for children."*.

In contrast, host households benefit from grid connections in areas like Ramu and surrounding regions, enabling evening cooking without lighting constraints. These cooking timeframes are also influenced by their daily activities as many host community members, particularly farmers, work until dark, leading to later meal preparation. In contrast, fewer refugee families have formal work, and women rarely engage in employment outside the home, allowing them to cook earlier. These structural and occupational differences largely explain the disparity in dinner preparation times between the two groups.

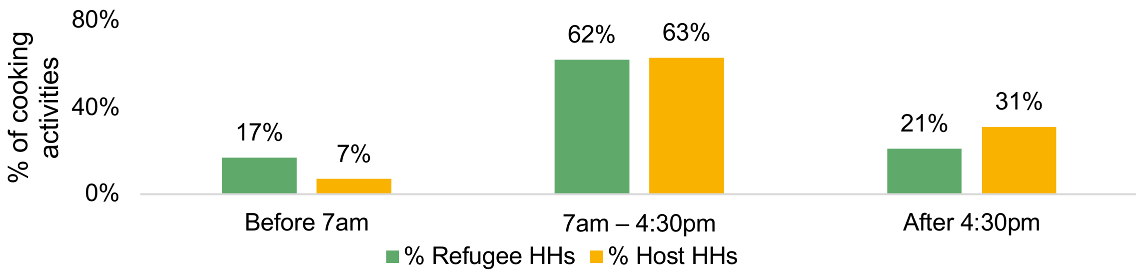
Figure 26: Percentage of dinner cooking activities by time slot and by communities



Aggregated cooking time slots: Synchronizing system capacity with solar radiation time

Seventeen percent (17%) of refugee cooking and 7% of host cooking occurs before 7 AM. Between 7 AM and 4:30 PM, which are typical solar hours, 62% of refugee and 63% of host household cooking takes place. The remaining 21% of refugee and 31% of host cooking happens after 4:30 PM. While most cooking aligns with productive solar hours, roughly one-third occurs outside this window, particularly among host households, underscoring the need for battery storage or back-up technologies to support evening cooking, or the need for behavioural change to shift almost all cooking activities to daytime cooking (Figure 27).

Figure 27: Daily aggregated cooking activities by time slots and per community



3.2.6. Willingness to continue using e-cooking solutions in the refugee camps and host communities

The household demonstrations revealed a strong appetite for solar-powered e-cooking in both refugee camps and host communities. Among refugee households, the enthusiasm was particularly striking, with more than four out of five (82.8%) expressing a clear willingness to continue using the appliances. Host households were also receptive, though to a slightly lesser degree, with 63.3% indicating interest.

The pilot exercises went beyond testing technology—they created spaces where families could directly compare e-cooking with their usual methods. For many, the experience was eye-opening. One host community woman reflected after a cooking session*, "It helped me to see how to cook khichuri and fish curry, just like on my gas stove."*

Women, who carry the greatest responsibility for household cooking, were especially vocal about the benefits. For them, the absence of smoke and fire was not just a matter of comfort but of safety. As one refugee mother explained after trying an electric pressure cooker, *"There is no smoke, no fire, my baby will be safe now."*

Safety concerns extended beyond the kitchen. Refugee households often run out of LPG before the next scheduled refill, forcing women and children to collect firewood from surrounding areas. This is a physically demanding task, fraught with protection risks. The e-cooking demonstrations showed a way out of this cycle. As one woman described, *"If we get this cooker, I will not need to go far to collect wood."*

These testimonies underscore the wider significance of solar e-cooking. For both refugees and host communities, it represents more than a new technology; it is a pathway to safer, cleaner, and more dignified lives. Despite the enthusiasm shown during the demonstrations, both refugee and host households raised several concerns that will need to be addressed for solar e-cooking to succeed at scale.

- **Unreliable electricity supply for host households:** For host communities, the unreliability of grid electricity emerged as a major concern. Evening meals are often prepared after sunset, yet frequent load-shedding during these hours undermines confidence in e-cooking. One host participant noted, "*Even if we buy it, what if there is no electricity? Our area faces power cuts every day in the evening*." Families emphasised that battery backup would be essential to make e-cooking viable for evening use.
- **Affordability:** Affordability was another recurring issue. While 63.3% of host households expressed interest in adopting e-cooking, fewer than half felt they could realistically afford the appliances. For refugees, the challenge was even starker: with no formal work opportunities, affording the systems are entirely out of reach. One refugee woman stated plainly, *"I want this stove, but we cannot buy it."* Even in host communities, families called for subsidies or instalment-based payment models to make adoption feasible, while higher income households such as those of teachers or NGO workers noted that they could only manage smaller, lower-cost devices like rice cookers.
- **Security:** Security was also a key concern in the camps. The prospect of theft was raised frequently, with one man cautioning, "*If they see a panel on my roof, someone might steal it at night."* Women stressed that their families' safety had to come first: *"We cannot keep it if it brings danger to our house."* While some participants proposed community-level installations or shared cooking spaces as safer alternatives, others resisted the idea of shared kitchens due to past negative experiences with communal kitchens, citing long queues, distances from home, and difficulties with childcare during cooking hours.
- **Camp infrastructure:** The fragile nature of camp shelters added another layer of complexity. The shelters are predominantly made of bamboo, and many are rebuilt each year after the monsoon (rainy) season, making permanent rooftop solar panel installations difficult to maintain.

- **System repairs:** Both refugee and host community members voiced frustration about the lack of local repair services. *"If it stops working, where will I go? I cannot take this cooker to town"* one refugee explained. To address this, several participants called for training to enable minor repairs within the camps themselves. As one young NGO volunteer suggested: *"Give us training so we can fix small problems ourselves"*
- **Concerns around LPG support withdrawal:** Another concern came from refugee participants worried about losing their existing LPG support. *"If we say yes to electric, will they stop giving us gas?"* one man asked, highlighting the importance of a phased, hybrid approach that maintains LPG provision during the transition.
- **Need for continued training:** While over 90% of participants reported satisfaction with the appliances, many called for extended and repeated training. A camp volunteer urged, *"Please do this in every block so more people can learn."* Hands-on practice, visual aids, and recipes tailored to local cooking traditions were identified as critical for building confidence and ensuring proper use.

Overall, these concerns underscore how solar e-cooking is just as much a social transformation process as it is a technical intervention. As such, addressing issues of reliability, affordability, safety, and training will be essential for building trust and ensuring that e-cooking truly improves the daily lives of both refugee and host households.

3.3. Key considerations and recommendations for the next e-cooking pilot

The feasibility study on solar-powered e-cooking systems in Cox's Bazar reveals that while technical and financial metrics support its viability, other key factors/variables such as lived experiences, social structures, and behavioural patterns of users ultimately determine its success. This study integrates quantitative data with qualitative feedback, highlighting the critical importance of designing energy solutions that align with daily routines, cultural practices, and cooking responsibilities. Summarised below are key recommendations for similar pilots or next phase of e-cooking roll out in Rohingya refugee camps.

The analysis of household cooking patterns yields several important considerations for the design of subsequent solar e-cooking systems for these communities.

- The study was based on a small convenience sample of 40 households, with 20 selected from refugee camps and 20 from host communities, for the household-level demonstration of solar-powered e-cooking appliances. While this sample provided useful initial insights, the limited size and non-random selection limit the ability to generalize findings to a wider population. To build on these results, future studies should consider using a randomized sampling approach with a larger number of refugee households. This would help ensure that the findings are more robust, replicable, and reflective of broader community dynamics.
- 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, orientation of houses (east-west vs. north-south), and varying weather conditions (rainy vs. sunny seasons) to ensure the design is adaptable for all weather scenarios.

- During the next phase, efforts should also focus on altering cooking behaviours to minimize the use of LPG and to improve cooking energy efficiency. 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.
- During the study, data loggers were installed only in the fourth (final) round and in just one household from each community, which limited the ability to capture detailed energy usage across different meals and time periods. To address this, the pilot phase should include the installation of data loggers in all participating households. This will enable continuous and precise monitoring of electricity consumption, and provide deeper insights into cooking behaviour, appliance performance, as well as energy demand.
- 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.
- Although the prospect of using community-based solar panels to distribute electricity across multiple households was discussed, it was not implemented during the pre-pilot phase. This left a gap in understanding whether a shared system might be more efficient or cost-effective. The next phase should include a test of this cluster-based electricity distribution model. Evaluating its performance against individual household systems will help determine the most suitable and scalable approach for e-cooking in refugee camp settings.
- Solar radiation window alignment: Not all households cook during optimal solar radiation hours (approximately 10AM to 4 PM). While summer months may extend this window to about 5:30 PM, it reduces to about 4:30 PM during winter. A significant share of cooking, especially breakfast and dinner, occurs outside this timeframe, particularly among host households.
- Need for battery integration and back-up energy source: For refugee households, cooking mainly occurs during the day and mainly within solar hours. With integrated battery storage, these households could potentially almost eliminate reliance on LPG. In contrast, host households commonly cook breakfast early in the morning and dinner after sunset. Battery support is therefore critical to meet their energy needs during non-daylight hours.
- Cost efficiency through appliance selection: Electric Pressure Cookers (EPCs) are widely used for cooking rice, but they are more costly/expensive and more energy-intensive than standard electric rice cookers. A switch to dedicated e-rice cookers would provide a more cost-effective and energy-efficient solution for households primarily cooking rice.

4. Conclusion and next steps for e-cooking roll-out in Cox's Bazar refugee camps and host communities

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The feasibility assessment demonstrates that solar-powered e-cooking presents a technically viable, socially acceptable, and environmentally beneficial alternative to the current reliance on LPG and biomass in Cox's Bazar. The demonstrations confirmed strong willingness to adopt among both refugee and host households, highlighting benefits such as improved health, reduced safety risks, and relief from the burdens of fuel collection. At the same time, critical barriers remain, the most notable of which include security concerns, affordability, infrastructure fragility, unreliable electricity supply, and the fear of losing existing LPG support. Addressing these challenges requires a phased, community-centred approach that prioritises affordability through innovative financing and carbon revenue, ensures battery backup for off-peak cooking, strengthens local repair and maintenance capacity, and builds trust through sustained training and engagement. With the right design and support, solar e-cooking can move beyond a technical intervention to become a catalyst for safer, healthier, and more dignified lives for both refugee and host communities in Cox's Bazar.

The immediate priority is to determine the economic and financial feasibility of scaling e-cooking, particularly in refugee camps where households are unable to purchase systems due to work restrictions. The first pilot deployed large, free systems—including EPCs, induction, and infrared stoves—at an average cost of USD 2,600 per household. Such systems are not scalable, even with end-user financing, given the exceptionally low-income levels documented in both refugee and host communities. To chart a realistic pathway forward, the project team is conducting detailed economic and financial modelling. The scenarios under review include:

- Business-as-usual: continued free LPG provision by IOM and UNHCR for the next one to two decades, with associated costs and emissions.
- Smaller solar PV systems: with battery backup and one or two appliances (e.g., EPC, induction stove, infrared stove, or electric rice cooker), supported by LPG as a backup fuel.
- Host community configurations: including appliance-only models, appliance-plus-battery systems, and other hybrid solutions tailored to income levels and grid availability.
- Carbon finance opportunities: modelling emission reduction potential and conducting sensitivity analyses to identify the carbon price thresholds required to make e-cooking financially viable for both refugees and host communities.

With the right mix of system design, financing mechanisms, and community engagement, solar e-cooking can evolve from a promising pilot into a sustainable, large-scale solution that enhances energy access, protects the environment, and improves daily life for both refugee and host populations in Cox's Bazar.

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Annex A: Determination of Sample Size

The sample size for both refugee and host community households were determined using the following 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

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

From a methodological standpoint, the sample sizes for both refugee and host communities were determined based on statistical rigor and practical considerations to ensure the reliability of findings and support evidence-based planning.

For refugee households, a 5% margin of error and a 95% confidence level were used, yielding a minimum required sample size of 384. To enhance the robustness of the estimates, this was increased to 400 households. Furthermore, an additional 25 households were pre-selected for inclusion in the e-cooking experimental survey, five of which served as backup to address potential absenteeism. This brought the total sample size for the refugee community's baseline survey to 425 households.

For host community households, a 4% margin of error with a 95% confidence level was applied to achieve higher precision, resulting in a required sample size of 600. An additional 20 households were included for participation in the e-cooking experimental component, with one replacement sample added due to non-availability of a pre-selected household. Consequently, the total sample size for the host community baseline survey was 621 households.

Annex B: Political, social, environmental, and technological considerations for different cooking fuels and technologies in Cox's Bazar

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
Government Policies and regulations	The LPG sector in Bangladesh is governed by a mix of pricing regulations, safety standards, and operational rules overseen by different authorities. Pricing and Market Regulation: The Bangladesh Energy Regulatory Council (BERC) regulates LPG prices. Since April 2021, BERC has revised LPG prices for private operators at the beginning of each month. For instance, the price of LPG per kilogram was set at BDT 121.25 (USD 1.0) for January 2025, the same as in November and December 2024 (BERC, 2025). Safety Oversight: The Department of Explosives is the main regulatory authority responsible for safety in	Firewood use is regulated under the Forest Act, 1927 (amended 2000), enforced by the Forest Department. Collection from reserved forests requires official permits, and unauthorised extraction is punishable, particularly in sensitive areas like Cox's Bazar and the Chittagong Hill Tracts (GoB, 2000). Firewood trading is monitored, with large-scale transport prohibited (GoB, 2000). Recent reforms, including the Forest Bill 2023 and Forest Conservation Bill 2023, aim to strengthen biodiversity protection and extend restrictions on tree cutting beyond forest areas. The Environment Conservation Act 1995 also provides protection for ecologically critical zones. Despite these	In line with the government's policy to promote sustainable energy use, the Revised Draft Renewable Energy Policy 2025 prioritizes the expansion of solar-based solutions, including solar-powered cooking technologies, particularly for off-grid and underserved communities (SREDA, 2025). In Bangladesh, **solar-based electricity systems are currently exempt from taxes**, which supports the government's goal of expanding renewable energy adoption. However, **used solar batteries fall under waste management obligations**, and according to the **Battery Recycling and Management Rules, 2006**, manufacturers and importers are responsible for collecting and recycling used batteries to prevent environmental harm (GoB, 2006; SREDA, 2025).	Limited policy interventions, though some regulations exist on charcoal production. For instance, the **Environment Conservation Rules, 1997** under the **Bangladesh Environment Conservation Act, 1995** require environmental clearance for operations like charcoal kilns, which can cause deforestation and air pollution (GoB, 1997). Charcoal production in Bangladesh is monitored in certain areas, particularly near forest reserves, due to environmental concerns such as deforestation and air pollution; this oversight is

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
	LPG handling, storage, and transport. LPG operators have adopted international safety codes and standards covering cylinder design, safety valves, tank construction, and emergency procedures. Under the LPG Operational & Safety Code 2020, retailers and distributors must maintain minimum safety distances, fire extinguishers, and cylinder storage limits (Department of Explosives, 2020). However, enforcement varies, and small-scale outlets in suburban areas often fail to comply, creating safety risks. Regulatory Framework: Bangladesh has a number of laws and regulations governing LPG operations, including the LP Gas Operational Licensing Regulation 2017, Liquefied Petroleum Gas (LPG) Rules 2004 (amended 2016), Auto Gas Act 2016, Pressure Vessel Rules 1995, and the Gas Cylinder Rules 1991. Together, these rules establish licensing requirements, technical standards, and safety obligations across the value chain.	frameworks, weak enforcement, corruption, and low community engagement continue to drive illegal harvesting and forest degradation		guided by provisions in the **Forest Act, 1927 (amended 2000) (GoB, 2000).**

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
	Persistent Challenges: Despite this regulatory framework, several issues persist. Cylinder scrapping is a recurrent problem, where unethical intermediaries sell empty cylinders as scrap metal when metal prices exceed the value of an empty cylinder, undermining safety and supply security (The Financial Express, 2023). Cross-filling of cylinders—prohibited under existing LPG rules—remains common within distribution networks, posing further safety concerns (GoB, 2016). These practices highlight the need for stronger enforcement and penalty clauses.			
Incentives	In Bangladesh, while there is no direct subsidy for LPG use, the government offers fiscal incentives such as zero import duty on bulk LPG and raw materials for cylinder manufacturing, along with a reduced 5% VAT on LPG distribution. These measures, outlined by the National Board of Revenue and supported in the Energy and Power Sector Master Plan, aim to promote LPG as a cleaner cooking fuel in areas without access to piped gas (Power Division, 2016; NBR, 2023). In addition, there	In Bangladesh, there are **no formal incentives for firewood use**. In fact, the government actively discourages reliance on firewood due to concerns over deforestation, biodiversity loss, and environmental degradation (GoB, 2000).	As of now, **there is no dedicated, large-scale government incentive programme specifically targeting e-cooking (electric cooking) in Bangladesh**	Little to none in place.

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
	is active support for adoption of LPG by the government and donors in Cox's Bazar and at the same time rising firewood prices			
Community Acceptance	Urban communities with higher educational endowments and awareness are ready to accept it while rural communities view this as a luxury item (Dey et. al., 2024). With rising prices of piped natural gas and the suspension of new residential connections, the use of LPG for cooking in both urban and rural areas is increasing. As Tanzeem Chowdhury, CEO of Omera Petroleum Ltd., noted in The Financial Express (2023), LPG has become a significant boon for rural Bangladesh—replacing firewood and helping curb deforestation and desertification [1].	Firewood is widely used mainly for cultural reasons as well as availability and affordability factors. Can be used for cooking diverse food items using clay-pot, aluminium pot, iron plate, etc. Requires no training. According to the BBS Report on Socio-Economic and Demographic Survey 2023, 69.59% of rural households in Bangladesh rely on wood, chalk, or chopped wood as their primary cooking fuel, while the figure is 32.20% for urban households (BBS, 2023c).	Need to make people aware of it. While compatible utensils are available in the market, key system components such as solar panels are still imported.	Popular in some rural areas, especially where firewood is scarce. Ready market supply used to exist locally.
Cultural Factors	For cooking some specific food, people often prefer earthen pot. Aesthetic product compared to firewood.	The use of firewood is deep rooted in cooking traditional dishes; often preferred for (perceived) taste of food.	There will be a need to adjust cooking time preferences, encouraging households to cook more during daylight hours rather than at night or early in the morning.	Used in both rural and urban areas where other fuels are expensive or unavailable.
User Experience	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	Polluting fuel but locally available.

[1] https://thefinancialexpress.com.bd/special-issues/lpg-industry-in-focus-1/rural-lifestyle-change-fuelled-by-lpg

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
			possible without battery support.	
Carbon Emissions	Lower than biomass but still a fossil fuel; contributes to CO_2 emissions. A 12 kg LPG cylinder emits approximately **33.6 kg of CO_2**, based on an emission factor of 2.8 kg CO_2 per kg of LPG (IPCC, 2006).	High emitter of greenhouse gases. Burning **1 kg of firewood** emits around **1.5 kg of CO_2**, depending on moisture content and combustion efficiency (FAO, 2010).	Zero emissions at the point of use.	Significant emissions from production and use, including carbon monoxide. Burning **1 kg of charcoal** emits approximately **3.67 kg of CO_2**, due to its higher carbon content and energy density compared to raw biomass (IPCC, 2006).
Health Impact	Cleaner than other solid fuels, reduces indoor air pollution, and improves health. However, a Stanford University study found that Cooking with natural gas or propane stoves poses serious health risks due to indoor air pollution. Research shows that using gas stoves significantly elevates levels of nitrogen dioxide, a respiratory irritant that can inflame airways and worsen asthma. These pollutants can spread throughout the home, often exceeding safe exposure limits within an hour of use. Gas stoves also release benzene, a known carcinogen, at levels comparable to or greater than second-hand tobacco smoke. Together, these emissions highlight that gas stoves not only compromise indoor air	Exposure to smoke causes respiratory tract illnesses and contributes to indoor air pollution.	No indoor emissions; reduces respiratory illnesses.	Produces harmful pollutants that contribute to respiratory diseases.

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
	quality but also contribute to long-term health risks.			
Availability	There is an existing and well-developed supply chain. With more than 20 active LPG operators in Bangladesh, the combined storage and logistics infrastructure currently exceeds national demand. Projections indicate that these existing facilities are sufficient to meet the country's LPG requirements through to 2030	Feasible and readily available in the market.	Feasible, but requires changes to make repair and maintenance easy in the local area.	It is commonly used but requires improved production and efficiency measures.
Efficiency **(World Bank, 2020)**	In Bangladesh, classified as Tier 4–5, LPG is considered a clean and efficient cooking fuel due to its high thermal efficiency, low emissions, and ease of use.	Low efficiency: high energy waste and requires more time to cook. In Bangladesh, firewood typically falls within Tier 1–2, depending on stove type and combustion quality, due to low efficiency and high levels of indoor air pollution.	It depends on cook stove and utensils. When paired with reliable photovoltaic and battery systems, these appliances can achieve Tier 4 or higher, offering a clean and efficient alternative where grid or LPG access is limited.	Moderate efficiency; higher energy density than firewood but wasteful burning. In Bangladesh, charcoal typically fall within Tier 1–2, depending on stove type and combustion quality, due to low efficiency and high levels of indoor air pollution.
Infrastructure Needs	The infrastructure requirements for LPG in Bangladesh span the entire supply chain, from international imports to household use. At the national level, LPG is imported by sea and requires robust port facilities, storage terminals, and safe bulk transport systems to move cylinders and bulk LPG across the country. Dedicated distribution and storage networks at	Minimal infrastructure is needed, mostly manual collection.	Stable electricity supply and durable appliances are essential, and in some instances, specialised utensils for stoves like induction cookers.	Charcoal kilns and transport networks contribute to inefficiencies.

Particulars	LPG	Firewood	Electric Cooking using Solar	Charcoal
	both regional and local levels are critical to maintaining safety and reliability, particularly given the highly flammable nature of the fuel. At the community level, LPG availability depends on licensed retail outlets with proper storage capacity and adherence to safety codes. Transport systems must ensure timely delivery of cylinders to urban, peri-urban, and rural areas, with strong oversight to prevent unsafe practices such as cross-filling. For end-users, the requirements are relatively simple: an LPG stove compatible with existing household utensils, making adoption more straightforward than other modern cooking solutions.			

Table 18: Comparative analysis of cooking fuel options in Bangladesh: political, social, environmental, & technological aspects

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

Communities often experience from inertia against changes or moving away from the status quo. Such rigidity is often linked to the existing socio-political situation, the availability of technology and the regulatory regime in which they reside. During the baseline survey, group discussions were held with community leaders and elders in the communities to ascertain these factors. This section, therefore, presents a comparative analysis of cooking fuel options in Bangladesh from the perspective of political, social, environmental and technological features (**Table 18**).

Electric cooking offers a modern and efficient alternative with zero emissions at the point of use, delivering clear benefits to indoor health and air quality. The scope of large-scale adoption of electricity based modern cooking fuels is currently limited given the instability of the grid electricity connection in the host communities and the lack of access to electricity in refugee camps. The relatively higher price of solar system components including batteries and price of these cookers are also impediments for large-scale adoption of e-cooking. 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 when 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.

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