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Powering progress: market creation strategies for solar e-cooking technologies in off-grid and displaced communities

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unitar United Nations Institute for Training and Research
GPA GLOBAL PLATFORM FOR ACTION

Last Mile Climate
IKEA Foundation
GeCCo
SOLCO SOLAR ELECTRIC COOKING

SUSTAINABLE ENERGY FOR ALL
CLEAN COOKING ALLIANCE
CLIMATE & CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS
UKaid from the British people
MECS Modern Energy Cooking Services

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Executive Summary

This report underscores the significance of energy for cooking as a pivotal climate issue, in addition to being a critical concern for economic development, health, gender equality, and the local environment in low-income countries. The challenge is acute across sub-Saharan Africa (SSA) where population growth is driving up total greenhouse gas emissions. While per-capita emissions remain far lower across SSA compared to most other regions, energy for cooking accounts for the largest share of household emissions, especially in rural areas. Within this broader landscape, we focus primarily on displacement settings where there are growing challenges and opportunities for creating and shaping the market for clean and modern energy cooking solutions, necessitating a change in thinking as well as operational reforms within the humanitarian sector. The report finds that:

- A clear path towards low-carbon development in SSA is partly built by solar electric cooking (e-cooking), offering a means to integrate the historically distinct realms of electrification and clean cooking within Sustainable Development Goal 7.

- Solar e-cooking technologies offer a promising and increasingly cost-effective solution to household cooking needs, in part thanks to growing rates of electricity access and falling costs of solar photovoltaic technologies.

- The price point of solar e-cooking technologies is rapidly falling, offering potential pay back periods of 2-4 years compared to the baseline scenario in many places. New business models are enabled by Internet of Things (IoT) technologies to track usage, measure and verify carbon reductions and provide end-user finance.

- International carbon markets (including Article 6 of the Paris Agreement and voluntary carbon markets) have the potential to generate carbon finance that not only promotes sustainable cooking practices but also contributes to global climate change mitigation efforts and sustainable development.

- Looked at solely through a greenhouse gas emissions lens, solar e-cooking can save 2-4 tonnes/year of CO2 emissions per stove, per year, against the average baseline scenario across SSA.

- While the carbon credit prices in existing carbon markets are volatile, our consultations suggest that the high-integrity carbon credits from solar e-cooking technologies could secure USD 10-25 per tonne. This would generate an income of USD 20-100 per year in carbon financing, which over 10 years equates to USD 200-1000, enough to cover 40-100% of the expected capital cost of solar e-cooking systems.

- As with any 'green energy transition', interventions are needed to activate or boost both the supply and demand side, to create and grow the market for this group of game-changing technologies which also deliver adaptation-side climate benefits.

- Forging new partnerships with private sector and financial institutions, including mandate-sharing within the UN, is key in creating and growing markets for e-cooking in displacement settings, where there exists a largely untapped (and growing) demand for clean and modern cooking solutions.

- The complexity of the problem necessitates a systems-based approach and the creation of platforms such as the Global Electric Cooking Coalition and SOLCO[1] that are managed by neutral, independent 'systemic intermediaries'.

- While clean cooking targets feature prominently in the Nationally Determined Contributions (NDCs) across Africa, including some that set explicit targets for e-cooking (though not solar e-cooking specifically), there are opportunities to highlight this further in revised NDCs and include a broader range of existing e-cooking technologies.

The report aims to contribute to discussions at the International Energy Agency's Clean Cooking Summit for Africa in May 2024, to inform and guide policy deliberations and collective action towards sustainable solutions. The launch at COP28 of the Global Electric Cooking Coalition and its associated 'SOLCO' Climate Action Partnership for solar electric cooking in situations of displacement, signifies a concerted effort and possible inflexion point for this agenda.

1. Introduction

In the pursuit of sustainable development and climate resilience, this report focuses on off-grid solar electric cooking (e-cooking) technologies as a dual solution encompassing both climate change mitigation and adaptation strategies. Globally, cooking with biomass amounts for as much as 2% of CO2 emissions[2]. Given the rapid advances and price reductions in solar e-cooking technologies, there is an opportunity to scale these solutions to help close the emissions gap[3] and deliver a range of co-benefits in support of numerous Sustainable Development Goals (SDGs). However, barriers to uptake remain and so a range of supply and demand-side interventions are needed to overcome these, to enable the provision of affordable financing for households to purchase solar e-cooking systems.

The choice of displacement settings as our focal point is not arbitrary but grounded in key trends. With escalating rates of displacement due to conflict and environmental factors - including climate change itself - these settings are at the front line in what we refer to as 'last mile communities'. These are defined as rural communities, often far from the electricity grid, mostly low-income, facing high levels of climate risk and heavily dependent on biomass energy to meet basic energy needs. Many such communities host displaced populations who often fall outside of national policy and planning for public services. Our analysis draws upon these dynamics, identifying opportunities for strategic State and donor interventions and private investment in clean, modern and sustainable energy transitions that can deliver co-benefits to host communities as well as displaced populations, and stimulate socio-economic development.

Moreover, our discussion is intricately linked to the Nationally Determined Contributions (NDCs), particularly in light of the upcoming 2025 submission of the next generation of NDCs[4]. As countries reassess their climate commitments, the mainstreaming of renewably powered e-cooking technologies, including the use of energy efficient appliances, offers a route to access climate finance to help create and shape markets for this sub-set of clean cooking technologies that can deliver significant socio-economic and environmental benefits called for in the Paris Agreement[5].

At the theoretical level, we align with the notion that both the State and a diversity of stakeholders play an important role in creating and shaping markets for sustainable development, beyond just addressing market failures[6]. The Solar Electric Cooking Partnership (SOLCO) (see Annex 1) exemplifies this approach, spearheading a multistakeholder effort to create and shape the market for e-cooking in displacement settings. Motivated to address the challenges and externalities of traditional cooking methods, SOLCO seeks to catalyse investment in solar e-cooking in situations of displacement, to deliver on various SDGs.

In essence, this report serves as a call to action, identifying specific needs and opportunities for both demand and supply-side market activation for solar e-cooking technologies, as a linchpin of climate resilience and sustainable development at the last mile, in the global south. Through collaborative partnerships, policy innovation, and market transformation, we can pave the way towards a more equitable, just and environmentally sustainable future.

Nyomon Blandina, 72, cooks food outside her home in Kyangwali refugee settlement, Uganda, 2023. © WFP/Beth Njoroge.

2. Unpacking a complex challenge

Solid fuels, predominantly firewood and charcoal, are the primary energy source used to cook food for 2.3 billion people globally, resulting in negative health and environmental impacts, which lead to global economic losses amounting to USD 2.4 trillion each year[7]. While 2.3 billion people rely on burning biomass fuels on open fires to cook their food, there are an estimated total 4 billion people who lack access to clean, modern, efficient, convenient, safe, reliable, and affordable cooking energy[8,9]. This definition corresponds to the technology-neutral umbrella term of "modern energy cooking services" (MECS), where cooking systems (the combination of fuels, appliances and practices) reach at least Tier 4 on the 0-5 scale of the Multi-Tier Framework (MTF)[10]. Bridging this gap and providing affordable access to MECS for all while leaving no one behind presents a multifaceted socio-technical and political challenge, and one that should not only be looked at as critical for the provision of basic services, but also a climate change mitigation and adaptation opportunity.

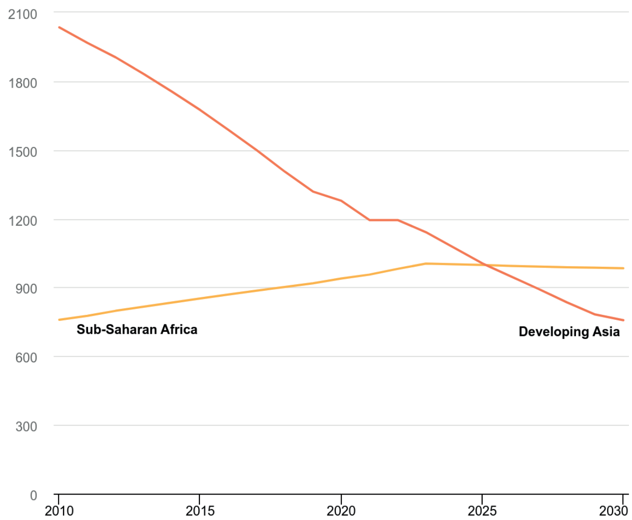
2.1. Energy for cooking as a climate issue

The consumption of biomass fuels is one of the drivers of land degradation and deforestation, and the burning of these fuels contributes approximately 2% of global CO2 emissions, including short-lived climate forcing black carbon emissions[11]. This equates to almost 1Gt of CO2e per year, or as much as emissions from the global aviation industry[12]. In many countries across Asia and Africa, household cooking can account for as much as 60%-80% of national black carbon emissions[13]. According to the Emissions Gap Report 2019, the amount of fuelwood burned across sub-Saharan Africa (SSA) is estimated to be over 400 million m3 a year, releasing over 760 million tons of CO2e into the atmosphere[14]. Further, according to the United Nations (UN), more than half of global population growth between now and 2050 is expected to occur in Africa, where the total population of SSA is projected to double between 2020 and 2050[15].

This presents major challenges in both absolute and relative terms, where figure 1 shows the International Energy Agency's (IEA) projection for the population without access to clean cooking in SSA versus developing Asia under the Stated Policies Scenario, 2010-2030.

The need to align clean cooking strategies with the NDCs directly incentivises the promotion of modern energy cooking solutions, including e-cooking[16].

Figure 1. Population (in millions) without access to clean cooking in sub-Saharan Africa and developing Asia in the Stated Policies Scenario, 2010-2030[17].



Doing so will help to significantly curb greenhouse gas (GHG) emissions derived from global energy cooking – by as much as 40% by 2040 as compared to 2018 levels – if universal access to e-cooking were achieved[18]. The International Renewable Energy Agency's (IRENA) World Energy Transitions Outlook 2021 report showed that renewably powered e-cooking should account for 85% of cooking energy by 2050, in order to align with the 1.5°C warming limit[19].

Further, in 2023 IRENA reiterated that renewables-based e-cooking is the cleanest form of cooking[20]. Yet, only 22 countries out of the 183 assessed in the same IRENA report included e-cooking in their NDCs or long-term low emission development strategies (LT-LEDS), while 52 countries included some other form of clean cooking in their NDCs or LT-LEDS, with most focusing on improved cookstoves (ICS), liquid petroleum gas (LPG), biogas and sustainable biomass.

The need to accelerate the transition to MECS technologies, especially e-cooking, was highlighted at the Africa Climate Summit in 2023 (commitments #11 and #26 in the Nairobi Declaration[21]) and at the Conference of the Parties (COP) 28 where the Global Electric Cooking Coalition[22] (GeCCo) and its displacement-focused sub-initiative SOLCO[23] were launched.

While the shift away from inefficient and polluting fuelwood or charcoal-based cooking presents a clear climate change mitigation opportunity, the adoption of renewables-based e-cooking solutions also offer adaptation co-benefits.

This is mainly due to minimising the dependence on scarce biomass resources and exposure to climate risks facing biomass species growth and availability[24]. The combined impacts of climate change, growing regional human pressures from population and economic growth, and heightened fire disturbances in densely vegetated areas are anticipated to decrease woody biomass by 4 – 8% throughout SSA[25].

Access to MECS results in improved socio-economic outcomes, such as time savings, enabling more time for productive and income-generating activities; improved health, well-being, and educational attainment; and an overall healthier indoor and outdoor environment[26]. Additionally, decentralised energy access solutions such as solar e-cooking can help boost resilience to climate shocks such as droughts or floods, which can affect the availability of biomass for cooking, or extreme weather events which can interrupt the provision of services through centralised infrastructure.

2.2. Clean cooking needs in displacement settings

According to the UN High Commissioner for Refugees (UNHCR), there were 110 million displaced persons worldwide by mid-2023, as a result of persecution, conflict, violence, human rights violations or events seriously disturbing public order[27]. Africa alone is home to more than 40 million displaced people, a figure that has doubled since 2016. 77% are internally displaced persons (IDPs), with refugees, asylum seekers and other people seeking humanitarian protection making up the 23%. The majority of IDPs and refugees live in protracted situations, defined as a stable displaced population in one location for more than 5 years[28].

Across SSA, displaced populations are often hosted in marginal areas with minimal government infrastructure and limited access to public services, including access to national grids and other critical energy access infrastructures.

The majority of displaced households in SSA (>90%) use either fuelwood or charcoal for cooking. Overdependence on woody-biomass therefore results in significant environmental degradation and increased biomass resource scarcity[29,30]. Women and children, being typically the ones responsible for fuel procurement, are required to walk long distances in search of firewood, often at risk of exposure to sexual and gender-based violence and conflict with host communities competing for the same resources[31].

Climate change and protracted environmental degradation was reaffirmed at the 2nd Global Refugee Forum (GRF) in December 2023 as a major concern to governments hosting refugees and IDPs, as well as development partners supporting humanitarian response in countries with significant displaced populations. The establishment of settlements or camps and limited attention to natural resource management in these contexts, further exacerbated by the lack of clean cooking access, have contributed to high rates of forest resource degradation[32].

Innovative and long-term strategies are therefore urgently required for sustainable forest management and natural resource protection in areas hosting displaced persons. Critically, these strategies should be inclusive of access to affordable, reliable, sustainable and modern energy for cooking for the most vulnerable groups at the last mile.

Lunch time in Ikipengbele Primary School, Republic of Congo. © WFP/Gabriela Vivacqua

The clean cooking challenge is further exacerbated in displacement settings which often fall outside of national policy and planning processes[33]. In particular, refugee camps and settlements in the Global South have often been subject to exclusion from national clean cooking initiatives due to the perceived temporary status of those settlements, lack of political will to include refugee populations into national development planning[34,35]. However, this is changing; where the challenge has become protracted it is also clear that the protection mandate of humanitarian organisations is not fit for purpose and often hinders the development of long-term, sustainable energy access solutions, also to the detriment of the local host communities. A good example of how host governments are acting to change this is Uganda's Sustainable Energy Response Plan (SERP) for Refugees and Host Communities, overseen by the Ministry of Energy and Mineral Development (MEMD)[36]. The SERP, and the processes and structures it has created in the Ugandan Government, is what enables the country to embrace the SOLCO initiative[37].

2.3. A turning point for solar electric cooking technologies[38]?

Clean cooking solutions that address the basic needs of the most vulnerable communities affected by humanitarian crises already exist. However, radical shifts in the selection of cooking solutions and the mobilisation of financing are required to enable transitions away from biomass, at scale. E-cooking is a critical technology that can help achieve a low-carbon energy transition, especially if powered by renewables-based electricity, whether from the grid, mini-grids, or by standalone, off-grid power systems, such as solar photovoltaic (PV) systems[39]. According to the IEA[40], as of 2020 solar PV became the cheapest form of electricity generation, with prices of solar PV modules declining significantly over the last decade, and by almost 50% year-on-year in 2023[41]. It is therefore imperative to help grow the market for solar e-cooking, particularly in off-grid and last mile contexts, including displacement settings.

At the same time, the cost trajectory of e-cooking technologies over the last decade shows they have reached a price point of affordability when considering the cost of energy-efficient appliances and the ongoing costs of cooking with electricity over the lifespan of those appliances[42]. Super energy-efficient e-cooking appliances (such as electric pressure cookers (EPCs), rice cookers, induction stoves) require a fraction of the power needed to cook, compared to inefficient appliances (e.g., hot plates): from 10-30kWh to 2-4 kWh per day, which makes it not only feasible but also cost-competitive against alternative cooking solutions if power is accessible at affordable rates. Better still, if power is supplied directly from a solar PV system and there is no ongoing cost of electricity, this solution becomes the cheapest option available today.

However, in addition to slow uptake among end-users (often due to low or no familiarity with the technologies), the biggest barrier remains the high upfront cost of e-cooking appliances as compared, for example, to ICS technologies. This calls for innovative business models and increased financing efforts to enable Pay As You Go (PAYG)-type schemes for end-users, thus addressing the upfront affordability gap. Additionally, the lack of familiarity with e-cooking technologies requires marketing and effective communication campaigns aimed at increasing uptake highlighting cost saving, convenience and broader benefits[43].

While their market share remains small, e-cooking technologies stand to disrupt the clean cooking access agenda. This is of particular importance in SSA which has one of the best solar resources in the world and in 2022 solar home systems (SHS) contributed to more than half of access increases in SSA[44]. Indeed, this is the direction of travel. For example, the World Bank Group has developed a strategic framework for expanding energy access for East and Southern Africa[45], to scale up grid and off-grid electricity connections, including solar mini-grid systems which could sustainably power 380 million people across Africa by 2030[46].

Moreover, it has recently become clear that access to clean cooking cannot (and should not) be disconnected from electrification policy and planning, especially in order to leverage progress made on electrification to speed up transitions to clean and modern cooking services[47]. Such integrated energy planning efforts should ensure that no one is left behind and that all groups are considered, including displaced populations. However, in most countries hosting refugees, IDPs and other displaced persons, energy policy planning, reporting and implementation frequently excludes displacement settings. Integrating e-cooking, and clean cooking at large, into the electricity sector can also help leverage electricity investment finance[48], which has historically far exceeded investment levels in the clean cooking sector. This is of particular importance for displacement settings and more broadly for last mile communities where energy access investment has been insufficient to meet even the most basic energy needs of end-users.

Detailed country-specific market assessments are available through the Roadmaps for Energy Access in Displacement Settings (READS) programme, implemented by the team at the Global Platform for Action on Sustainable Energy in Displacement Settings (GPA), hosted by the UN Institute for Training and Research (UNITAR)[49]. They found that e-cooking solutions offer viable solutions in each of its first three focus countries (Kenya, Rwanda, and Uganda), offering insights into the circumstances, issues and opportunities for clean energy access in displacement settings.

3. Aligning the humanitarian, energy, and climate agendas: the need for policy integration, systemic intermediaries, and inclusivity

Approximately 75% of displaced persons are hosted in the Global South, with more than 30% in Africa alone, where the average age of a refugee settlement is almost 20 years[50]. In response, there is a consensus on the need for longer-term and development-oriented (rather than purely humanitarian) solutions to the local and global environmental problems that are both a cause and effect of forced migration[51]. This is aligned with the Global Compact on Refugees (GCR)[52], which calls for actions to 1) help ease pressures on host countries and 2) enhance refugee self-reliance. As such, this demographic profile and status lends itself to the introduction of clean energy technologies that can not only alleviate the environmental pressures caused by the lack of clean energy access but can also trigger positive spill-over effects for local host communities, including job creation and peaceful coexistence.

Indeed, countries like Uganda have adopted comprehensive humanitarian and development programs in line with the GCR with specific commitments aimed at mitigating protection risks faced by the over 1.5 million refugees living in the country. Uganda's 2015 Settlement Transformation Agenda and subsequent inclusion of refugees into the National Development Plans, for example, allow for comprehensive planning and inclusion of refugees into the country's development planning[53]. The inclusion is actualised through the adoption and implementation of sector response plans, such as the SERP.[54]. Similarly, one of the Government's pledges to the 2nd Global Refugee Forum in 2023 was to include displaced populations into the country's NDC[55].

These developments necessitate and enable government-led strategies and investment plans for restoring and maintaining a healthy natural environment and ensuring universal access to affordable, reliable, and clean energy for improved social services for displacement-affected communities[56]. Pursuing this integration agenda[57] also aligns with UNHCR's Global Strategy for Sustainable Energy 2019-2025 which aims to enable refugees, host communities and other persons of concern to meet their energy needs in a safe and sustainable manner and to ensure that UNHCR's response is also environmentally sustainable[58]. The UNHCR Strategy aims to ensure that refugees have access to affordable, sustainable, safe energy sources and applications for cooking. These should be selected in consideration of the expected demand, local infrastructure, regulations, resource availability and technical feasibility. The Strategy further states that "*wherever possible, avoid establishing dependency on locally harvested biomass, give preference to clean modern cooking energy over firewood or other traditional solid fuels*."

However, the complexity of addressing sustainability challenges in displacement settings necessitates a systems-based approach and the creation of platforms such as SOLCO that are driven by neutral, independent and non-profit 'systemic intermediaries'[59]. Such intermediaries need to be lean organisations that are independent from any particular interest of partner organisations, governments, or companies. Last Mile Climate, an international NGO, is an example of one such 'systemic intermediary' operating in this space and, in the case of SOLCO, operates between the humanitarian and private sectors to enable large humanitarian agencies and host governments to more effectively and efficiently leverage proven solutions that exist in the private sector through a phased approach of 1) problem definition, 2) solutions piloting, and 3) scaled-up financing[60].

Further, the UNITAR-GPA team highlight the importance of following a bottom-up approach to energy access project design, where refugees and displaced persons are engaged from the ideation to implementation stage. This is not only a matter of principle, but also logic as refugee-inclusive projects help design solutions that are locally and culturally relevant, more likely to secure buy-in from the communities within displacement settings[61]. Such engagement is also best managed by a systemic intermediary, able to think and act outside of any given UN mandate or operational silo.

4. Growing and shaping the market for e-cooking in displacement settings: challenging the status quo and 'business as usual' scenarios

4.1. The baseline scenario

Donations and small-scale projects and programmes to distribute ICS technologies in situations of displacement have historically often been led by organisations with minimal expertise on market-based energy access and have often failed to reach scale. This tends to result from either short-term project design dependent on donor funding, or as a result of poor end-user follow up and continued support, such as after-sales services and ongoing maintenance. Many clean cooking programmes have also neglected partnerships with refugee-led organisations, thus missing the opportunity to benefit from the advice of those with lived experience of displacement, able to articulate the most pressing needs and preferences. As mentioned in the previous section, such collaborations are indispensable in designing locally relevant, culturally fit and contextually appropriate energy solutions in displacement settings.

Various recent initiatives aiming to provide modern cooking solutions in refugee camps have been called into question, including the sustainability (in every sense) of bulk purchases and free distribution of stoves and fuels to refugees by humanitarian agencies. Examples include Cox's Bazar (Bangladesh) and Mahama Refugee Camp (Rwanda) where the provision of a cooking solution in the form of LPG will only last so long as UNHCR receives sufficient donor funding to continue the free provision of fuel to households. The moment the funding is cut, the operations might be forced to scale down or cut supplies, leaving refugees with limited or no access to clean cooking, often having to resort to self-collected or purchased biomass[62].

Uganda. Newton Avuti, a Forest Supervisor with National Forest Authority (NFA), and collleague spot a kiln of charcoal that was prepared by illegal charcoal burners. © WFP/Arete/Kibuuka Mukisa

It is commonly, and mistakenly, assumed that MECS technologies offered under market-based approaches are beyond the reach of last mile communities, and particularly refugee populations, due to their cost, limited availability (if at all), and minimal awareness of their benefits. However, there is evidence of latent demand and a willingness to pay for MECS among displaced populations in SSA[63]. Due to local scarcities, a significant proportion of refugees pay for their biomass cooking fuel (e.g. USD 18 per household per month in Kakuma and Kalobeyei (Kenya)[64], USD 12 in Nyarugusu (Tanzania)[65], and USD 11 per refugee household in Uganda[66]). The per-kilo prices paid among refugees are up to three times higher than those paid elsewhere in the host countries, mainly due to the distances needed to collect and transport biomass from an ever-widening circumference around what can be city-like camps in existence for >30 years. Consequently, the purchase of cooking fuels can account for up to 50% of refugee household incomes[67].

4.2. The price of solar e-cooking and experience to-date in displacement settings

If we assume that a 1 kW solar PV system generates 4 kWh per day and costs USD 1,000 then this equates to less than USD 0.10 per kWh amortised over 10 years. E-cooking requires 2-4kWh for daily cooking for a family of 5 (if energy efficient appliances are used), meaning daily cooking costs are around USD 0.20-0.40 per day. This is far less than current biomass fuel expenditure in the average baseline scenario[68].

Cooking on PV-supported electric cookstoves or electric cooking systems (e.g. PV-powered pressure cookers) has been shown to have the potential to reach a competitive pricing level for those already paying for LPG or charcoal[6970]. In Malawi, Kachione LLC have demonstrated the feasibility of cooking with electricity on low-power SHS, with a significantly lower CO2 emissions and competitive cost against LPG and comparable cost with charcoal or firewood[71,72].

Pilots of solar e-cooking solutions such as the one implemented by Pesitho and Mercy Corps in Bidibidi, Uganda, have demonstrated that there is considerable demand among refugee households for such e-cooking products. This is particularly true if some key considerations are taken into account to stimulate both demand and supply for the new technology, which needs to be appropriate for the specific cooking needs of the population. Some of these factors include an accurate understanding of the willingness and ability to pay for these products, extensive market stimulation campaigns to demonstrate the practical use of the offered cooking solution, end-user credit products and the possibility to pay in instalments (Pay As You Cook[73]). Experience shows that financial and logistical support for e-cooking companies is key to enable them to supply quality products, to sustainably operate in displacement settlements. This includes the provision of after-sales services and the creation of green job opportunities to the refugee and host communities[74], both of which are non-conventional policies in many displacement settings managed by humanitarian agencies.

It is also important to highlight that e-cooking offers benefits beyond access to a clean and modern cooking solution. As asserted by Matola and Ogunbiyi[75], electrification and clean cooking should (and do) go hand in hand. Offering access to electric cooking can be paired with, and thus enable, access to electricity for other needs, such as lighting or phone charging. Conversely, the provision of access to electricity through solutions such as PV mini-grids that have been rolled out in refugee settlements (e.g. in Kakuma and Kalobeyei[76]) can be paired with a scheme to offer affordable access to e-cooking systems as well as productive uses of energy (PUE) applications to power income generating activities. Such market creation strategies open up further avenues for bankability of energy access solutions and higher levels of demand among both households and businesses.

Refugee testing the ECOCA Home 3 solar cookstove in Masaka District, South Sudan, 2023. © Ronald Kaweesa / EEA / Pesitho.

Open-access geospatial tools have also been used for more integrated approaches (e.g. in Kenya[77]). However, as previously mentioned, displacement settings, and in particular refugee camps, are typically not considered in national level planning due to their perceived impermanence, and/or a lack of understanding of the needs and realities of refugee households[78].

In the following sections, we discuss how further activating both the demand and supply side of e-cooking in displacement settings can help speed up progress towards the achievement of universal access to clean energy more broadly, in host countries.

4.3. Supply side activation

4.3.1. E-cooking providers

The limited availability of solar e-cooking solutions in much of SSA, and in particular in hard to reach, rural and displacement settings, is a key barrier to technology uptake. It is therefore critical to activate the supply of solar e-cooking technologies, and other modern cooking solutions. To date, there are only a handful of private sector providers of solar-electric cooking systems, as well as companies providing e-cooking solutions willing to explore their applications for off-grid areas, by either adding solar PV and (optional) battery components or partnering with mini-grid developers willing to offer e-cooking to their customers.

A notable example of a company with an established presence in refugee settlements is Pesitho (also known by their product name ECOCA), who in recent years have run solar-electric cooking pilots with communities in Bidibidi and Kyangwali refugee settlements in Uganda and have established local assembly facilities under a locally-registered cooperative model[79]. However, Pesitho's ability to establish presence in the refugee settlements, supplying approximately 1,200 households, has been heavily supported by grant funding. Scaling up commercial supply will require additional (ideally concessional) capital investment. To date, no other solar e-cooking provider has entered Uganda's refugee settlements on a commercial basis.

In Malawi, 230 ECOCA solar electric cookstoves have been distributed to refugee households with the support from the World Food Programme (WFP)[80]. In Kenya, e-cooking solutions, such as EPCs, have been piloted in households, businesses and more recently in health clinics (large-scale EPCs) with support from SNV in partnership with Renewvia – a mini-grid developer – and the Modern Energy Cooking Services (MECS) programme[81].

Village Infrastructure Angels (VIA) has been working on a battery-free solar electric cooking system to further reduce capital costs, developing the world's first cooking appliance to use energy-based instead of time-based automation so the cooker automatically cooks longer if there is a decrease in the input power (e.g. due to overcast conditions). VIA are yet to enter displacement settings with this solution and raising working capital remains a challenge, hindering technology roll out and testing.

While these small-scale pilots and operations are a step in the right direction and provide valuable lessons on technology performance and use, the challenge now is to channel concessional financing to the solar e-cooking providers. In general, they suffer from a lack of adequate working capital needed to establish operations or additional outlets in and around refugee settlements and to manufacture enough stoves to meet the latent demand (discussed in section 4.4).

4.3.2. Financing for e-cooking

Although investment in the clean cooking sector has increased in recent years - in 2022 the total investment exceeded USD 200 million - 90% of this was captured by the seven largest players[82], none of whom are yet present in displacement settings. Even if the USD 200 million were dedicated to e-cooking alone, it would be far below the significantly higher financing and investment required to create access to Tier 4+ cooking solutions for all the displaced communities globally.

Further, there has been virtually no 'patient capital'[83] coming into the humanitarian and displacement sector to create access to clean cooking technologies. The perceived risks associated with entering and operating in displacement settings have been a hindrance in the private sector's ability to raise commercial capital, especially debt and equity (with grant funding being the most common, yet also scarce). These risks include the administrative challenges associated with entering refugee camps or settlements[84]; lack of clarity over who's in charge of energy access, particularly refugee camps; risk of refugee relocations; risk of lack of ability and willingness to pay among refugee households and businesses; and risks of supply chain disruptions in times of crisis, among others[85]. Additionally, displaced populations are often located far from urban centres which increases the operational expenditure needs, posing supply-related risks on top of structural and policy risks.

There is a need to develop and offer access to de-risking mechanisms to the private sector where there is willingness to serve the large, growing and largely untapped market of displaced populations[86], in SSA and beyond. Broadly speaking, this means re-allocating, sharing or reducing the existing or potential risks associated with energy (or climate) investment – political risk, regulatory risk, financial/capital market risk and technology risk[87]. Typically, public entities such as donor governments, multilateral development banks, development financial institutions and climate funds encourage private investors to deploy capital by offering to bear a proportion of the risk. Table 1 provides a summary of possible mechanisms to support the development of various e-cooking solutions in displacement settings. Examples of such mechanisms are also drawn from across the clean cooking, electrification, and climate action sectors.

LtoR: James Wasonga, Lucy Kagure, Catherine Njeri and Charity Wairimu working at the Ecoa Induction Cooker Line.
© BURN Manufacturing.

Table 1. Examples of financial de-risking mechanism appropriate for clean cooking, including solar e-cooking, in displacement settings.

De-risking mechanism	How does it work?	Examples of where it has been used
Non-repayable grant	Non-repayable funds donated by a government agency, foundation, corporation or individual	NEFCO MCFA provides non-repayable grants to companies offering modern cooking solutions in selected countries in SSA. The Mitigation Action Facility provides grant funding to invest in catalytical projects with a strong GHG emissions reduction effect
Results-Based Finance (or Funding) (RBF)	Involves a mechanism through which a funder is willing to make payments to an agent who assumes responsibility for achieving pre-defined results. Results are defined in advance and funding is only released upon the achievement of these results that are verified independently.[88]	RBF for mini-grid development in Kalobeyei settlement (Kenya)
Repayable grant	Repayable funds donated by a government agency, foundation, corporation or individual	EEP Africa - offer both repayable and non-repayable grants
Convertible grant	Grants that support risky activities which, if successful, will result in the grant being turned into a loan (often with favourable repayment terms)	FMO's Access to Energy Fund and the Climate Action Windows at the African Development Bank (AfDB)
First-loss loan	A form of credit enhancement in which a third party agrees to cover a certain amount of an investor's loss	Climate Innovation and Development Fund (CIDF), managed by Asian Development Bank
Insurance or re-insurance	Investment insurance or re-insurance (or both), tailored for sector-specific risks including weather related risks.	Africa Energy Guarantee Facility (AEGF) - enhancing access to finance for energy projects by eliminating potential risks faced by energy sector investors through a system of backstops and insurance tools
Blended finance	Combines an investment, often from the government, with a commercial investment (e.g. % of grant funding with % of capital from a commercial loan)	UNHCR's commercial development of an LPG market in Niger
(Direct or quasi) Equity or convertible bonds	Money put into private or public company/ies by buying the company's shares and becoming partial owner(s) of the company according to the proportion of shares they own; a convertible bond is a bond with a stock option	Financial Sector Deepening (FSD) investment in Africa Climate Ventures (ACV), a Rwanda-based venture fund that invests in green companies across Africa.
Debt	Funds paid to a company or person with the expectation that the borrower will pay the investment back with interest	Public sector loans to clean cooking companies e.g.: SPARK+ which invests in designers, manufacturers, distributors, and retailers of cooking solutions in Africa Africa Go Green Fund which provides medium and long-term senior debt, mezzanine financing and guarantees
Mezzanine financing	Hybrid of debt and equity financing that gives the lender the right to convert to an equity interest in the company in case of default	

Blended finance

Current levels of funding and financing for clean cooking solutions in displacement settings are far below what is needed to meet even basic needs[89]. In particular, reducing reliance on grant funding and encouraging a shift from funding to financing will be key to scaling up these solutions in a financially sustainable way. Blended finance[90] has been gaining prominence in the humanitarian energy sector as a way of encouraging more commercial capital to flow in. It allows organisations with different objectives to invest in joint ventures, while achieving their own objectives and not carrying the entire investment risk on their own.

According to the Organisation for Economic Co-operation and Development (OECD) and the World Economic Forum (WEF), blended finance can include one or more of the following financial support mechanisms: direct funding for the removal of commercial barriers; technical assistance; risk transfer mechanisms; and/or market incentives[91]. Examples of blended finance application in humanitarian settings include the solarisation of the Humanitarian Hub in Malakal (South Sudan) managed by the International Organisation for Migration (IOM) and the commercial development of an LPG market led by UNHCR in Niger[92].

Clean cooking concessions

Another prominent idea that has been explored to speed up clean cooking transitions in displacement settings is clean cooking concessions, whereby companies bid to supply clean cooking fuels and technologies to a refugee camp and host community for a specified period of time, based on a price capped at an affordable level for the local population. A concession fund, set up to support this mechanism, then pays the difference between the capped price and the price of the successful bidder.

When designing clean cooking concessions, several factors should be considered, namely: long-term and flexible donor funding, sufficient de-risking for the private sector, a coordinated approach to fuel provision, a strong contractual framework, and a strategy for phasing out the concession so as not to create a long-term dependency. An example of a clean cooking concession concept for a displacement setting is the Moving Energy Initiative's (MEI's) concession for the development of an LPG market in Kakuma (Kenya)[93]. In principle, this could be adapted and applied to e-cooking technologies.

Carbon finance

Cookstove projects, particularly those promoting clean and efficient technologies like solar e-cooking, have the potential to generate carbon finance using international carbon markets. More importantly, clean cooking projects have significant sustainable development impacts and often bring multiple co-benefits such as improved indoor air quality, reduced deforestation, health benefits, and gender and economic empowerment.

Carbon financing has received increasing attention in the clean cooking sector as more projects and companies benefit from generating and selling carbon credits[94]. It is an innovative financing tool whereby large companies mostly in the Global North (e.g. Fortune 500 companies) can offset their own emissions by purchasing carbon credits earned from sustainable projects (such as clean cooking solutions for households and businesses who would otherwise use polluting and inefficient cooking stoves and fuels).

Currently, the demand for carbon credits from clean cooking projects is coming from the voluntary carbon market (VCM) offset programs such as Gold Standard. The evolution of international carbon markets under Article 6 of the Paris Agreement will provide further opportunities for scaling up clean cooking projects through mobilising carbon finance. Article 6 of the Paris Agreement provides a framework for countries to cooperate towards the implementation of their NDCs through two market-based mechanisms (under Article 6.2 and 6.4) and non-market modalities (Article 6.8).

The Paris Agreement Crediting Mechanism (PACM), previously known as Article 6.4 mechanism, is the UN's high-integrity carbon crediting mechanism. The PACM is currently under development and not yet agreed by Member States, though it offers opportunities for verifiable emission reductions, attract funding for implementation, and allow for cooperation among countries and other groups to conduct and benefit from these activities[95]. It allows for certain Clean Development Mechanism (CDM) projects to transition to PACM. As of December 2023, 1,379 CDM activities applied for the transition to Article 6 with a total estimated emission reduction potential of 0.9 billion tonnes. Of this total, around half of the estimated reductions originate from renewable energy projects, and around 1 in 5 credits came from energy-efficient clean cooking solutions[96].

The revenue from the sold carbon credits allows clean cooking companies to finance their operations. One way to do this has been to partially lower the capital cost of clean cooking solutions, effectively passing it onto consumers as a subsidy. An example is UNHCR's partnership with Atmosfair set up in late 2013 to bring fuel-efficient stoves to refugees in Rwanda[97]. This was UNHCR's first carbon financing agreement aiming to increase refugee access to energy, decrease environmental degradation and reduce carbon emissions from cooking. However, an evaluation of the project conducted one year on showed that only 31% of the 83 distributed stoves were being used, with 69% either sold or stolen, therefore compromising the expected emission reductions and pointing to the need for closer monitoring, more awareness raising for improved ownership, and better engagement with the refugee community, including through training[98]. Although this problem can often be challenging in households, it is less so in the case of institutions, for example schools, where stoves are typically fixed or cannot be easily moved.

While ICS technologies have widely benefited from carbon financing[99], the potential of e-cooking, and in particular solar e-cooking solutions, to tap into carbon finance is even greater. According to recent studies[100], the price of carbon emission reduction credits for clean cooking is higher than the average credits price for mitigation projects in the Global South. In particular, the robustness and integrity of measured emission reductions through accurate data collection on the usage of cooking appliances, e.g. by using consumption metres or Internet of Things (IoT) solutions (remote monitoring of stoves or appliances), is especially promising in e-cooking solutions for which a dedicated Gold Standard methodology has been developed[101]. This combination of measured e-cooking solutions has the potential to generate higher-quality and therefore higher-value carbon credits.

Such 'metered measuring' of clean cooking solutions can also directly benefit both the provider and the user of the clean cooking technologies, with ATEC Global being one of such providers that has implemented a 'Cook to Earn' scheme[102]. Such models could have a significant transformative potential for how clean and modern cooking solutions are offered and

Carbon financing for e-cooking: the basic maths

Solar electric cooking can save 2-4 tonnes/year of CO2 emissions per stove, per year. If valued at USD 10-25/tonne, this generates an income of USD 20-100/year. Over an average lifespan of 10 years, this is USD 200-1,000, which is enough to cover 40->100% of the expected capital cost of solar e-cooking systems, which can range between USD 500 - 1,000 (or above) depending on their capacity and functionality.

used by refugee households or businesses, with the earned revenue coming from carbon credits helping to pay off the already lower upfront cost of the stove (or cooking system).

More broadly, digitalisation has opened up avenues for outcome-based carbon finance whereby companies can pay for social and environmental outcomes generated through clean cooking projects to support the achievement of their own Environment, Social and Governance ambitions[103]. However, among the challenges with carbon finance is the instability of the VCMs, which can impact on long-term planning of energy projects and the uncertainty of future funding. As a result, some initiatives, such as the FairClimateFund, offer a fixed price for carbon off-setting that guarantees to cover the costs of the specific projects. Moreover, the high cost of accessing carbon credit schemes can be prohibitive to many clean cooking providers, especially small and medium-sized enterprises with little to no available capital to cover the high upfront costs associated with getting carbon accreditation.

Other challenges with carbon finance have emerged, including the integrity of carbon credits in the clean cooking sector that were documented in a study published in Nature Sustainability[104]. The study, led by University of California Berkeley, reviewed 51 clean cooking carbon projects developed under five cookstove methodologies and recalculated their emissions reductions using input parameter values from other published literature sources. They found significant differences among certain parameters including the fraction of non-renewable biomass (fNRB) [105]; firewood-charcoal conversion rates; stove adoption, usage, stove stacking; and fuel consumption. While the researchers did not evaluate the individual projects themselves, they speculate that the difference between their calculations and the projects' emissions claims are evidence of over-crediting. They note that the above-mentioned Gold Standard's Methodology for Metered and Measured Energy Cooking Devices, which directly monitors fuel use, is most aligned with their estimates and has the largest potential for emission abatement and health benefits.

4.4. Demand side activation

To boost demand for solar electric cooking in displacement settings, a number of strategies could be deployed by the private sector, humanitarian organisations and local and national governments.

Firstly, where solar e-cooking solutions have already been introduced, more awareness raising around the benefits of such cooking technologies and consequent behaviour change is needed to grow demand and encourage households to switch from biomass fuels[106]. To this end, engagement with local community-based or refugee-led organisations is critical to establish trust and ensure that such campaigns speak to the local context, as the non-financial barriers to uptake vary depending on the context and location.

Inclusive approaches to the design and provision of energy services are a key means to boost awareness, local buy-in and ultimately increase demand for new technologies[107]. Leveraging the familiarity with solar energy technologies *per se* in settings such as refugee settlements in Uganda or refugee camps in Rwanda or Kenya could also prove helpful as many households and businesses are already using SHS to power electric appliances or are familiar with solar energy provided through mini-grids[108,109]. Other countries hosting displaced populations where such distributed solar energy access technologies have also been deployed could also leverage the familiarity with solar products.

Secondly, ensuring product fit and product quality along with after-sales services will be critical to offer high performance and longevity. For that, understanding local cooking habits, common foods cooked, and wider cooking preferences will inform the choice of products that are able to satisfy the cooking needs of displaced persons and their host communities. It is important to recognise that those cooking practices and preferences can vary greatly even within the same settlement or region, especially in refugee settlements or camps where different countries and cultures are represented[110]. Ideally, products that have been quality-verified (e.g., under the International Organization for Standardization (ISO) standards or through Verasol) should be prioritised to build robust markets and customers' trust and satisfaction. Building the provision of after-sales services into any business model of private sector providers, whether already established or in the planning stages, will ensure that the offered cooking

WFP's plan to build household demand for solar power through decarbonising its field operations

WFP's Energy Efficiency Programme (EEP) is the flagship initiative for WFP's organisation-wide decarbonization strategy. The EEP is mainly funded by internal carbon taxes on vehicles and commercial flights and provides technical and financial support to Country Offices to decarbonize their operations and facilities. Thanks to the EEP and other efforts, WFP is frequently supplied with green electricity while aiming to lower its carbon footprint, which totalled 108,000 tCO2eq in 2022 and thus accounted for almost 8% of total UN system-wide emissions.

EEP-funded projects present opportunities for green energy access to the communities surrounding decarbonized facilities, increasingly powered by solar PV. WFP's offices, warehouses, food distribution points, etc. can act as "anchor loads", from which household energy access projects can be leveraged and built-out in various ways, including by direct supply of electricity from WFP facilities and innovative means design a financially sustainable business model.

solutions can have a long-term impact by offering repairs and assistance in case the cooking systems break or fail. The importance of this aspect has been seen in the off-grid solar electrification efforts in refugee camps across SSA[111].

Thirdly, demonstrating cost-competitiveness of solar e-cooking solutions against fuels that are already being used, in particular local markets for firewood and charcoal, can be challenging due to the capital cost of a solar e-cooking solutions being significantly more expensive than, for example, an improved charcoal or firewood stove. Clearly presenting the long-term savings of using solar e-cooking[112] alongside offering financing for such solutions and enabling payments on instalments (under PAYG-type models, also known as Pay As You Cook) could have a significant impact on addressing the possible hesitation to switch and the financial barriers to doing so.

Stove stacking should also be considered when talking about economic (and cooking needs) considerations: this is when households use two or more cooking technologies due to the frequent insufficiency of one single cooking solution to meet all the cooking needs (e.g. a cookstove that can only be used for one pot might not be enough when several dishes are cooked at the same time and the family size is large); for convenience (including speed of cooking) or personal preference reasons; or because certain foods are believed to be more economically cooked on fuels such as charcoal or firewood (e.g. beans) while others can more easily be cooked on fuels such as LPG or electricity[113]. Shifting those beliefs by showing the viability and cost-competitiveness of cooking long-boiling foods on electric cookstoves and in particular in EPCs (where access to electricity is available) can make for an important economic nudge to encourage a switch away from biomass[114]. Nonetheless, it is widely accepted that weather-induced limitations of off-grid solar e-cooking likely means that solid biomass will be used by households as a 'back up' fuel for approximately 20% of meal preparation.

Following on from the above, the lack of access to finance not only for clean cooking companies (especially local ones) but also for end-users is among the biggest barriers to uptake of clean cooking solutions, including e-cooking. Demand-side financing can support higher uptake of energy products and services in the target displacement settings, provided that market-based activities are already present and in need of a boost. In situations where markets are extremely fragile or even non-existent, supply-side financing should also be provided[115], as discussed in section 4.3. Microfinance Institutions (MFIs) can play an important role in filling in the financing gap. For example, Kiva – one of the largest lending platforms globally – has over the years extended loans to refugees around the world and, given the demonstrated viability of that segment (and one with a considerable need for access to microfinance), now prioritises refugees as part of their new strategy[116]. MFI loans can substitute appliance financing, including for solar e-cooking solutions, where private sector providers are unable to offer it. This calls for a close collaboration and partnership among different product and service providers with complementary offerings to tackle the clean cooking demand activation challenge. Figure 2 presents examples of generic barriers and opportunities to growing the market for sustainable energy services in displacement settings, most of which also apply to solar e-cooking solutions.

Comparing the financial costs of cooking

The capital expenditure (CAPEX) of e-cooking solutions is often higher than the cost of more carbon-intensive alternatives. The average CAPEX of a battery-supported solar electric unit can range between USD 500-1,000, while induction/hot plate units (which can be used on grid or on AC off-grid power systems) cost around USD 75. Electric Pressure Cookers, sold at approximately USD 80-100, far exceed the cost of traditional biomass ICS technologies (average USD 15-20) and also more than LPG start kits (on average USD 70). However, the operational expenditure (OPEX) per year of zero USD for e-cooking compare very favourably to the direct fuel cost for firewood or charcoal, estimated to be over USD 200 per year per household in rural areas and for other modern cooking solutions, like LPG and improved biomass. If paid upfront, the decision to replace biomass cooking with an off-grid solar e-cooking system would pay off after approximately 2-5 years.

Figure 2. General barriers and opportunities for growing the market for sustainable energy services in off-grid refugee hosting economies in Uganda[117].

Barriers	Opportunities
High costs of clean cooking and electricity access technologies	Instalment payments, flexible repayment mechanisms, customer subsidies, savings groups, easier access to credit
Limited private sector engagement in remote, rural areas where refugee settlements are located	Provide funding through RBF schemes and grants to establish shops, outlets, and storage facilities
Mixture of free distribution and market-based approaches	Improve coordination between stakeholders, promote both supply-side and demand-side mechanisms that are gradually phased out
Variable quality of energy technologies and lack of quality repair services	Support training and capacity building which provide recognised qualifications, establish hubs with trained technicians for basic repair and maintenance services, promote high-quality and certified products
High upfront costs of solar systems for social institutions and limited long-term funding for maintenance	Structure financing to include funding for maintenance, develop maintenance plans in partnership with stakeholders, implement plans under long-term agreements with the private sector

5. Climate action: driving both supply and demand for e-cooking as a group of mitigation and adaptation-side technologies

As discussed in section 2.1, the clean cooking agenda is also a climate action agenda. The use of biomass fuels is a significant driver of land degradation and deforestation, contributing about 2% of global CO2 emissions, including short-lived black carbon emissions. Beyond helping to reduce GHG emissions, solar e-cooking also offers adaptation benefits by reducing dependence on scarce biomass resources and enhancing resilience to climate shocks that can impact the market for biomass fuels.

Region-specific evidence exists to show that climate change has led to a shift in rain patterns, increased frequency of droughts, and desertification, making access to biomass for cooking increasingly difficult and expensive for those most vulnerable. For example, in Chad these phenomena have had significant impacts on agricultural practices that support local livelihoods of refugees and their host communities and have exacerbated the scarcity of resources, resulting in tensions arising over limited natural resources[118]. Competition for land and forest clearing have also made biomass resources scarcer for refugees and their host communities in Tanzania, where the UN Environment Programme (UNEP) is leading a USD 19 million 5-year project funded by the Green Climate Fund (GCF) to build climate resilience though ecosystem-based adaptation in the Kigoma region[119].

IOM's Displacement Tracking Matrix (DTM)[120], operating across several countries in SSA, has also shown multiple challenges associated with accessing energy, including for cooking, among displaced populations. This includes the risks posed by environmental shocks, such as droughts and landslides. There is, therefore, a clear need for building resilience to climate shocks by simultaneously moving away from biomass-based cooking, providing viable clean and sustainable cooking alternatives, and preserving and replenishing natural resources (e.g., through reforestation). For refugees, UNHCR has developed the Strategic Plan for Climate Action 2024-2030, though there is no clear route to funding its implementation[121].

Opportunities to transition to solar e-cooking should be seized where there are existing plans to shift away from firewood and charcoal provision for refugee populations. For example, Rwanda has already taken action to transition refugees to cleaner cooking, instituting a gradual firewood ban in refugee camps, though this appears to have been a reactive measure as opposed to the result of joined up thinking on wider energy transitions policy[122] . Although LPG has been prioritised as an alternative to biomass fuel in two camps – Mahama and Mugombwa – solar e-cooking could also be considered, particularly given the need for both access to electricity and clean cooking among refugees[123].

Yet on the supply-side, concessional climate financing to help kick-start markets for MECS as a whole is relatively low, once carbon financing has been discounted. To some extent this reflects the historical focus on biomass-based ICS technologies where the CAPEX is relatively low, but also because MECS technologies, including e-cooking, are not yet widely referenced in country's NDCs or LT-LEDS.

However, this appears to be changing with high-level commitments made at the Africa Climate Summit in 2023 and COP28 underscoring the need to transition to MECS technologies, particularly e-cooking. Initiatives like GeCCo and SOLCO (discussed in Annex 1) are pivotal in driving this transition.

Anchoring renewables-based e-cooking in the revised NDCs will help countries to secure large flows to concessional climate finance from various quarters, including multilateral public funds like the GCF. And ensuring displaced persons are also included in the NDCs will provide the strategic bridge to accessing climate finance for refugee and IDP populations[124]. However, operationalising this will require systematic and dedicated collaboration between the humanitarian and climate-mandated UN agencies grouped within the GPA platform[125] (see Table 2 for the accreditation status of various GPA members).


ATEC eCook IoT stoves in Rwandan household, January 2024. © ATEC.

Table 2. Multilateral climate financing accreditations among GPA members[126].

	Green Climate Fund (GCF)	Global Environment Facility (GEF)	Adaptation Fund
UNHCR	X	X	X
IOM	X	X	X
WFP	√	X	√
FAO	√	√	√
UNEP	√	√	√
UNDP	√	√	√
UNITAR	X	X	X
SEforAll	X	X	X
MercyCorp	X	X	X
Practical Action	X	X	X
GIZ	√	X	X
SNV	X	X	X
Clean Cooking Alliance	X	X	X

Women carry firewood home from the coast near al-Khokha, Yemen. © WFP/Sayed Asif Mahmud.

6. Conclusions

Solar e-cooking technologies offer a key means to pursue low-carbon development in SSA, helped in part by the trend to converge electrification and clean cooking policy and investments to deliver on SDG7.

The growing accessibility and declining costs of PV technologies contribute to the viability of solar e-cooking solutions, promising cost-effective alternatives for household cooking needs. With payback periods potentially as short as two years, coupled with innovative business models facilitated by IoT technologies, the economic case for solar e-cooking has become increasingly compelling.

Moreover, the environmental benefits of solar e-cooking are substantial, with potential CO2 emissions reductions of 2-4 tonnes per stove annually. When monetised at USD 10-25 per tonne, this not only offsets the capital costs of e-cooking systems but also generates additional income over time, potentially allowing carbon credits to fully finance the technology CAPEX.

However, to realise the full potential of solar e-cooking, concerted efforts are needed to stimulate both supply and demand sides of the market. Partnerships with the private sector and financial institutions, as well as collaborative initiatives such as the GeCCo and SOLCO, are essential for market development and scaling of these transformative technologies, particularly in displacement settings where opportunities are significant yet largely untapped.

As countries work to revise their NDCs, there is a strategic opportunity to elevate the prominence of e-cooking (inclusive of solar e-cooking) targets and investment strategies, further underscoring the importance of clean cooking solutions in the region's sustainable development agenda. By embracing a systems-based approach and collaborative platforms, African countries - home to significant populations of displaced persons - can chart a course towards a more sustainable, resilient, and equitable energy future.

Annex 1: SOLCO – a partnership approach to climate action in displacement settings

Creating access to solar e-cooking technologies in displacement settings requires new partnerships which can secure concessional finance, grow the market through awareness raising campaigns, to overcome barriers on both the demand and the supply side. While there are some market-ready e-cooker suppliers operating in Africa (e.g. BURN, Pesitho and ATEC), there are numerous startups that are struggling to get off the ground, particularly in the off-grid e-cooking space.

SOLCO is a multistakeholder initiative launched at COP28 under the GeCCo umbrella, focused specifically on situations of displacement[127]. The stated aim is to replace biomass-based cooking methods with solar electric systems for a minimum of 250,000 displaced households by 2027, across the number of African host countries. It aims to achieve this ambition by building a coalition of stakeholders ranging from national governments to private sector companies, NGOs and Community Based and Refugee-Led Organisations (CBOs/RLOs). SOLCO aims to achieve its stated ambition over an initial 4-year implementation period from Jan 2024 – Dec 2027.

SOLCO recognises the pivotal role of capital and investors in realising its mission. To leverage the targeted investment of at approximately USD 125 million, the partnership will actively seek various types of capital sources and investors committed to sustainable impact. SOLCO's approach involves engaging impact investors, philanthropic foundations, climate finance mechanisms, and strategic corporate partnerships. Impact investors with a focus on clean energy and social impact will be pivotal in providing the necessary financial support to scale up solar-electric cooking solutions across Africa. Philanthropic foundations, such as those dedicated to climate action and sustainable development, will play a vital role in supporting SOLCO's initiatives by funding the crucial roles carried out by local non-profit partners (e.g. awareness raising and community mobilisation, technical assistance and market development support, e.g., RBFs and demand subsidies).

Additionally, the SOLCO partnership will explore climate finance mechanisms, including carbon finance, to harness the growing interest in carbon credits as a means to fund clean cooking solutions. Leveraging the potential of carbon markets, SOLCO aims to attract investors interested in mitigating climate change while promoting sustainable cooking practices. Strategic corporate partnerships with companies aligned with SOLCO's vision will facilitate access to expertise, resources, and market reach. These partnerships will involve solar-electric cooking companies, technology firms, and energy-focused corporations that can contribute to the growth and sustainability of SOLCO's initiatives. The importance of favourable Government policies and regulation is also crucial[128], with countries such as Uganda paving a way forward with the SERP and decision to integrate refugees into NDC policy and planning.

GeCCo

SOLCO
SOLAR ELECTRIC COOKING

Annex 2: Key numbers, impact indicators, assumptions and drivers to support the business case for solar e-cooking

Table 3 summarises the key numbers, indicators and estimated impacts of SOLCO based on the roll-out of a broad group of solar e-cooking technologies with an 80% use rate[129] by the target 250,000 households (HH)[130]

Table 3. Indicators for the social and environmental impacts of solar e-cooking

Savings on direct cooking expenditure per household (HH), per year	USD 228
Direct financial savings and income benefits from improved health per HH, per year (estimated, based on health care costs and increased productivity)	USD 100
Time saving from reduction in fuel acquisition and preparation per HH, per year[131]	800 hrs
Lives saved from premature deaths due to household air pollution for 250,000 HHs[132]	8,333
Averted Disability Adjusted Life Years (ADALYs) for 250,000 HHs[133]	899,264
Annual carbon emission reductions for 250,000 HHs[134]	680,000 - 1,114,000 tCO2e

There are numerous other environmental and social co-benefits of solar e-cooking, including an increased percentage of local biodiversity maintained, x number of hectares of forest saved and new 'green jobs' created. However, since these are very context-specific they are excluded from table 3.

Table 4. Assumptions and drivers to support the business case for solar e-cooking

Direct expenditure on solid biomass cooking fuels, per year per HH[135]	USD 285
Savings from phone charging and lighting if powered by solar e-cooking system, per HH per year	USD 25
Direct fuel cost per year of cooking with solar-electric cooking	n/a
Cost (CAPEX) per solar e-cooking systems	USD 400 -1,000
Cost of insurance over 5 years per solar electric unit	USD 100
Cost of financing (microfinancing at HH level) per solar e-cooking system, over 5 years	USD 50 - 100
Price per tCO2e verified emission reduction from switch to solar e-cooking	USD 10 – 25
Carbon credit value over 5 years, per HH	USD 100 - 500
Net tCO2e carbon emission reductions per HH per year	2 – 4 tCO2e
Total net tCO2e carbon emission reductions for 250,000 HHs, over 5 years	3.4 – 5.6 MtCO2e

Further reading

Barbieri, Jacopo, et al. "Cooking in Refugee Camps and Informal Settlements: A Review of Available Technologies and Impacts on the Socio-Economic and Environmental Perspective." *Sustainable Energy Technologies and Assessments*, vol. 22, no. Supplement C, Aug. 2017, pp. 194–207, http://www.sciencedirect.com/science/article/pii/S221313881730098X.

Betts, A., Bloom, L., Kaplan, J., and Omata, N. (2014). *Refugee Economies: Rethinking Popular Assumptions.* Oxford University.

Bisaga, Iwona and Long Seng To. *Funding and Delivery Models for Modern Energy Cooking Services in Displacement Settings: A Review*. Energies, vol. 14, no. 14, 2021. https://doi.org/10.3390/en14144176

Bisaga, Iwona, and Long Seng To. *Clean Cooking in Refugee Camps and COVID-19: What Lessons Can We Learn?* Modern Energy Cooking Services Programme, Apr. 2021, p. 7, https://mecs.org.uk/wp-content/uploads/2021/04/Clean-cooking-in-refugee-camps-and-COVID-19-what-lessons-can-we-learn-1.pdf.

Chatham House (2019) *Cooking in Displacement Settings - Engaging the Private Sector in Non-wood-based Fuel Supply*

Chowdhury, Hemal, et al. "Role of Biogas in Achieving Sustainable Development Goals in Rohingya Refugee Camps in Bangladesh." *Sustainability*, vol. 14, no. 19, Jan. 2022, p. 11842, https://doi.org/10.3390/su141911842.

Clements, W., Batchelor, S., Nsengiyaremye, J. *Cooking Support on Mini-grids (COSMO): Synthesis report*. April 2024. https://mecs.org.uk/wp-content/uploads/2024/04/Cooking-Support-on-Mini-Grids-COSMO-Phase-1-Synthesis-Report.pdf

GPA (2023) *Inclusivity Strategic Outlook.*

GOGLA (2024) *Uganda Productive Use of Renewable Energy Market Assessment*. Kampala.

Halford, Alison, et al. "Off the Boil? The Challenges of Monitoring Cooking Behaviour in Refugee Settlements." *Energy Research & Social Science*, vol. 90, Aug. 2022, p. 102603, https://doi.org/10.1016/j.erss.2022.102603.

Haselip, J. and Bourbon de Parme, J. (2020) *The UNHCR Clean Energy Challenge: Setting Up Processes for Implementation*. UN Inter-Agency Global Platform for Action, Geneva

Haselip, J. (2019) *From assessment to investment: the role of research, data and evidence to deliver the UNHCR energy strategy*. UN Inter-Agency Global Platform for Action, Geneva

Humanitarian Response Info. *Fuel and Energy | Humanitarian Response*. 2017, https://www.humanitarianresponse.info/en/topics/environment/page/fuel-and-energy.

Khavari, B., Ramirez, C., Jeuland, M. et al. *A geospatial approach to understanding clean cooking challenges in sub-Saharan Africa*. Nat Sustain 6, 447–457 (2023). https://doi.org/10.1038/s41893-022-01039-8

MECS, and Energy4Impact. *Clean Cooking: Structuring Concessions for Displaced People*. Loughborough University, 2021, https://mecs.org.uk/wp-content/uploads/2021/09/Clean-Cooking-Structuring-Concessions-for-Displaced-People.pdf.

Nagpal, D. (2023) *Why Public Financing Needs to Be Centre Stage for Universal Energy Access*. IRENA expert insights.

Nerini, Francesco Fuso, et al. "The Cost of Cooking a Meal. The Case of Nyeri County, Kenya." *Environmental Research Letters*, vol. 12, no. 6, June 2017, p. 065007, https://doi.org/10.1088/1748-9326/aa6fd0.

Njenga, M., et al. "'The Problem Is a Lack of Firewood': Charcoal Briquettes for Cooking Energy in Refugee and Host Communities." *Social Sciences & Humanities Open*, vol. 9, Jan. 2024, p. 100852, https://doi.org/10.1016/j.ssaho.2024.100852.

Patel, Laura, and Katie Gross. *Cooking in Displacement Settings Engaging the Private Sector in Non-Wood-Based Fuel Supply*. Moving Energy Initiative Report, Chatham House, Jan. 2019, p. 48, https://www.chathamhouse.org/sites/default/files/publications/2019-01-22-PatelGross2.pdf.

Project Gaia. "Project Gaia: Humanitarian Work in Ethiopian Refugee Camps." *Project Gaia*, 2017, https://projectgaia.com/projects/refugees/.

Rafa, Nazifa, et al. "The Pursuit of Energy in Refugee Contexts: Discrimination, Displacement, and Humanitarian Energy Access for the Rohingya Refugees Displaced to Bangladesh." *Energy Research & Social Science*, vol. 83, Jan. 2022, p. 102334, https://doi.org/10.1016/j.erss.2021.102334.

Rivoal, M., and James Haselip. *Delivering Market-Based Access to Clean Cooking Fuel for Displaced Populations the Kigoma Region, Tanzania: A Business Plan*. UNEP DTU Partnership, 2018, pp. 1–36, https://orbit.dtu.dk/files/144864187/LPG_market_creation_plan_for_refugees_in_Tanzania.pdf.

Rosenberg-Jansen, S. *The Secret Life of Energy in Refugee Camps: Invisible Objects, Technologies, and Energy Systems in Humanitarianism*. Journal of Refugee Studies, Volume 35, Issue 3, September 2022, Pages 1270–1291, https://doi.org/10.1093/jrs/feac026.

Rosenberg-Jansen, S. *The emerging world of humanitarian energy: A conceptual research review.*
Energy Research & Social Science, Volume 92, 2022. https://doi.org/10.1016/j.erss.2022.102779.

Rosenberg-Jansen, S. and Haselip, J. (2021) *Critical Concepts and Research Needs in Humanitarian Energy. GPA Working Paper*. UNITAR, Geneva Switzerland.

SEforAll (2021) *Energizing Finance: Understanding the Landscape 2021*.

Tran, Anh, et al. *Landscape Analysis of Modern Energy Cooking in Displacement Settings*. Loughborough University, 2021, p. 96, https://mecs.org.uk/wp-content/uploads/2020/12/Landscape-Analysis-of-MECS-in-Displacement-Settings_17022021.pdf.

UNDP (2024). *Financial Aggregation for Distributed Renewable Energy in Uganda: Regional Assessment and Action Plan*, New York.

UNEP CCC (2021) *Unlocking support for local clean energy companies: insights from the solar PV industry in Uganda*, Copenhagen

UNHCR. *Protection-Sensitive Access to Clean Cooking (2021)*. UNHCR, 2021, https://www.unhcr.org/publications/brochures/61af71194/compendium-protection-sensitive-access-clean-cooking-2021.html.

van Hove, Elena, and Nathan G. Johnson. "Refugee Settlements in Transition: Energy Access and Development Challenges in Northern Uganda." *Energy Research & Social Science*, vol. 78, Aug. 2021, p. 102103, https://doi.org/10.1016/j.erss.2021.102103.

Vianello, Mattia. *A Review of Cooking Systems for Humanitarian Settings*. Toolkit for the Moving Energy Initiative, Chatham House, 2016, pp. 1–46, https://www.chathamhouse.org/sites/default/files/publications/research/2016-05-19-mei-review-of-cooking-systems-vianello.pdf.

Partners

UNEP Copenhagen Climate Centre (UNEP-CCC)

The UNEP-CCC is a project-based Centre, part of UNEP's Climate Change Division, that delivers science-based advisory services to partner countries, central to implementing UNEP's programme of work on climate change and sustainable energy. UNEP-CCC is also a co-founder and steering group member of the inter-agency 'Global Platform for Action' on SDG7 in situations of displacement and has published various technical outputs on this topic.

The Global Platform for Action on Sustainable Energy in Displacement Settings (GPA)

The Global Platform for Action (GPA) is a global initiative to promote actions that enable sustainable energy access in displacement settings, as laid out in the Global Plan of Action Framework Document, thereby ensuring SDG7 is inclusive of displacement situations. By connecting individuals and organisations in productive partnerships, the GPA helps advance energy programming in the humanitarian response in quality, scale, and replicability. The GPA offers a platform to connect and collaborate with partners in bringing clean energy solutions to displacement settings. The GPA Coordination Unit is hosted by the United Nations Institute for Training and Research (UNITAR).

Last Mile Climate (LMC)

LMC is a non-profit organization dedicated to assisting grassroots, humanitarian, and government entities in addressing climate-related challenges encountered by individuals residing in the last mile. LMC acknowledges that vulnerable communities bear a disproportionate burden of climate change impacts, with existing solutions often hindered by policy, cultural, and financial obstacles. The organization's mission revolves around serving as a facilitating and partnership-enabling NGO, bridging the divide between the private sector and the humanitarian sphere. Beginning with a thorough examination of the issue at hand, LMC collaborates with partner organizations to facilitate access to affordable solutions tailored to meet the needs of end-users. Employing a three-step approach encompassing problem analysis, solution testing, and financing for scalability, LMC aids partners in identifying the most suitable and cost-efficient solutions, along with optimal delivery mechanisms, tailored to address specific challenges within distinct contexts.

IKEA Foundation

The IKEA Foundation is a strategic philanthropy that focuses its grant making efforts on tackling the two biggest threats to children's futures: poverty and climate change. It currently grants more than €200 million per year to help improve family incomes and quality of life while protecting the planet from climate change. Since 2009, the IKEA Foundation has granted more than €1.5 billion to create a better future for children and their families. In 2021 the Board of the IKEA Foundation decided to make an additional €1 billion available over the next five years to accelerate the reduction of Greenhouse Gas emissions.

Endnotes

1 The Solar-Electric Cooking Partnership for Displacement Contexts (SOLCO)
2 IRENA, 2023: Renewables-based electric cooking: Climate commitments and finance
3 UNEP, 2023: https://www.unep.org/resources/emissions-gap-report-2023
4 UNFCCC: https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs
5 UNEP-CCC, 2022: https://unepccc.org/wp-content/uploads/2022/12/transformational-change-guidance-for-tna.pdf
6 Mazzucato, M. (2021): "Mission Economy: A moonshot guide to changing capitalism"
7 The State of Access to Modern Energy Cooking Services, World Bank, 2020 https://www.worldbank.org/en/topic/energy/publication/the-state-of-access-to-modern-energy-cooking-services
8 This means that approx. 1.7 billion people have access to some form of clean cooking, however, the solutions used cannot be classified as MECS (generally Tier 4 or 5 under the MTF).
9 ESMAP, 2020. The State of Access to Modern Energy Cooking Services.
10 For details on the MTF and the 5 Tiers of energy access, see here: https://www.worldbank.org/en/topic/energy/brief/fact-sheet-multi-tier-framework-for-cooking
11 Emissions Gap Report 2019, UNEP https://www.unep.org/resources/emissions-gap-report-2019
12 https://www.iea.org/energy-system/transport/aviation
13 https://cleancooking.org/the-issues/climate-environment/
14 Emissions Gap Report 2019, UNEP https://www.unep.org/resources/emissions-gap-report-2019
15 UN, 2023: https://www.un.org/en/global-issues/population
16 Yumkella, K., Batchelor, S., Haselip, J. and Brown, E. (2021) Solving the clean cooking conundrum in Africa: technology options in support of SDG7 and the Paris Agreement on Climate Change. UNEP DTU, Copenhagen
17 https://www.iea.org/data-and-statistics/charts/population-without-access-to-clean-cooking-in-sub-saharan-africa-and-developing-asia-in-the-stated-policies-scenario-2010-2030
18 Floess et al., 2023. Scaling up gas and electric cooking in low- and middle-income countries: climate threat or mitigation strategy with co-benefits?
19 IRENA. 2021. World Energy Transitions Outlook 2021.
20 IRENA, 2023: Renewables-based electric cooking: Climate commitments and finance
21 https://africaclimatesummit.org/resources
22 https://www.gecco.org/
23 https://www.gecco.org/countryengagement/solco/
24 Perera, N.; Boyd, E.; Wilkins, G.; Phillips Itty, R., 2015: Literature review on energy access and adaptation to climate change. Evidence on Demand: https://assets.publishing.service.gov.uk/media/57a0896b40f0b652dd0001fe/LitRev-EnergyAccessandAdaptation-Final-2.pdf
25 Ross, C.W., Hanan, N.P., Prihodko, L., Anchang, J., Ji, W., and Yu, Q. (2021) Woody-biomass projections and drivers of change in sub-Saharan Africa. Nature Climate Change.
26 Parikh, J., Cloke, J., Puzzolo, E., Pope, D., and Singh, C., 2020: Electric Cooking: Needs, Challenges and Way Forward. https://irade.org/website/wp-content/uploads/2021/03/Electric-Cooking_p4.pdf
27 https://www.unhcr.org/refugee-statistics/
28 UNHCR, Global Trends: Forced Displacement in 2016 https://www.unhcr.org/globaltrends2016/
29 Anywar, D., Shaban, K. S., Labeja, R.L., Loki, R. O., Beyihayo, G.A., Okello, C. and Haselip, J. (2023). The search for sustainability amid displacement: exploring the potential of fast-growing exotic tree species as fuelwood alternative for refugees and host communities in Northern Uganda. Journal of Environment and Development.
30 UNITAR-GPA (2022) The State of Humanitarian Energy Sector
31 Bellur, S. and Anish, A. (2023). Breaking Barriers: Improving Access to Clean Cooking in Displacement Settings. World Bank, Washington, DC.
32 Rivoal, M. and Haselip, J. (2017) The true cost of using traditional fuels in a humanitarian setting. Case study of the Nyarugusu refugee camp, Kigoma region, Tanzania.
33 UNEP (2023) Integrating displaced populations into national climate change and energy policy and planning. UNEP, Paris.
34 Bisaga, I. and To, L.S. (2021). Funding and Delivery Models for Modern Energy Cooking Services in Displacement Settings: A Review. Energies, 14 (14).

35 Rosenberg-Jansen, S., Tunge, T. & Kayumba, T. (2019). Inclusive energy solutions in refugee camps. Nature Energy 4, 990–992.
36 Grafham, O., Lahn, G. and Haselip, J. (2022) Scaling sustainable energy services for displaced people and their hosts: How policy and governance make a difference. Chatham House Research Paper, London
37 https://unepccc.org/uganda-leads-the-way-on-electric-cooking/
38 By solar electric cooking we refer to a broad category of both on and off-grid technologies, AC and DC systems.
39 IRENA. 2023. Renewables-based electric cooking: Climate commitments and finance.
40 IEA (2020) World Energy Outlook 2020.
41 IEA (2024) Renewables 2023.
42 IEA (2023). A Vision for Clean Cooking for All
43 MECS: Global Market Assessment for electric cooking
44 https://www.iea.org/commentaries/access-to-electricity-improves-slightly-in-2023-but-still-far-from-the-pace-needed-to-meet-sdg7
45 https://www.worldbank.org/en/results/2023/11/21/transforming-lives-through-energy-access-afe-1123-in-eastern-and-southern-africa
46 https://www.worldbank.org/en/news/press-release/2023/02/26/solar-mini-grids-could-sustainably-power-380-million-people-in-afe-africa-by-2030-if-action-is-taken-now
47 https://mecs.org.uk/
48 IRENA, 2023: Renewables-based electric cooking: Climate commitments and finance
49 https://www.humanitarianenergy.org/thematic-working-areas/reads-programme/
50 https://www.chathamhouse.org/2022/10/scaling-sustainable-energy-services-displaced-people-and-their-hosts
51 https://www.unhcr.org/what-we-do/how-we-work/environment-disasters-and-climate-change/clean-energy-challenge
52 https://www.unhcr.org/us/media/global-compact-refugees-booklet
53 https://data.unhcr.org/en/documents/download/93226
54 https://www.iea.org/policies/14566-sustainable-energy-response-plan-for-refugees-and-host-communities-in-uganda
55 https://unepccc.org/wp-content/uploads/2023/11/uganda-grf-pledges-2023.png
56 DG ECHO: approach to reducing the environmental footprint of humanitarian aid
57 https://www.unep.org/technical-highlight/un-agencies-call-climate-change-policies-consider-displaced-persons
58 https://www.unhcr.org/us/media/global-strategy-sustainable-energy-2019-2025
59 https://www.worldscientific.com/doi/abs/10.1142/S1363919603000817
60 https://www.lastmileclimate.org/
61 Rosenberg-Jansen, S., Hangi, J., and Ndahimana, E. (2023) Inclusivity Strategic Outlook. GPA-UNITAR. Geneva, Switzerland.
62 Haselip, J., Chen, K., Marwah, H. and Puzzolo, E. (2022) Cooking in the margins: exploring the role of Liquefied Petroleum Gas for refugees in low-income countries. Energy Research & Social Science, Vol. 83.
63 https://orbit.dtu.dk/en/publications/the-true-cost-of-using-traditional-fuels-in-a-humanitarian-settin https://www.chathamhouse.org/sites/default/files/publications/2019-01-22-PatelGross2.pdf.
64 https://www.unhcr.org/sites/default/files/legacy-pdf/640b53507.pdf
65 https://orbit.dtu.dk/en/publications/the-true-cost-of-using-traditional-fuels-in-a-humanitarian-settin
66 https://www.humanitarianenergy.org/assets/resources/Compress_Uganda_READS_report.pdf
67 https://orbit.dtu.dk/en/publications/the-true-cost-of-using-traditional-fuels-in-a-humanitarian-settin
68 Annex 2 contains key numbers, impact indicators, assumptions and drivers to support the business case for solar e-cooking, including the accumulative financial savings on direct cooking expenditure per household.
69 https://assets.publishing.service.gov.uk/media/57a08975ed915d3cfd00025a/Solar_Electric_Cooking_Synthesis_Report.pdf
70 https://www.esmap.org/cooking_with_electricity_a_cost_perspective
71 https://www.mdpi.com/2071-1050/13/21/12241
72 https://mecs.org.uk/blog/an-off-grid-solar-photovoltaic-electric-pressure-cooker-system-that-costs-only-200-in-malawi/
73 Similar to the Pay As You Go model prevalent among off-grid solar companies in much of SSA.
74 https://www.elrha.org/project/first-sustainable-off-grid-e-cooking-business-in-east-africa/
75 https://www.project-syndicate.org/commentary/africa-electrification-and-clean-cooking-integrated-strate-

gy-by-ibrahim-matola-and-damilola-ogunbiyi-2022-10
76 https://www.snv.org/update/sustainable-electric-cooking-pilot-households-and-institutions
77 https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1830268&dswid=4933
78 https://www.nature.com/articles/s41560-022-01006-9
79 https://pesitho.com/updates-on-pesithos-ecoca-cooperative-in-uganda/
80 https://pesitho.com/malawi-pilot-230-ecocas-with-wfp/
81 https://www.snv.org/update/sustainable-electric-cooking-pilot-households-and-institutions
82 https://cleancooking.org/wp-content/uploads/2023/12/CCA-2023-Clean-Cooking-Industry-Snapshot.pdf
83 https://acumen.org/wp-content/uploads/Accelerating-Access-Role-of-Patient-Capital-Report.pdf
84 This refers to the process of an organisation gaining authorisation to commercially operate in the camps, although the administrative challenges of physically entering can also be burdensome, depending on local policies.
85 https://mecs.org.uk/wp-content/uploads/2020/12/Landscape-Analysis-of-MECS-in-Displacement-Settings_17022021.pdf
86 https://europe.mercycorps.org/en-gb/closing-energy-access-gap
87 https://www.wri.org/insights/de-risking-low-carbon-investments
88 https://www.oecd.org/dac/peer-reviews/Results-based-financing-key-take-aways-Final.pdf
89 According to the UN's State of the Humanitarian Energy Sector report (2022), the total energy and environmental investment funding requirements listed in current humanitarian response plans, covering 28% of global refugee populations, was estimated at US$300 million for 2021. Scaling this to all refugee populations would have cost over US$1 billion for 2021. To cover all refugee energy needs globally between 2022 and 2030 would require over US$10 billion.
90 Commonly defined as "an approach for increasing the amount of project funding by combining different types of financing from different sources and/or for different purposes, which contribute to development, social, environmental or humanitarian goals and generate financial returns": https://www.nrc.no/globalassets/pdf/reports/blended-finance-solutions-for-clean-energy/blended-finance-solutions-for-clean-energy-in-humanitarian-and-displacement-settings.pdf
91 https://www3.weforum.org/docs/WEF_Blended_Finance_A_Primer_Development_Finance_Philanthropic_Funders.pdf
92 NRC (2022). Blended Finance Solutions for Clean Energy in Humanitarian and Displacement Settings.
93 https://mecs.org.uk/wp-content/uploads/2021/09/Clean-Cooking-Structuring-Concessions-for-Displaced-People.pdf
94 https://blogs.worldbank.org/energy/balancing-opportunity-and-risk-harnessing-carbon-markets-expand-clean-cooking
95 https://unfccc.int/process-and-meetings/the-paris-agreement/article-64-mechanism
96 https://unepccc.org/article-6-pipeline/
97 https://www.atmosfair.de/en/climate-protection-projects/energy_efficiency/rwanda/
98 https://www.unhcr.org/sites/default/files/legacy-pdf/55005b069.pdf
99 https://www.goldstandard.org/blog-item/gold-standard-improved-cookstove-activities-guidebook
100 mecs.org.uk/wp-content/uploads/2023/05/FINAL-The-Role-of-Voluntary-Carbon-Markets-in-Clean-Cooking-17-April-2023-with-photo-accreditation.pdf
101 https://globalgoals.goldstandard.org/standards/431_V1.2_EE_ICS_Methodology-for-Metered-and-Measured-Energy-Cooking-Devices-1.pdf
102 https://mecs.org.uk/blog/atec-and-fairclimatefund-launch-cook-to-earn-based-on-fair-principles/
103 https://www.gsma.com/mobilefordevelopment/resources/digitalising-innovative-finance-emerging-instruments-for-early-stage-innovators-in-low-and-middle-income-countries/?ID=a6g69000000HojoAAC&JobID=1725373&utm_source=sfmc&utm_medium=email&utm_campaign=M4D_XX_12_2023_Newsletter_December&utm_content=Read+more
104 https://www.nature.com/articles/s41893-023-01259-6
105 https://www.ci-dev.org/index.php/knowledge-center/fraction-non-renewable-biomass-emission-crediting-clean-and-effiecient-cooking
106 https://a.storyblok.com/f/191310/b722a7eaa4/bcc-20report-20-28final-2-29.pdf
107 https://www.nature.com/articles/s41560-019-0516-x

108 https://practicalaction.org/knowledge-centre/resources/improving-energy-access-for-refugees-in-rwanda
109 IRENA (2019). Renewables for refugee settlements: Sustainable energy access in humanitarian situations. International Renewable Energy Agency, Abu Dhabi.
110 https://endev.info/wp-content/uploads/2022/05/EnDev_Behavioural-change-campaign_Kakuma_Refugee_Camp.pdf
111 https://www.chathamhouse.org/sites/default/files/publications/research/2018-01-30-meeting-refugees-energy-needs-burkina-faso-kenya-mei-corbyn-vianello-final.pdf
112 https://www.mdpi.com/1996-1073/14/12/3371
113 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7259482/
114 https://documents1.worldbank.org/curated/en/920661600750772102/pdf/Cooking-with-Electricity-A-Cost-Perspective.pdf
115 https://energypedia.info/images/3/31/End_User_Finance_System.pdf
116 https://nextbillion.net/announcing-kivas-new-impact-strategy-nonprofit-microfinance-pioneer-refined-approach-process-behind-development/
117 Source: READS Programme (UNITAR/GPA Coordination Unit): https://www.humanitarianenergy.org/thematic-working-areas/reads-programme/
118 https://docs.wfp.org/api/documents/WFP-0000146472/download/?_ga=2.38476643.1739468473.1708003777-385968321.1707304559
119 https://www.unep.org/news-and-stories/press-release/tanzania-builds-climate-resilience-major-push-restore-landscapes
120 https://dtm.iom.int/
121 https://reporting.unhcr.org/climate-action-focus-area-strategic-plan-2024-2030
122 https://www.unhcr.org/sites/default/files/legacy-pdf/632481844.pdf
123 According to the READS programme, 69% of households in the refugee camps and host communities in Rwanda reported having electricity access, but only 24% have access to electricity for more than six hours. Additionally, electricity connections to the national grid are not allowed for refugees living in camps in Rwanda. Raising awareness of these realities among the private sector who can step in to provide alternatives to biomass-based cooking should be prioritized among both humanitarian actors operating in refugee camps and settlements, and national governments who are ultimately responsible for the wellbeing and protection of refugee and other displaced populations.
124 https://wedocs.unep.org/handle/20.500.11822/43203
125 https://www.humanitarianenergy.org/news/latest/pathways-to-implementing-multi-stakeholder-pledges
126 Source : https://www.chathamhouse.org/sites/default/files/2022-10/2022-10-04-scaling-sustainable-energy-displaced-people-and-hosts-grafham-et-al.pdf
127 https://www.gecco.org/countryengagement/solco/
128 This aspect was explored in case study detail in a report published by Chatham House (2022): Scaling sustainable energy services for displaced people and their hosts: How policy and governance make a difference.
129 Most experts assume a 20% continued reliance on traditional fuels in combination with solar e-cookers, depending on weather conditions which can affect performance.
130 The figures are based on data gathered in Uganda from various research projects, including the UK-funded Modern Energy Cooking Service (MECS)
131 Data based on the MECS eCooking Market Assessment https://mecs.org.uk/wp-content/uploads/2022/02/MECS-EnDev-Uganda-eCooking-Market-Assessment.pdf. This could be as >1040hr, assuming 20hrs per week on fuel collection (where firewood is the primary fuel). In additional fuel preparation time can be conservatively assumed to be 1 hr per day making the total >1400 hrs per year) https://www.brookings.edu/articles/africas-just-energy-transition-could-boost-health-outcomes/
132 Data from WHO: https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
133 Data based on the MECS eCooking Market Assessment: https://mecs.org.uk/wp-content/uploads/2022/02/MECS-EnDev-Uganda-eCooking-Market-Assessment.pdf; calculated as proportion of the 1.7M HHs covered in the report. Also see: https://www.goldstandard.org/consultations/consultation-averted-disability-ad-

justed-life-years-adalys

134 This number is calculated based on average HH emissions of 5.57 tCO2e derived from biomass-based cooking, as a result of 80% switching to solar e-cooking for 250,000 HHs. The 5.57 tCO2e per HH per year figure is derived from the national average consumption of 4t of primary wood fuel for cooking, which generates approx. 6.8t tCO2e, multiplied by the official fraction of Non-Renewable Biomass (fNRB) of 82% for Uganda = 5.57 tCO2e per HH per year. When multiplied by the purchase and verified use of 250,000 solar e-cooking units at an 80% use rate = a max mitigation effect of 1,114,000 tCO2e per year. If the fNRB falls to 50%, the mitigation effect is 680,000 tCO2e per year. This gives us the net mitigation effect of 2-4 tonnes/year of CO2 emissions per solar e-cook stove, per year.

135 This is a key baseline figure, which can vary significantly within and between countries (and between seasons), where urban fuel prices can be as much as 300% higher in urban areas. However, research reveals that fuel prices paid by displaced populations and their rural host communities can pay between 12 to 25 dollars per month, when not collecting fuel (references: https://mecs.org.uk/wp-content/uploads/2022/02/MECS-EnDev-Uganda-eCooking-Market-Assessment.pdf and https://orbit.dtu.dk/en/publications/the-true-cost-of-using-traditional-fuels-in-a-humanitarian-settin). Generally speaking, this a function of biomass scarcity surrounding what are often large and densely populated settlements in place for >20 years. Even based on conservative figures for fuel consumption and prices, the business case for solar e-cooking in Northern Uganda makes sense; if we assume a consumption rate of 8.5kg firewood per HH per day (or 3.1t per year, less than the national average of 4t) at a low $0.05 USD price per kg, this equates to USD 155 per HH per year. To which should be added supplementary charcoal expenditure (as on average 45% HHs use charcoal) = USD 155 + 1 x 50kg bag of charcoal per month at UGX40,000 = total USD 285.