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BUSINESS AND FINANCING MODELS FOR PV-SUPPORTED CLEAN COOKING AS A CRITICAL CLIMATE TECHNOLOGY FOR LAST MILE COMMUNITIES

JUNE 2025

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Photo frontpage

Electric Pressure Cookers (EPCs) piloted at schools in Tanzania. © SEforALL, 2025.

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1 Introduction

The uptake of higher-tier (4+) clean cooking solutions, especially in last mile communities[1], is a critical but often underfunded and insufficiently prioritised need[2]. Despite a diversity of viable technologies, including pure electric cooking (eCooking) powered by photovoltaic systems (solar PV) and PV-supported biomass gasifier stoves, as well as ethanol stoves, their widespread adoption remains a challenge due to various barriers, including upfront costs and low awareness among end-users about potential financial and health benefits. However, the decreasing cost of solar PV modules, and the increasing affordability of PV-supported clean cookstoves and appliances, have made that specific category of technologies more financially viable, cost-competitive and better aligned with the Nationally Determined Contributions to the Paris Agreement on climate change (NDCs)[3].

PV-supported cooking addresses both climate change mitigation and adaptation by reducing CO_2 and other pollutant emissions by decreasing the dependence on unsustainably harvested biomass from local (and often fragile) ecosystems[4][5][6]. With significant advancements and cost reductions in PV-supported clean cooking (see figures 1 and 2), scaling these solutions can help bridge the Emissions Gap[7] and support several Sustainable Development Goals. Overcoming barriers to uptake requires supply and demand-side interventions, including affordable financing for viable business models, to facilitate household adoption of clean cooking technologies through scalable market-based approaches[8].

1 In this context we define last mile communities as all those that are off-grid and/or marginalised in national energy and climate change policy and investment planning, including long-term displaced populations as well as peri-urban and informal settlements. More broadly this aligns with UNDP's definition of last mile communities as "not only the poorest of the poor but also the people, places, and small enterprise levels that are under-served and excluded, where development needs are greatest and where resources are most scarce." https://www.undp.org/publications/getting-last-mile-least-developed-countries

2 > 81% of displaced people living in camps and protracted settlements lack anything other than the most basic fuels for cooking and are forced to use firewood or charcoal to cook over open fires (Grafham et al., 2022). Meanwhile, according to UN-HABITAT, the majority of urban and peri urban poor, which represents between 50 to 60 of the urban population in Africa, rely on firewood and charcoal for cooking. The supply of biomass results in deforestation, land degradation, loss of biodiversity and scarcity of water and other resources, including the disruption of farming.

3 While other cooking systems exist in the market (including Liquid Petroleum Gas - LPG), we limit the focus on renewably powered and net-zero GHG clean cooking technologies, e.g. those aligned with the SOLCO partnership (see the section "Understanding Solar-Powered Cooking Technologies: A SOLCO Partnership Overview" at the end of the report for more detail). These are Tier 4+ solutions, so as to align with WHO Air Quality Guidelines where Household Air Pollution presents the biggest economic externality of 'dirty cooking': https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

4 Of the 2.1 billion people lacking access to clean cooking, most use solid biomass fuels—mainly firewood and charcoal burned in open fires—as their primary means of cooking (IEA 2023). This results in harmful household air pollution, which caused an estimated 3.2 million deaths (WHO, 2019). GHG emissions from non-renewable biomass for cooking amount to ~ 1Gt of CO_2e per year, about 1.9-2.3 percent of global emissions (ESMAP, 2020a). In Sub-Saharan Africa (SSA), over 90% of households depend on unsustainable biomass fuels. Transitioning to clean cooking solutions is essential for both climate and health, with each low-carbon stove potentially reducing 2 to 4 tonnes of CO_2e emissions annually compared to common baselines in SSA (UNEP-CCC, 2024).

5 Localised studies on the health impacts of indoor air pollution due to unclean biomass fuels or incomplete combustion are few and far between. To address this gap, Makerere Lung Institute, in collaboration with the Climate and Clean Air Coalition (CCAC) under the Africa Clean Air Programme (ACAP) are implementing a multi-country initiative aimed at improving household and institutional clean cooking transitions to protect health and the environment by raising awareness to influence decision-making, fostering collaborations with stakeholders that will scale up clean cooking programmes, as well as contribute to the development of national policies for clean cooking, air pollution, and climate health in Uganda, Kenya and Tanzania.

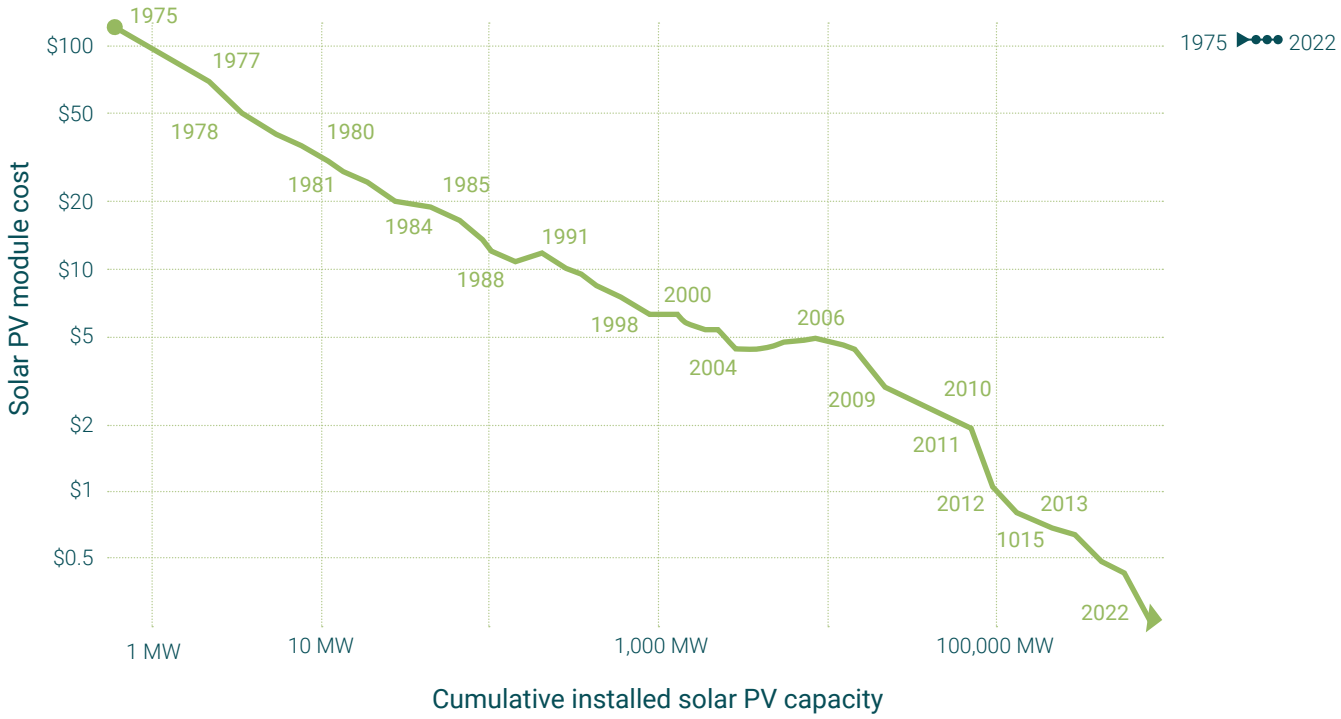
6 For a summary of tools available for assessing the climate change and resilience co-benefits of off-grid solar technologies see textbox on p.XX

7 The Emissions Gap Report assesses the latest scientific studies on current and estimated future greenhouse gas emissions and compares these with emission levels needed to achieve the goals of the Paris Agreement. This difference between "where we are likely to be and where we need to be" is known as the 'emissions gap': https://www.unep.org/resources/emissions-gap-report-2024

8 For a detailed discussion around the enabling framework to grow the market for eCooking, see the SOLCO report published in May 2024: https://unepccc.org/wp-content/uploads/2024/05/powering-progress-market-creation-strategies-for-solar-e-cooking-in-off-grid-and-displaced-communities.pdf

Figure 1. Solar panel costs have fallen by around 20% for every doubling of global cumulative capacity

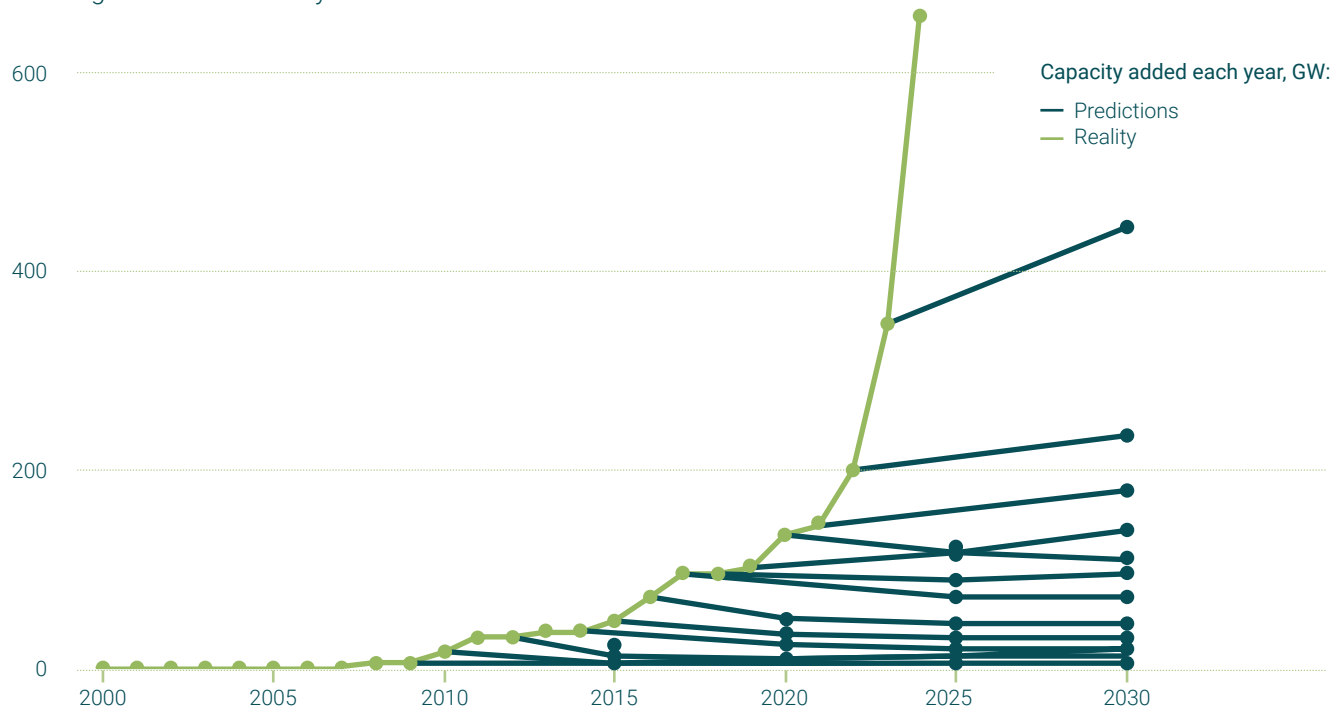
Costs are measured in US dollars per Watt, adjusted for inflation.



Source: Our World in Data, 2024.

Figure 2. Growth of the global PV market vs. IEA forecasts

On average, actual installations have been more than three times higher than their five-year forecast



Source: Economist, 2024 based on data from the IEA, Energy Institute and BloombergNEF.

2 Financing and business models to grow the market for PV-supported clean cooking

To enable the transition to clean cooking solutions at scale, there is a need for radical shifts in the use of grant-based funding, concessional financing, guarantee mechanisms and private sector business models. In doing so the aim is to move away from the 'purchase and distribute' model that is common in the humanitarian sector and which is clearly unsustainable and insufficient to meet growing needs.

Private sector participation is crucial in closing the infrastructure and service gaps, though attracting private financing remains a challenge, especially for last mile communities. As such, there is a continued need for public or private philanthropic funds and high-risk private capital to help de-risk and crowd-in other forms of investment capital, with varying degrees of risk appetite. In summary, traditional approaches to financing energy access have been limited, particularly in attracting private investment due to the perceived high risk and low returns in the market. While grant funding can support initial operations, it is essential to integrate financial sustainability into delivery models to reduce reliance on grants over the long term (GPA 2022).

Box 1. ***Household experience with eCooking technologies at the Last Mile***

Pilot programmes in Uganda have shown that solar eCooking can be affordable for low-income and displaced households when supported by tailored financing mechanisms. Across refugee, host, and smallholder farming communities, households were typically able to cover monthly instalments of $8.50 to $16 through reduced spending on cooking fuel, lighting, and phone charging. In many cases, these savings exceeded $20 per month, and some households also used the systems to generate small supplementary income, e.g. through phone charging. However, limitations such as large household sizes, poor solar panel placement, and occasional equipment downtime reduced impact for some users (Caritas, 2022)

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

Table 1. Indicators for the social and environmental impacts of solar e-cooking[9]

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	800 hrs
Lives saved from premature deaths due to household air pollution for 250,000 HHs	8,333
Averted Disability Adjusted Life Years (ADALYs) for 250,000 HHs	899,264
Annual GHG emission reductions for 250,000 HHs	680,000 - 1,114,000 tCO_2e

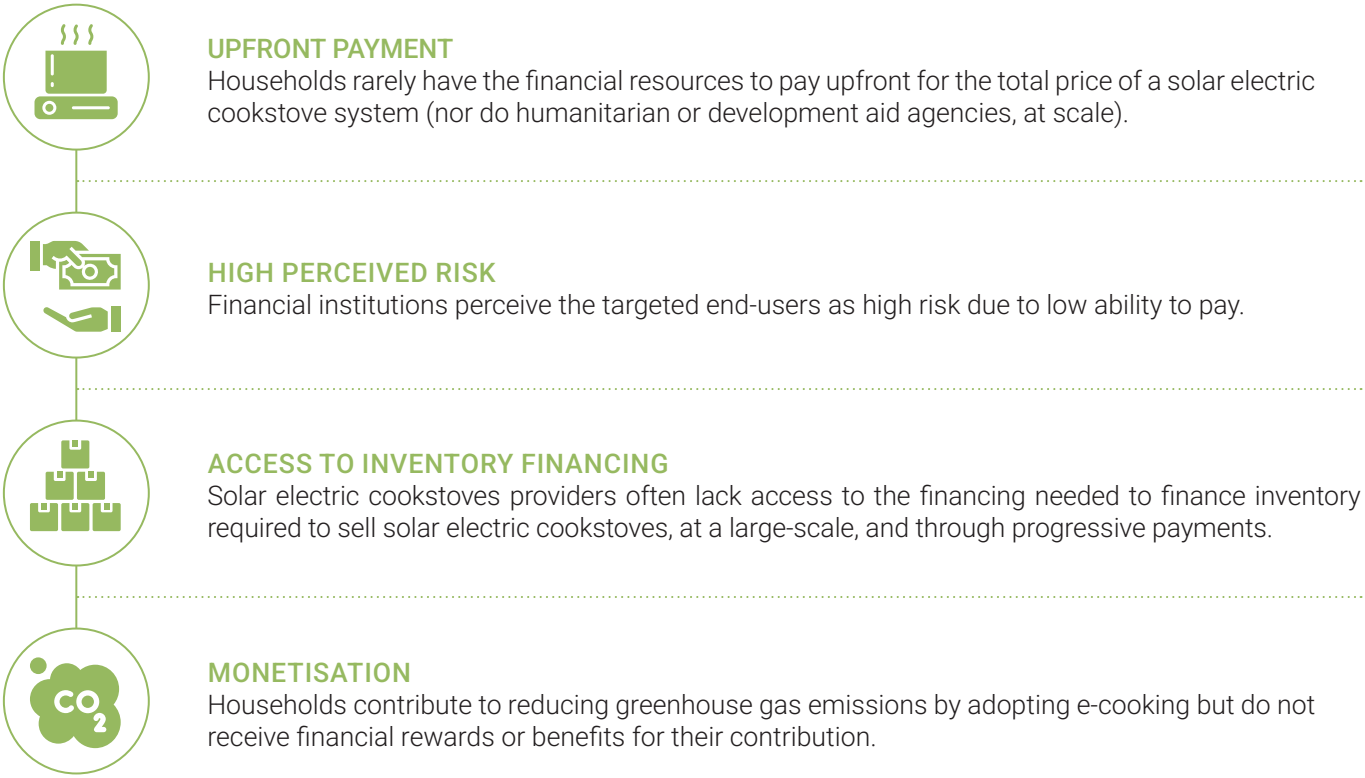
9 For more detail on the technology cost data and key assumptions underpinning the social cost benefit analysis see: https://unepccc.org/wp-content/uploads/2024/05/powering-progress-market-creation-strategies-for-solar-e-cooking-in-off-grid-and-displaced-communities.pdf

There are numerous other environmental and social co-benefits of PV-supported clean 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 2.

Table 2. Assumptions and drivers to support the business case for solar e-cooking

Direct expenditure on solid biomass cooking fuels, per year per HH	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 tCO_2e verified emission reduction from switch to solar e-cooking	USD 10 – 25
Carbon credit value over 5 years, per HH	USD 100 - 500
Net tCO_2e GHG emission reductions per HH per year	2 – 4 tCO_2e
Total net tCO_2e GHG emission reductions for 250,000 HHs, over 5 years	3.4 – 5.6 $MtCO_2e$

Figure 3. Key barriers to the uptake of solar cookstoves in last mile settings



Overcoming these challenges requires innovative finance solutions that attract diverse funding sources, reduce risks, and enable scalable, sustainable adoption of solar electric cooking solution

Adapted from Human Planet (formerly KOIS Advisory), for the SOLCO partnership

In this report we summarise various innovative business and financing models needed to further accelerate efforts to provide clean cooking solutions in last mile communities[10], particularly PV electric cooking systems[11]. These models can help address critical barriers to uptake by de-risking investments for both public and private sector providers to attract a mix of public and private capital, making products more affordable. In summary this can be achieved by:

- Reducing upfront costs of appliances for development agencies and end users as high initial costs of appliances remain a significant barrier to adoption;
- Enabling the development of optimal market conditions which involves understanding local contexts and tailoring solutions accordingly;
- Leveraging carbon emission reductions: transitioning to PV-supported cooking technologies can significantly reduce carbon emissions against a verified baseline, which can be quantified and monetised through carbon credits, providing an additional revenue stream to support the scaling of clean cooking solutions.

Figure 4. Innovative financing can help unlock clean cooking for last mile communities

CHALLENGE	FINANCING INSTRUMENT	DESCRIPTION
Upfront financing	PayGo	Customers pay for the cookstove based on usage rather than upfront. Payments are made incrementally
	Leasing	One party pays for the use of an asset owned by another party over a specified period
	Micro-finance loan	A microfinance loan is a small loan given to individuals or small businesses without access to traditional banking
High perceived risk	**Guarantee**	A third party guarantees the payments of the cookstove user. This reduces the risk to offer financing to customers who might otherwise be considered high-risk
	Results-based financing scheme	Solar electric cookstoves manufacturers receive a bonus payment for each system sold to a last mile household and used to a pre-defined extent
Working capital financing	**Working capital facility**	Short-term loan or credit line provided to the cookstove companies to finance their inventory (e.g. to enable PayGo)
Demand-side activation	Grant funding to NGOs	Grant provided to perform demand-side activation and advocacy towards target communities to incentivise them to adopt solar electric cooking solutions
Monetisation of Externalities	**Carbon credits**	Credits generated from using solar cookstoves to provide a revenue stream to subsidize costs, fund community outreach, and replenish financing facilities

Adapted from Human Planet (formerly KOIS Advisory), for the SOLCO partnership

Prioritised financing instruments for SOLCO

10 For a Policy Brief on Humanitarian Innovative Financing in fragile settings, see: https://odi.org/en/publications/humanitarian-innovative-financing-in-fragile-settings-taking-stock-and-charting-the-road-ahead/

11 While solar-electric cooking offers a cleaner and safer alternative to biomass, its long-term sustainability depends on more than just the technology itself. Field experience highlights the importance of local repair, maintenance, and end-of-life services. In contexts where such systems are lacking, solar-electric devices risk becoming unusable within a few years—particularly due to battery degradation—leading to increased e-waste and lost investments. Ensuring access to spare parts and establishing on-site maintenance capacity, including through local service providers, extended producer responsibility schemes or 'energy as a service' (ESCO) models, is essential to maximise the technology's lifespan and climate benefits.

2.1 Blended finance

Blended finance combines development finance with commercial capital and has emerged as a potential solution to attract private investors and develop sustainable market-based approaches for energy access and other critical climate development challenges (OECD, 2021; NRC, 2022). It offers a promising pathway to scale up eCooking solutions in underserved last mile communities, where affordability, risk, and infrastructure challenges often hinder adoption. Blended finance can help de-risk investments in such contexts by:

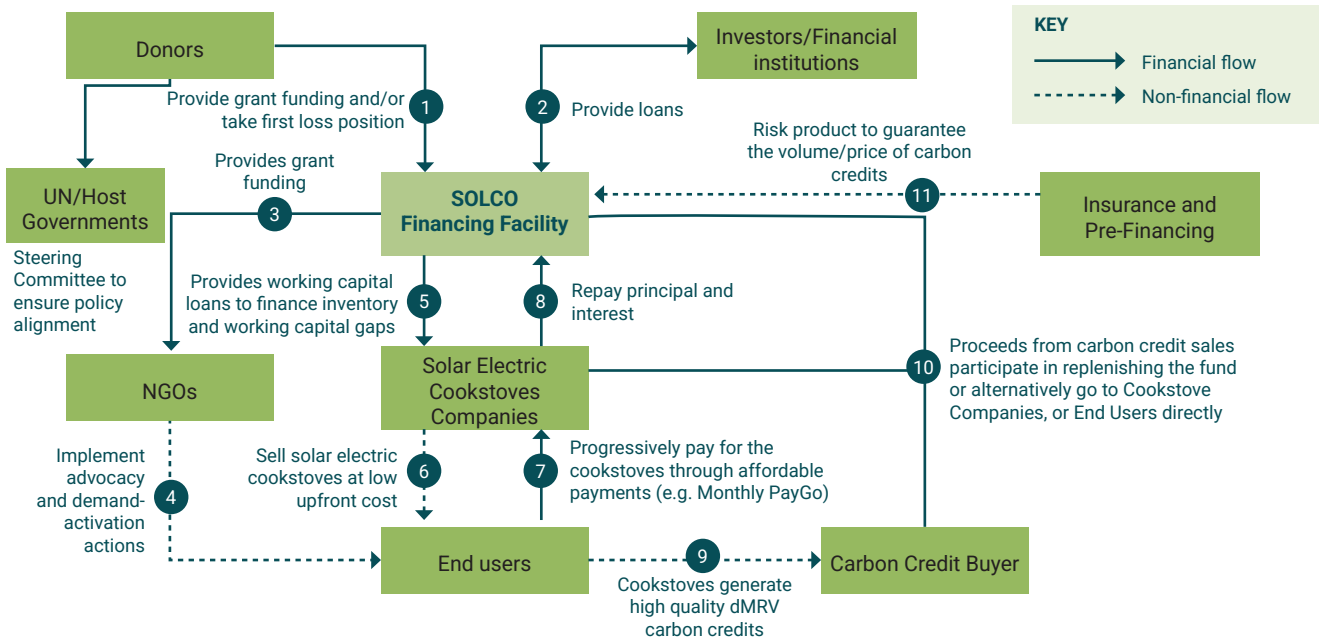
- Offering high-risk (first loss) capital from donors or development finance institutions (DFIs), which absorbs initial losses and shields private investors;
- Providing guarantees or insurance to cover risks such as payment default or political instability. This creates confidence among private investors to enter markets that would otherwise be deemed too risky;
- Integrating market-based approaches to interventions usually financed with public funds (for example leveraging school electrification as an entry point to bring the private sector to off-grid communities) and coupling energy projects with other development programmes (e.g. food security, nutrition, livelihoods and resilience).

Given that PV-supported cooking solutions, in particular pure eCooking solutions, require relatively high upfront capital investment, blended finance can also help address this challenge by subsidising capital costs through results-based financing (RBF), grants or energy vouchers lowering retail prices for end users. Further, it can support PAYGO (Pay-as-you-go) models[12], where concessional funding backs the infrastructure required for payment in instalments, helping low-income households access solar eCooking systems.

12 See later in this section for an elaboration on RBF and PAYGO models and their application to humanitarian and displacement settings.

Mohammed Shuaibu (GISCOR Project Field Manager) explaining operation and usage of solar panel and other ECOCA parts during Cookstove supporters training, Nigeria. © GISCOR

Figure 5. Financing structure to mobilize private capital for SOLCO



Adapted from Human Planet (formerly KOIS Advisory), for the SOLCO partnership

Finally, public or philanthropic grant capital remains key to funding activities such as market assessments and demand-side activation activities and studies to reduce entry barriers for businesses; capacity-building and technical support for local suppliers and distributors to develop robust solar eCooking supply chains; and policy and regulatory support for host governments to integrate clean cooking into national energy and humanitarian frameworks. These activities are critical for informing business model developments that adequately address the needs of the end-users, while also establishing the critical backbone of a favourable market and policy environment in which solar eCooking businesses can thrive and deliver energy services sustainably, while delivering GHG emissions reductions. Addressing the need to build such sustainable energy systems can in turn help transition from donor-dependent programmes to scalable market-driven solutions that continue over the long-term.

35.2 kWp PV system to power a school kitchen and surrounding businesses in Kasungu, Malawi. Credit, Ida Giese, WFP, 2025.

Box 2. ***eCooking as an anchor load for institutional electrification at the last mile***

In Kasungu, Malawi, WFP has engaged DIFFER, an international social enterprise with local presence, to bring electricity to three pilot schools to enable cooking with Electric Pressure Cookers (EPC), lighting and other energy services. While the upfront cost funds have been made available through grants, after sale services and opportunities for growth are an integral part of the delivery model design. The solar PV systems belong to the schools, while the company that operates them also manage several small entrepreneurial activities including milling and the leasing of batteries and lanterns. There are plans to expand into additional business opportunities, including renting (unused) irrigated school land to local farmers and powering the refrigeration of high value crops. Under this business model the profits are split between the schools and the company.

Similarly, in Madagascar eight schools have been electrified, either through stand-alone PV systems or connected to Rural Rapid Transformation energy hubs set up by WFP, with a plan to hand these over to local enterprises. In both cases, the combined use of energy for public services (e.g. school cooking with electric rice steamers, lighting, digital education) and productive uses such as water pumping for drinking and irrigation and a number of entrepreneurial activities (equipment renting e.g. sound systems; drinks and dairy products processing and storage, multi-cereal milling machines, refrigeration, egg incubators, battery charging etc.) make the model sustainable in the longer term.

12 x 40 litre PV-powered electric pressure cookers in a school kitchen, Kasungu, Malawi. Credit, Ida Giese, WFP, 2025

2.2 Results-based financing (RBF)

RBF involves allocating public funds to businesses based on their fulfilment of predetermined outcomes (such as the sale and installation of functioning solar eCooking solutions and their active usage over time), followed by an independent verification of the intended results. This ensures greater accountability among implementing partners and suppliers, and shifts the focus from inputs (e.g., distributing devices) to outcomes (e.g., sustained usage, user satisfaction, reduced firewood reliance and emission reductions). PV-supported clean cooking technologies can help households and businesses to make significant cost savings over time and/or unlock income generation opportunities, thus increasing the overall sustainability of the intervention.

Given that many last mile communities are often seen as high-risk and low-return markets, RBF can help de-risk these investments by offering performance-based incentives to companies for each verified unit deployed or user onboarded. Importantly, it can be an effective tool for attracting local enterprises, early-stage energy access companies, and technology providers to enter and innovate in these underserved markets (MECS & Energy4Impact, 2022).

With regards to alleviating the affordability barrier, RBF can help lower costs for end-users as it is effectively used to subsidise the gap between market prices and what off-grid and last mile communities can afford, particularly in contexts with limited regular income or no access to credit (Stritzke et al., 2021). It also supports tiered incentives for reaching more vulnerable or remote populations, often falling outside of the priority segments among the well-established, profit-driven businesses, encouraging more equitable distribution.

RBF schemes have also played a role in promoting the use of digital monitoring, such as IoT devices or mobile-based surveys, to verify performance and usage. The widespread adoption of such tools in the off-grid

solar sector has in recent years been translated into the modern energy cooking services which lend themselves to such monitoring solutions, e.g. in the case of electric cooking appliances where electricity consumption can be remotely monitored (Little et al., 2023). This innovative approach to MRV of cooking systems enables evidence-based learning that can feed back into RBF programme design as well as policy advocacy, which can be particularly impactful in last mile contexts with evolving needs.

Box 3. ***Results-Based Financing in action for eCooking***

The Uganda Energy Credit Capitalisation Company (UECCC) has launched a subsidy programme under its Results-Based Financing (RBF) initiative to enhance the adoption of clean energy technologies, including solar electric cooking solutions, across Uganda (UECCC, 2024). The programme offers significant price reductions on various clean energy products, including clean cooking solutions (powered by solar, briquettes, ethanol and biogas) at a 30%–50% discount, depending on the technology. It is designed to benefit a broad spectrum of households, including rural and remote households, vulnerable groups and refugee-hosting communities (including refugees). By reducing the upfront costs associated with solar electric cooking technologies, the UECCC subsidy scheme addresses one of the primary barriers to adoption in Uganda.

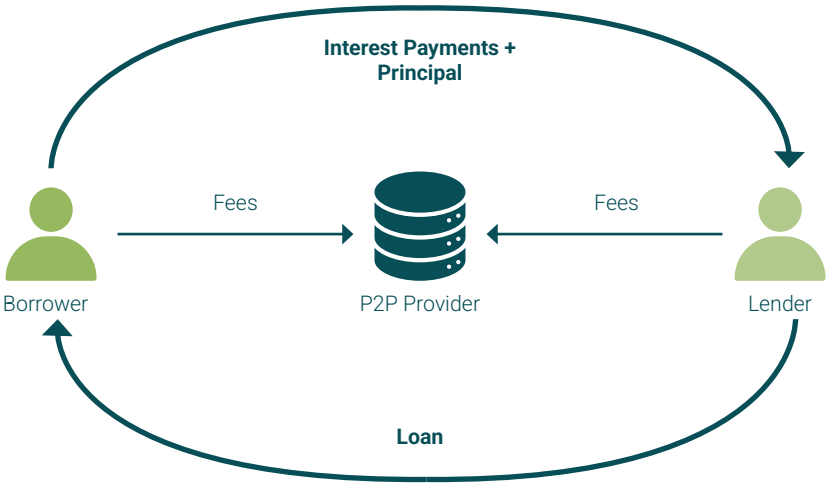
2.3 Peer-to-peer lending (P2P)

P2P lending allows energy providers to receive loans from an individual or a group of lenders through crowdfunding platforms (e.g. Kiva, M-Changa, Thundafund).

Last mile communities often lack access to formal banking services, making it difficult to obtain credit for clean energy products. P2P platforms can help address this barrier by bypassing traditional banks and enabling individuals to secure loans directly from impact-driven lenders or diaspora networks (MECS & Energy4Impact, 2021). Typically, crowdfunding platforms use alternative credit scoring methods, such as community reputation or mobile phone data, to assess risk and enable lending to people without formal credit histories.

As a more flexible lending mechanism, P2P platforms more commonly offer small-ticket loans which are well-tailored to the cost of PV-supported cooking solutions. They also allow for PAYGO integration, where loan repayment aligns with actual usage and ability to pay. In the case of P2P group-based lending models, refugee or host community savings groups are involved to share risk and increase repayment reliability. Moreover, P2P platforms can be used to channel diaspora remittances or capital from social impact investors toward clean cooking initiatives (FSD Africa, 2016). These individuals often seek to contribute to development in their countries of origin or specific target geographies and can fund solutions such as PV-supported clean cooking devices for relatives living in last mile communities.

Figure 6. **Schematic of basic financing flows in a P2P scheme**



Given the growing interest in P2P lending, these models could be combined with other financing mechanisms, such as subsidies or RBF schemes which can cover part of the capital cost, while P2P loans fill the remaining gap. Additionally, development agencies or humanitarian actors can guarantee or co-invest in P2P portfolios to reduce risk and attract more lenders.

Box 4. ***Peer-to-peer lending to kick-start last mile community businesses***

Energy4Impact, through its Women Integration into Renewable Energy (WIRE) programme, partnered with M-Changa, a leading African crowdfunding platform, to boost clean energy access and support women-led enterprises in rural Kenya and Tanzania (M-Changa, ND). Targeting around 450 women entrepreneurs in the clean cooking and off-grid lighting sectors, the initiative aimed to overcome the financing barriers these micro-enterprises typically face. M-Changa's mobile-friendly platform enabled easy fundraising through Kenya's mobile money services like M-Pesa and international options such as PayPal and VISA. Funds raised were used to purchase electric briquette machines, solar lighting stock, raw materials, and construct cookstove production kilns. A referral system boosted campaign reach: for every three successful referrals, Energy4Impact matched the donation. This innovative approach not only mobilised community resources but also empowered women entrepreneurs to grow sustainable clean energy businesses.

2.4 Carbon and outcome-based finance

PV-supported cooking solutions displace traditional biomass fuels (e.g., firewood or charcoal), significantly cutting CO_2 and black carbon emissions (UNEP CCC, WFP & UNITAR-GPA, 2024). These reductions can be quantified, verified, and sold as carbon credits on voluntary or compliance carbon markets. The revenue generated can be used to subsidise appliance costs for end-users; support PAYGO business models with performance-linked payments; or finance after-sales service, training, and maintenance to ensure long-term adoption (UNCDF, 2023). Carbon finance can also act as a de-risking mechanism for private sector actors by providing a predictable revenue stream (MECS & Energy4Impact, 2022). This, in turn, can encourage market entry in more challenging contexts, including last mile contexts, and enable social enterprises to scale eCooking operations with blended finance (e.g., combining donor and investor capital with future carbon revenues to pay back up-front subsidies to the sale of eCooking systems).

African Youth Action Network (AYAN) demonstration on the use of ECOCA at Kiryandogo Refugee settlement Uganda. © Arou Kuol 2025

Carbon and outcome-based finance methodologies are evolving to reward not only CO_2 reductions but also co-benefits, such as improved health outcomes (from reduced smoke exposure), time savings for women and girls (gender/economic impacts), as well as biodiversity preservation through reduced deforestation. These broader impacts align with SDGs and stand to make solar eCooking projects more attractive to impact-driven investors and climate funds.

Carbon and outcome-based finance are promising tools to help propel the transition from grant-funded solar electric cooking pilots to sustainable market-based models. To effectively leverage such finance mechanisms for the acceleration of solar eCooking adoption in last mile communities, the following will play an important role:

- Use of existing and standardised methodologies (e.g., the Gold Standard methodology for metered devices) where humanitarian agencies and partners work with carbon and climate experts, as opposed to adapting methodologies to suit 'their' populations.
- Accurate monitoring systems (e.g., IoT-enabled stoves and mobile surveys) to track usage and emissions saved, as well as robust frameworks for the monitoring of health, social and outcomes;
- Aggregators or intermediaries to bundle small-scale projects and handle verification and sales of the generated credits on carbon markets and to impact investors interested in other outcomes.

Box 5. ***A practical approach to valuing gender-based outcomes***

In 2024, the Clean Cooking Alliance (CCA) started a pilot programme focusing on gender outcomes through RBF. This pilot aims to incentivise distributors of productive use appliances to target women consumers and encourage women to utilise these appliances to enhance their livelihoods. By tying financial incentives to gender-specific outcomes, the programme seeks to validate the impact of clean cooking solutions on women's empowerment and economic participation (CCA, 2024).

2.5 De-risking carbon financing for clean cooking at scale

To support high-integrity clean cooking projects in a volatile carbon market, the Clean Cooking Alliance is exploring a range of next-generation financial instruments to reduce risk and enhance revenue predictability. These include escrow-based lending linked to verified credit issuance, forward purchase agreements, loans securitized against future carbon revenues, and aggregation platforms or insurance instruments that pool risk. Among these, Contracts for Difference (CfDs) have shown particular promise in other sectors, such as renewable energy.

Recognizing the need for a practical and scalable solution in the clean cooking sector, the Clean Cooking Alliance has developed the Clean Cooking Price Anchor, an innovative adaptation of the CfD model tailored to the unique challenges of the voluntary carbon market. Text Box 6 provides a detailed look at how this adapted CfD model could work, including for Last Mile communities if transactions are bundled as scale, covering >5,000 households.

Box 6. ***Contracts for Difference (CfDs) for Clean Cooking Carbon Finance***

Price volatility is one of the biggest disincentives for investment in clean cooking carbon projects. For investors, it creates uncertainty in expected returns. For banks, it undermines the predictability of revenue needed to underwrite loans. In the absence of a reliable floor price, capital tends to flow toward lower-tier technologies or potentially lower-integrity credits - models that are more cost-flexible but less impactful.

Contracts for Difference (CfDs) offer a proven solution to this challenge, especially where there is a large market with lots of participants and contracts, and two parties with interests in seeing prices move in opposite directions. CfD are widely used in renewable energy markets in countries like the UK and Canada, providing a guaranteed minimum price to project developers by compensating them when market prices fall below a pre-agreed "strike price." However, these traditional CfDs rely on complex derivatives or government guarantees - structures that are not feasible in the voluntary carbon market for clean cooking, where price transparency is limited and market-based instruments are absent.

That's why the Clean Cooking Alliance is developing the Clean Cooking Price Anchor, which proposes to adapt this concept using a simpler, more practical approach: a reimbursable grant. This was chosen because a true market-based CfD does not yet exist for clean cooking carbon credits, and price asymmetry makes it difficult for DFIs or funds to offer such an instrument. By using a reimbursable grant, the Price Anchor provides temporary price protection while generating data to support future institutional adoption.

Here's how it works: The Price Anchor sets a "strike price" reflecting the marginal cost of generating a verified carbon credit - based on real project data - plus a modest margin. If the sale price of a credit falls below this strike price, the mechanism reimburses the developer for the shortfall. If the sale price exceeds the strike price, the developer retains a portion of the upside, with any excess gains partially recovered by the facility.

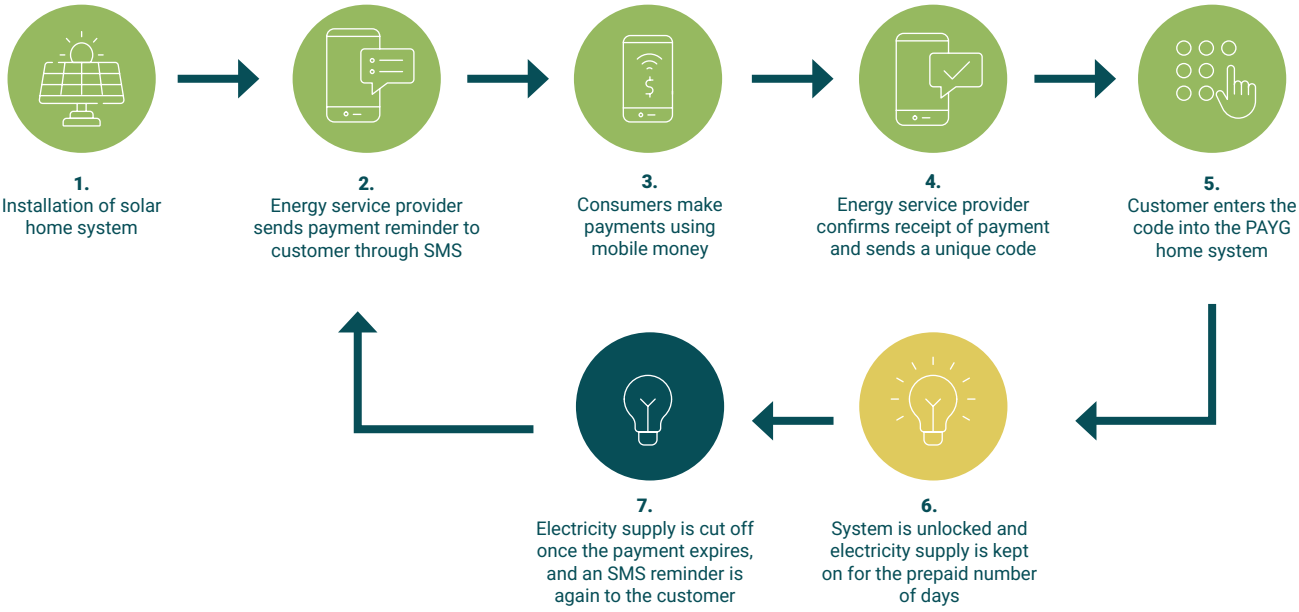
Beyond price stabilization, the Price Anchor serves as a data-generating tool. It captures transaction-level insights on credit prices, developer costs, and payout dynamics. These insights will be synthesized into transparent evidence, enabling funders and development finance institutions (DFIs) to consider adapting the instrument as part of their financial toolkit.

In this way, the Clean Cooking Price Anchor is both a smart-subsidy and a market-enabling tool - providing immediate revenue stability for developers while laying the groundwork for scalable, institutionalized price stabilization.

2.6 Pay as You Go (PAYGO) business models

PAYGO business models, where users pay in small, flexible, instalments over time, have been successful in the off-grid solar electrification sector and have been adapted to the cooking sector to overcome affordability issues. PAYGO models rely on asset financing, requiring upfront capital from providers or partnerships with financial institutions to cover the cost of technology hardware, which is then recovered over time. PAYGO-enabled eCooking solutions could significantly reduce the affordability barrier for last mile households by removing the high upfront cost of eCooking appliances and allowing smaller instalments over several months or years to pay off the value of the system (MECS & Energy4Impact, 2021). This aligns better with the relatively low monthly allocations for energy access, and often irregular or informal income flows.

Figure 7. Example Pay-as-you-go business model



Modified from IRENA (2020): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Pay-as-you-go_models_2020.pdf

PAYGO platforms often rely on Internet of Things (IoT)-enabled devices that allow for remote tracking of usage and technical performance of energy systems (whether off-grid solar or clean cooking solutions) (Bisaga et al., 2017) which is critical in humanitarian settings with limited technical support. Proven repayment performance under PAYGO structures and the remote-monitoring functionality can unlock blended finance and RBF to scale clean cooking programmes, with solar PV powered electric cooking showing particular promise given the ease of application of remote monitoring enabled by IoT technology (Halford et al 2022).

Lessons learnt from the off-grid solar sector point to a few important considerations when applying PAYGO models to clean cooking, including solar eCooking solutions, namely a:

- Need for tailored payment structures: adapting repayment timelines and amounts to match cooking fuel cost savings (e.g. replacing firewood or charcoal expenses) will help reduce customer defaults;
- Need to offer flexible payment pauses or resets during crises - a successful practice in solar PAYGO operations;
- Need for consumer education and after-sales support: just as with solar home systems (or other off-grid solar solutions), adoption hinges on end-user training and follow-up. Clean cooking solutions must be user-friendly and supported by community-based agents, offering technical support;
- Need for digital inclusion: widespread adoption of PAYGO energy systems is only possible with reliable access to mobile money and connectivity. In last mile settings, collaboration with telecom providers and digital finance actors is essential, especially where coverage is currently limited.

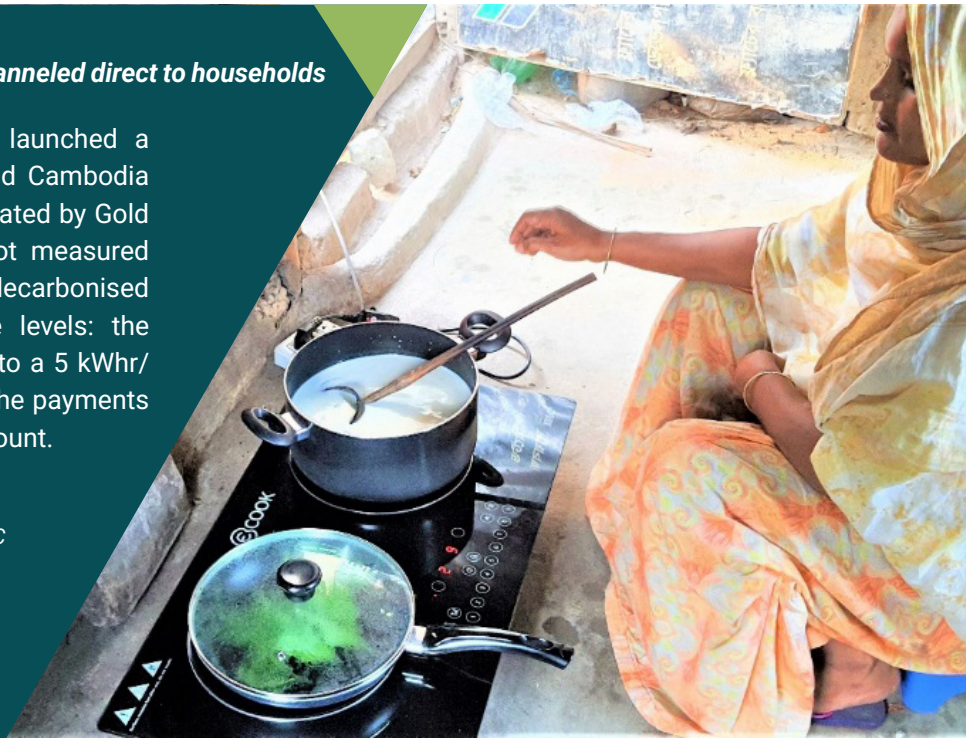
Box 7. Pay As You Go in Practice

Appliance manufacturing firms such as ATEC and BURN (both SOLCO partners) already offer PAYGO financing across Africa and South-East Asia. These rely on a modest upfront payment, with small increments towards the cost of the appliance made via mobile money over an agreed period of time.

Another novel business model, employing IoT technology, known as "Cook-to-Earn", promotes uptake of eCooking appliances by compensating households with cashbacks stemming from the generated carbon credits according to their appliance usage, monitored through the IoT-based remote sensing. Users are motivated to embrace and maintain the use of eCooking appliances through earning financial rewards which helps sustain cooking with electricity. By adding financial incentives to such modern cooking appliances, a self-sustaining cycle is established, stimulating increased adoption and market momentum.

Box 8. ***Cooking to earn: carbon financing channeled direct to households***

ATEC and FairClimateFund successfully launched a "Cook to Earn" scheme in Bangladesh and Cambodia in 2023 (Bricknell & Batchelor, 2023). Validated by Gold Standard's metered methodology, the pilot measured whether an incentive payment towards decarbonised cooking had a direct impact on usage levels: the more they cooked, the more they earned (to a 5 kWhr/ household limit). Based on the data flow, the payments are made into the users mobile money account.



A grid connected house in Bangladesh using and ATEC eCook IoT induction stove. © ATEC.

2.7 The use of digital financial solutions

Advancement in online crowdsourcing and digital financial instruments offer new opportunities to address the capital expenditure challenge and lower the price of energy products and services for last mile communities. This is enabled by the deployment of smart technologies, including IoT-enabled cookstoves and appliances, mobile-based PAYGO platforms, and blockchain-supported results verification.

In last mile settings, where technical capacity is often limited and infrastructure is fragmented, digital tools can also be used to offer real-time monitoring, usage tracking and performance-based disbursements, as well as instant identification of technical challenges, triggering customer outreach by relevant support teams through remote diagnostics and troubleshooting via connected devices. This, in turn, can reduce the burden of physical maintenance in hard-to-reach locations. Data insights also pave the way for a more personalised customer engagement, efficient inventory planning and targeted user training.

Mobile money is one critical application, enabling users to pay in small, manageable amounts and to receive carbon-backed incentives, such as under the 'Cook-to-Earn' model. The digital traceability can help enhance transparency and support the validation of social, environmental and health co-benefits - making solar PV-backed cooking more attractive to investors and for RBF mechanisms.

Rapid advancement in digitisation and development of digital solutions means that more impactful applications may become available in the near future, helping to more rapidly and efficiently transition households, as well as institutions and other users, to truly clean and sustainable cooking solutions.

Box 9. ***Tools for assessing the climate change and resilience co-benefits of off-grid solar technologies***

Practical Action and GOGLA, in collaboration with Efficiency for Access, have created a suite of resources to inform the design and evaluation of activities aimed at expanding access to off-grid solar (OGS) solutions that strengthen climate resilience. These tools can be used to inform theories of change, business plans, and monitoring and evaluation frameworks. Specifically, these tools are:

- An OGS Resilience and Adaptation Framework: A comprehensive repository of indicators and guidance to help stakeholders understand, assess, and evaluate the contributions of OGS to climate resilience and adaptation.
- OGS Resilience and Adaptation Sector Guidance: A complementary resource to the Framework, offering practical guidance for designing business models, projects, and programmes that leverage OGS to enhance resilience and adaptation outcomes. It includes strategies for linking OGS with other enablers, such as digital inclusion, to maximise impact.

These resources, together with an accompanying report, explore how OGS supports climate change resilience and adaptation across diverse contexts, including post-disaster response and recovery efforts, last mile communities including displaced populations.

2.8 Innovative fiscal policies

Traditional State subsidies and fiscal measures can also be used to help steer the cooking energy market towards sustainability. This can include the provision of time-bound and demand-side subsidies to cover the capital cost of eCooking systems, to kick-start market demand by unlocking positive feedback e.g. in terms of time savings from fuel collection that are converted into income-generating activities. Other indirect subsidy mechanisms include incentives such as tax breaks for a bundle of desirable (cleaner) technologies and/or taxes on dirty fuels to 'internalise the externalities' and even the playing field for otherwise more capital-intensive cleaner technologies.

Box 10 ***A holistic approach to building market ecosystems for eCooking***

In Bangladesh, EnDev utilized RBF mechanisms to incentivize sales by established manufacturers and distributors of eCooking appliances, such as Walton and ATEC, particularly in the Khulna region (EnDev, 2023). Walton promoted rice cookers, induction cookers, and infrared cookers, while ATEC focused on induction cookers. In 2023, EnDev reached 26,120 people with eCooking appliances under the RBF mechanism. On the demand side, EnDev collaborated with Practical Action on awareness-raising campaigns, promoting the benefits of high-quality eCooking appliances and reaching 25,000 households. Furthermore, EnDev supported partners like the Bangladesh Standards and Testing Institution (BSTI) and the Sustainable and Renewable Energy Development Authority (SREDA) to establish energy performance standards and testing protocols for eCooking appliances.

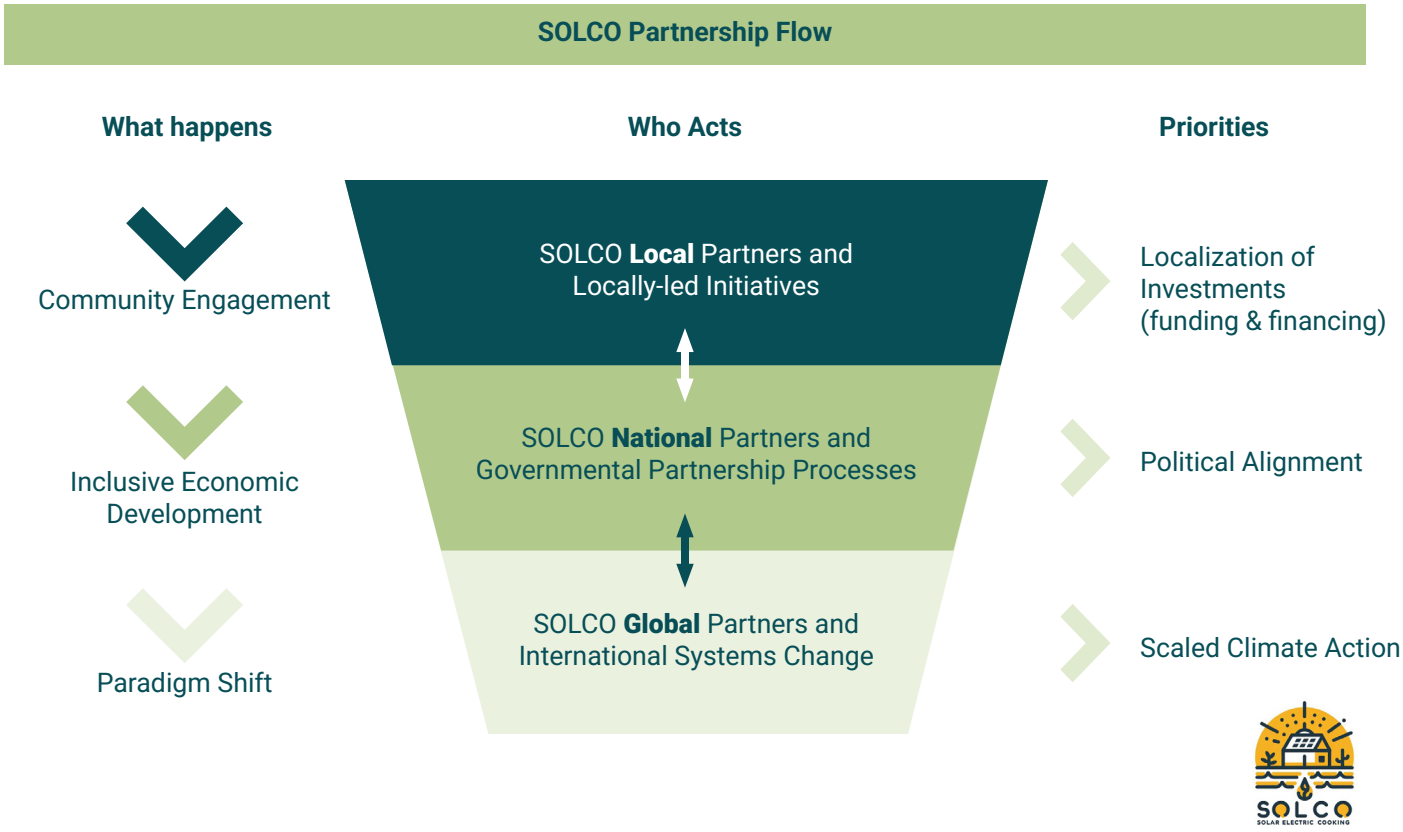
2.9 Conclusions

This report has explored a range of business model and financing options for PV-supported Tier 4+ clean cooking technologies to help overcome the barriers to modern cooking, drawing on a number of real-world examples. By mobilising various sources of public and private capital, engaging the private sector and adopting context-appropriate business models, it is possible for countries, with support from the UN and its partners, to accelerate the transition to clean, modern, safe, and affordable cooking solutions in last mile communities, including displacement settings.

3. Understanding Solar-Powered Cooking Technologies: A SOLCO Partnership Overview

What is SOLCO? The SOLCO Partnership is a transformative initiative aimed at accelerating the transition to clean cooking solutions in underserved communities, particularly in humanitarian settings like refugee settlements. By harnessing solar power, SOLCO brings together diverse technologies and stakeholders to create sustainable cooking solutions that meet health, environmental, and economic needs[13]. SOLCO was launched at COP28 as part of the Global electric Clean Cooking Coalition[14] (GeCCo).

Figure 8. SOLCO Partnership Flow



13 https://solcopartnership.org/

14 https://www.seforall.org/news/seforall-partners-unveil-new-commitments-on-sustainable-cooling-decarbonization-and-electric

Solar-Powered Electric Cooking Technologies: Solar-powered electric cooking is a promising solution for communities with or without reliable access to the electrical grid. Here's a breakdown of the technologies within the scope of the SOLCO Partnership:

1. Fully Electric Cookstoves:

- **On-grid and mini-grid powered Electric Pressure Cookers (EPCs):** these devices are highly efficient and use electricity to create a sealed environment where steam pressure cooks food quickly, conserving energy and reducing cooking time.
- **Induction Cookstoves:** utilising magnetic fields to heat pots made of ferrous materials, induction cooktops offer precise temperature control and high energy efficiency. They are ideal for grid-connected areas.
- **Off-grid standalone systems:** These systems typically integrate solar PV panels with battery storage to power cookstoves anywhere sunlight is available. This solution is pivotal in remote locations where grid electricity is absent.

Field tests of standalone solar-electric cooking systems in refugee-hosting and low-income settings have demonstrated that households can prepare daily staple meals, including those requiring longer cooking times. Trials conducted in East Africa and Southeast Asia show promising results, although users often continued using biomass alongside the electric systems, particularly for energy-intensive or high-heat cooking practices. Battery storage and charging capacity were noted as key limitations, especially during periods of low solar availability. These findings highlight the importance of appropriate system sizing, user training, and cooking behaviour adaptation (UNHCR, 2022).

Experience from modelling and pilot studies suggests that solar electric cooking systems designed for off-grid and humanitarian settings typically require around 0.6-1.2 kWh per meal for a household of 4–6 people. To meet this energy need, a system with a 250–630 watt solar PV array and a battery storage capacity of 1–2.2 kWh is generally sufficient, assuming typical solar conditions found across Sub-Saharan Africa (ESMAP, 2020b).

The ECOCA Set includes two ECOCA pots, an ECOCA base (with two inbuilt batteries), a solar panel array, 3 x light bulbs and 2 x USB charging ports.

Source: https://pesitho.com/home/our-products/

2. **Hybrid Systems:**

- **Forced Micro-gasification Stoves:** This technology combines solar power with biomass to create a clean-burning solution that meets WHO tier 4+ standards for clean cooking. The stoves use a small fan powered by solar electricity to force air into a combustion chamber, improving the burn efficiency and reducing harmful emissions.

ACE One stove cooking in Uganda; an example of a hybrid system where a PV panel powers a fan to gasify the combustion of biomass pellets in a chambered stove.

Photo credit: https://africancleanenergy.com/ace-media/

Why Focus on Diverse Technologies? Each technology offers unique benefits and is suitable for different environmental and social contexts. For instance:

- **Fully electric systems** are ideal where electricity is reliable or solar power can be consistently harnessed[15].
- **Hybrid systems** are beneficial in regions where biomass is available but its use needs to be optimized to reduce emissions, health and local environmental impacts.

The Importance of High Standards: SOLCO focuses on technologies that meet or exceed WHO tier 4 standards, ensuring they not only minimize environmental impact but also improve health outcomes by reducing or eliminating indoor air pollution.

SOLCO's Role: SOLCO works as a platform for public-private partnerships to deploy these technologies at scale. It engages with governments, non-profits, and the private sector to create a supportive ecosystem that includes financing, policy advocacy, and community engagement.

Call to Action: The transition to clean cooking requires collective action. Governments, investors, and other stakeholders in the global north are encouraged to support SOLCO partners by investing in the deployment of these technologies and purchasing high-quality carbon credits generated through SOLCO projects. This support will catalyse broader adoption and generate significant socio-economic and environmental benefits.

This explainer offers a basic understanding of the diverse PV-supported clean cooking technologies promoted by the SOLCO Partnership. It highlights the crucial role of each technology in achieving sustainable and scalable clean cooking solutions, essential for enhancing quality of life in last-mile communities.

15 Unlike solar-thermal cooking systems, solar-electric systems with battery storage offer greater resilience to variable weather conditions. They enable cooking during cloudy periods or at night, when sunlight is unavailable—addressing a major usability gap of thermal-only approaches. This reliability is critical in displacement settings where flexibility in meal preparation is essential for maintaining food security and adapting to unpredictable daily routines.

A customer making dinner on the EcoSafi BetterStove. Photo credit: EcoSafi.

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Links to further reading, articles and webinars

- Climate Action at the Last Mile: Policy and partnerships for sustainability in displacement settings – UNEP-CCC
- Powering progress: market creation strategies for solar e-cooking technologies in off-grid and displaced communities | World Food Programme
- Powering progress: market creation strategies for solar e-cooking technologies in off-grid and displaced communities (Webinar) - UNEP-CCC
- Pathways to Implementing Multi-Stakeholder Pledges on the Triple Planetary Crisis in Displacement Settings: UNEP's contribution to Climate Action at the Last Mile
- Cooking smoke kills millions every year. Here's what the world can do about that.
- How Uganda's push for "clean cooking" could save lives and counter climate change
- The eCooking Opportunity in Off-grid Contexts, and Country Examples (Webinar)

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