





## Article

# Results-Based Financing (RBF) for Modern Energy Cooking Solutions: An Effective Driver for Innovation and Scale?

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**Abstract:** Results-based financing (RBF) programmes in the clean cooking sector have gained increasing donor interest over the last decade. Although the risks and advantages of RBF have been discussed quite extensively for other sectors, especially health services, there is limited research-documented experience of its application to clean cooking. Due to the sheer scale of the important transition from ‘dirty’ to clean cooking for the 4 billion people who lack access, especially in the Global South, efficient and performance-proven solutions are urgently required. This paper, undertaken as part of the work of the UKAid-funded Modern Energy Cooking Services (MECS) programme, aims to close an important research gap by reviewing evidence-based support mechanisms and documenting essential experiences from previous and ongoing RBF programmes in the clean cooking and other sectors. On this basis, the paper derives key strategic implications and learning lessons for the global scaling of RBF programmes and finds that qualitative key performance indicators such as consumer acceptance as well as longer-term monitoring are critical long-term success factors for RBF to ensure the continued uptake and use of clean cooking solutions (CCS), however securing the inclusion of these indicators within programmes remains challenging. Finally, by discussing the opportunities for the evolution of RBF into broader impact funding programmes and the integration of energy access and clean cooking strategies through multi-sector approaches, the paper illustrates potential steps to enhance the impact of RBF in this sector in the future.

**Keywords:** results-based financing; clean cooking; modern energy cooking services; private sector development; energy access



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## 1. Introduction

Polluting cooking fuels such as biomass or kerosene are a significant source of black carbon, and currently threaten the health and the livelihoods of around four billion people [1]. The exposure to household air pollution (HAP) kills over four million people every year, which is more than HIV/AIDS, malaria and tuberculosis combined [2]. For large parts of the population in the Global South, there is a disproportionate effect on women and young children as they are more exposed to HAP. SDG7 aspires to universal access to clean cooking as well as electricity to avert these dangers, however, whilst the electricity access sector has accelerated rapidly, the clean cooking sector has struggled to gain traction [3,4].

Between 80% and 90% of households in sub-Saharan African (SSA) countries still rely partially or completely on biomass as their primary source of energy for cooking. Although the health and rural socio-economic impacts of the shift towards clean cooking, including time and cost savings, are widely documented [5–7], efforts to enhance the uptake of clean cooking solutions have not yet succeeded at scale. The transition from ‘dirty’ to modern energy cooking is embedded in complex and challenging parameters, including end-user needs and perceptions [7,8], as cooking and food consumption habits are central aspects of daily life which have emerged over centuries. Understanding a complex set of

inter-related factors is key to facilitate the transition to clean cooking. Among them are energy and appliance affordability [7,9], access to modern cooking devices and alternative fuels, including electricity [7,8], and an enabling environment, including national policies and strategies [10–12] which constitute critical barriers or drivers of that transition.

By acknowledging these drivers, the UKAid-funded Modern Energy Cooking Services (MECS) programme (<http://mecs.org.uk>, accessed on 1 March 2021) aims to leverage investment in renewable energies, both on-grid and off-grid, to address the clean cooking challenge by emphasising modern energy cooking services as a key component of the energy sector and its integration into energy access strategies. The multidisciplinary MECS programme is a collaboration between leading UK research partners, the World Bank's Energy Sector Management Assistance Program (ESMAP) and private and public sector organisations and businesses. The programme is implementing a strategy focused on integrating meeting the cooking needs of households and institutions across a diverse range of settings, including urban, rural and humanitarian, into the investment activity and policy action on SDG7: 'access to affordable, reliable, sustainable and modern energy for all'.

The sheer global dimension of the transition from 'dirty' to modern energy cooking practices and the complex challenges for the uptake of market-based approaches requires strategic efforts at scale, but funding for the sector still relies largely on grants. This is even more pronounced in the provision of energy for cooking in displacement settings. Refugees, internally displaced people (IDP) and asylum seekers either do not have access to clean, improved cooking and therefore rely on whatever fuels they might be able to collect, or have benefitted from free distribution of improved cookstoves or LPG stoves and refills supported nearly exclusively by donor funding [13]. This has severe implications for the longevity of such approaches, as projects and programmes depend on short-term funding to address a long-term challenge, and for the suitability of the provided solutions, which often do not respond to the needs, practices and preferences of the target population [14,15]. Addressing the modern energy cooking needs of vulnerable communities has the potential to increase their overall resilience by improving health, wellbeing and gender equality [16,17].

The market for clean cooking solutions (CCS) is still relatively immature in most countries and distinguishes between two primary business models. The 'tool-only' business model is purely based on the sale of appliances. The 'tool and fuel' model means the companies' revenue is tied to the supply of the cookstove and the fuel such as biomass pellets or LPG, which is also usually the primary source of profit for these companies. While the former requires a distribution infrastructure that is mainly focussed on the sale of appliances and can include maintenance and after-sales to some extent, based on the type of appliance, the latter requires permanent and reliable distribution structures which can be a challenge for remote, rural areas.

The share of commercial equity in the clean cooking sector is relatively small, with most of the funding being disbursed to a limited number of modern fuel companies applying the 'tool and fuel' model. In 2017, the global investment in clean cooking was just \$40 million [15], compared to around \$284 million of commercial investments in the off-grid solar sector in the same year. Between 2018 and 2020, an additional \$45 million of equity and debt was invested in six clean cooking companies [1]. The funding landscape in the clean cooking sector has become more diversified over the last decade, with around 10 active impact investors in the market, of which the majority have their roots in the energy access sector. Over the last three to four years, first debt investments in the sector have been made by impact funds, foundations and crowdfunding platforms.

Over the last few years, the sector has also been experiencing rising interest from Development Finance Institutions (DFIs) in applying RBF approaches instead of direct grants or investments in clean cookstove companies. RBF schemes, such as the Energising Development Programme (EnDev) or the World Bank's Clean Cooking Fund (CCF), have become a key instrument in the clean cooking market. Most of the RBF programmes in

the clean cooking sector have focussed on improved biomass cookstoves (ICS). However, the interest in alternative and modern cooking technologies which meet the standards of Tier 4 or higher of the World Bank's Multi-Tier Framework [18] and as defined by MECS [19] is slowly increasing. Consequently, some broader energy sector RBF programmes have started to include clean cooking components alongside solar home systems (SHS) and mini-grids (MG). Notable examples of such programmes include the Kenya Off-Grid Solar Access Project (KOSAP), the BRILHO Programme in Mozambique and the solar-hybrid MG RBF in Northern Kenya, which supported energy access for refugees in the Kalobeyei Integrated Settlement, an extension of the Kakuma refugee camp, in Northern Kenya [15], as clean cooking interventions are also becoming an emerging topic in the humanitarian context [20]. However, although recent clean cooking RBFs have largely been part of wider energy access programming, the clean cooking component of the programmes is often detached from the electricity access component. As a result, the integration of clean cooking solutions into broader electricity access strategies and as part of a more integrated approach towards the energy sector is at a very nascent stage [11].

RBF has been used in the clean cooking sector from the early 2010s onwards as a tool for scaling CCS, however, to date, it has generated limited attention in the academic world. As a result, there have been very few academic studies exploring the suitability of RBF for clean cooking, and we are not aware of any on integrated clean cooking and electrification RBF programmes. Despite gaining increased attention, critical questions remain on the suitability of the instrument for a nascent market, such as the modern energy cooking sector that lacks, to some extent, proven business and technology models and faces multiple challenges.

Consequently, this study systematically examines previous and ongoing RBF programmes that focus on CCS. The aim of the analysis is to generate important insights and strategic lessons for future RBF rounds, develop practical support mechanisms that might be deployed by funders, policymakers, clean cooking programme implementers, as well as the MECS programme or other stakeholders, and close the research gap in evaluating RBF as an approach for the clean cooking sector. The paper is divided into five main sections. Following the introduction, the second section provides an overview of the evolution of RBF from a financing tool in the healthcare sector towards its increased application in the energy sector, the RBF function logic and an overview of the most relevant cross-sectoral literature on RBF schemes. The research approach, selection of case studies and the methodology are presented in Section 3. Subsequently, we provide a detailed presentation of the evaluation results of three clean cooking RBF case studies in SSA. In Section 4, we discuss the key success factors for future RBF programmes and outline opportunities for innovative approaches for development impact funding, such as carbon credits. The section concludes with a critical evaluation of the relevance of RBF programmes for the last mile delivery of clean cooking solutions, including in the humanitarian context. Finally, Section 5 responds to the question of whether RBF can be a tool for innovation and scale-up of modern energy cooking solutions by presenting key success factors and limitations of RBF programmes based on the conducted analysis. It also points out the paper's limitations and offers recommendations for future research.

## **2. Background: Results-Based Financing (RBF) as a Catalyst for Services and Infrastructure Investment**

### *2.1. RBF Terminology and Drivers for Evolution*

The application of RBF at a larger scale originated in the health sector during the early 2000s [21]. It has been applied by donors within the public and private sectors in a variety of forms, such as performance-based contracting, financing, or performance-focussed subsidies, over several decades. In 2002, it gained greater prominence following global recognition at the Monterrey Consensus [21]. It led to RBF being incorporated within the World Bank's Private Sector Development Strategy as it pertained to areas including water and sanitation, forestry, climate action and very recently the energy sector, signalling its wider adoption into the global development agenda over the past 15 years [22].

RBF as a specific concept within international development assistance is based on the adoption of defined sets of determinants for grant payments linked to pre-defined performance criteria based around agreed outputs [23], although it still lacks a clear overarching definition. Various co-existing terms for development grants being paid on the basis of verified results exist, and these include: ‘performance-based financing’ [24] or ‘performance-based funding’ (PBF), ‘payment by results’ (PBR) [25], ‘results-based aid’ (RBA) [26], ‘results-based financing or funding’ (RBF) [27], or ‘performance incentives’ (PI) [28]. These terms are used interchangeably in the literature, but for the purpose of this paper, we resort to RBF. There is, however, a subtle distinction between the variants of RBF (PBF, PBR, PI) and RBA worth highlighting. Please see Table 1.

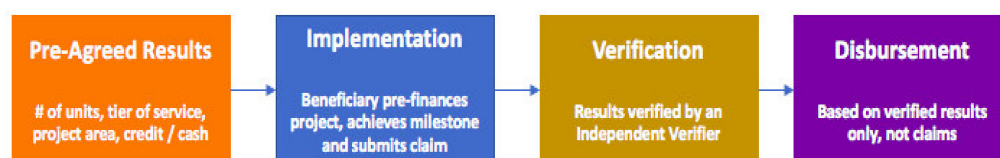
**Table 1.** RBF versus RBA.

	<b>RBF</b>	<b>RBA</b>
Principal	Central Government or local Government	Donor
Agent	Implementing agency (private sector, NGO, local Government or individual)	National or Central Government
Funds	Donor funds	Domestic or donor funds
Relationship between Principal and Agent	Contract- or incentive-based relationship	Aid partnership
Examples	BRILHO Mozambique, KOSAP, Clean Cooking Fund and all other RBFs reviewed in this paper	EU’s Millennium Development Goals (MDG) contracts, Rural Household Energy-Efficient Improvement Project (RHEEIP)

Source: Adapted from Grittner (2013) [21].

RBF can relate to a specific instrument [29] or be part of blended approaches involving upfront and results-based grant payments. A pure RBF usually refers to a contractual agreement between governments or government-funded bodies and an implementing agency, including local government, non-government entities or civil society organisations, where government resources are extended to these agents upon achieving certain results stipulated in the agreement [30].

Three key features and four stages which are outlined in Figure 1 fundamentally distinguish RBF from other development finance schemes. Firstly, payments made to the implementing partner are based on pre-agreed results. Secondly, strategies to achieve results are left mainly to the discretion of the recipient, although this seems to be a changing parameter as Key Performance Indicators (KPIs) for programme delivery are becoming more diverse. Thirdly, the disbursement of funds is activated by the independent verification of the claimed results [22].



**Figure 1.** Features of RBF options.

Compared to conventional upfront grant-financing, RBFs have a significant impact on the risk trajectories of development projects. The risks associated with project delivery and execution are largely shifted from the funder to the project implementer, which is an appealing feature for funders [27]. The funder/donor, however, still bears the reputational risk of non-performance and is likely required to invest a higher subsidy per unit of output than in programmes that provide upfront grant-financing due to the additional risks borne by the private sector or implementing partner. The debate in this context of which conditions and type of projects might produce the most successful application of the RBF

approach within different sectors is still ongoing and demands increased attention from researchers, funders and governments. Issues of bridge financing for the implementing agents and the impact of changing macroeconomic conditions, for instance, could cause RBF to produce unintended and countervailing effects.

For the energy sector, three general conditions have been observed as important in determining where RBF can be an appropriate medium for achieving a particular development goal [31]. Firstly, the capacity for monitoring, reporting and verification (MRV) of intended results to link intended outcomes and payments, as the disbursement of funding without the verification of results would contradict the logic of RBF. Secondly, since payments are made after project delivery, the funding recipient must be able to access upfront financing, which can be a challenge in developing markets due to associated financial risks, high interest rates or limited access to international capital markets. Access to upfront, or bridge, financing is a particular challenge for larger and more capital-intensive projects in countries with less mature financial sectors. Thirdly, parties, funder and recipient, need sufficient institutional capacity to develop and execute RBF programmes. Funders need to be able to set up and implement monitoring and evaluation systems that are accessible and adequate for the intended targets. Recipients must be able to plan their project execution in accordance with the RBF programme, map out cash flows and effectively respond to these systems.

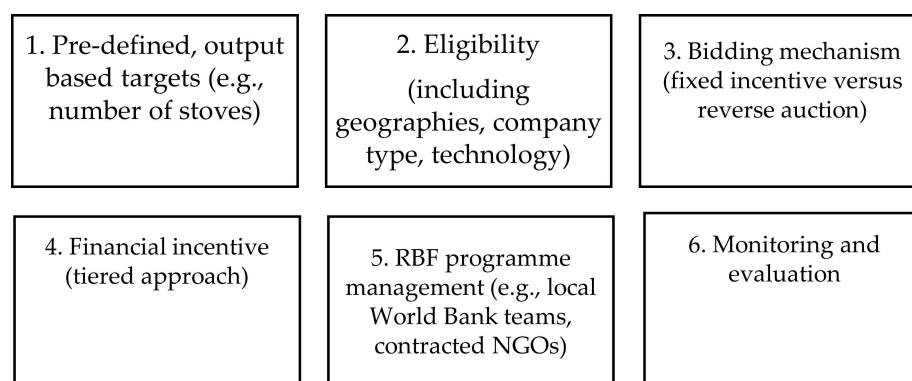
This paper evaluates in more detail how these conditions have been met in the past. Based on empirical evidence, the paper provides a discussion to which extent RBF may be a driver for scale and innovation in the modern energy cooking space.

## 2.2. *The Rise of RBF as a Preferred Tool in the Energy Sector*

The energy sector has not been bypassed by the growing international engagement with the RBF approach, although it has been a comparatively late adopter in comparison to some other sectors, such as healthcare. As of 2010 and in light of increasing global efforts to enhance energy access, around 30 different RBF programmes were run by the World Bank, in addition to 24 other similar schemes implemented via bilateral agreements to extend electricity access—mostly via off-grid solutions in Africa [23]. These programmes, running under the term ‘Output-Based Aid’ (OBA), were perceived as the upcoming dominant strategies to support off-grid energy sectors, and as such were focussed on the distribution of SHSs and other off-grid energy solutions, including MGs [18]. These programmes, however, largely did not integrate CCS, but this is gradually changing. Although the OBA energy portfolio, which amounted to around \$204 million, spread across Southern Asia, Latin America and Africa, SSA received the largest share in terms of both values of funding, including RBF, and number of projects. A decade on, the use of RBF in the energy sector continues to gain more ground, and the perceived success of these RBF schemes over time precipitated the development of more complex approaches encompassing a broad range of applications and outcomes [22]. Most RBF programmes in the energy sector apply payments to private companies after an independent verification of their results, for example, the number of SHS or clean cookstoves sold [32]. RBF programmes vary in terms of approaches, institutions and technologies, but are usually top-down interventions that aim to enhance product affordability for the end-user. The MRV process of an RBF programme is an essential element as it provides the mechanism by which the donor can confirm that the pre-agreed targets have been achieved.

A typical clean cooking RBF comprises six key elements, which are presented in Figure 2. The major aim for RBFs in the clean cooking sector is to enhance product uptake and rapidly increase market penetration of new technologies by enabling distributors to bulk-purchase innovative appliances, mitigate risks and improve unit economics.





**Figure 2.** Typical RBF components.

### 2.3. RBF Function-Logic and Potential Outcomes: Theoretical Considerations

The rise of RBF as a preferred tool in the energy sector (including clean cooking) may be underpinned by a mix of four distinct theoretical approaches, described as (1) pecuniary interest, (2) attention, (3) accountability and (4) discretion [33].

Proponents of RBF contend that by conditioning payments to the achievement of pre-agreed results, recipient central government or local government tends to apply greater pressure to ensure that the pre-agreed results are attained because of their pecuniary interest, which is to secure continued donor funding. This theoretical argument could also be extended to recipient non-government entities who, it is argued, respond more positively and go to greater lengths to achieve deliverables when payments are linked to achieving pre-agreed results because they have a pecuniary interest to keep on receiving financing [33]. This theory is embedded in institutional economics, specifically, the principal–agent model, where the funder or donor could be seen as the principal and the implementing entity as the agent [34]. The application of RBF minimises the principal–agent problem because, although the agent may have more information about his or her actions or intentions than the principal, the agent, because of how the financing is structured, is disincentivised from acting contrary to the wishes of the principal. Unlike traditional financing arrangements (e.g., debt financing models) where information asymmetry between the lender (principal) and borrower (agent) leads to moral hazard, RBF programmes significantly reduce the risk of moral hazard by linking payments to pre-agreed results. The size of the payment made is one that the donor (principal) believes will maximise its utility. The principal's utility is contingent on the programme's success and the payment made to the grant recipient (agent). In turn, the success of the programme is dependent on the level of efforts expended by the agent, as well as a host of risk factors (discussed in detail in Section 4). The contract should therefore be aligned with the interest of the agent and be able to incentivise him/her to achieve the set results [35]. This is the “incentive compatibility constraint” in the principal–agent theory, and it affects the payment received by the agent (as stipulated in the contract) in the case of programme success and programme failure [35].

The second theory, attention, posits that the payment mechanism of RBF helps to refocus the attention of managers to monitoring progress/outcomes—a more tangible signal to spark change [33]. Here, it does not necessarily matter if the payment amount is small; so far, as the payment system makes performance visible, the attention of managers will be diverted from less effective activities or inputs to more important measures such as progress on outcomes. If the fundamental method for change is attracting attention to outcomes, then paying for outcomes is one of the most critical components of RBF programmes. It must be noted that verifying outcomes of RBF programmes requires more effort than other forms of aid, however, this could be offset by potential efficiency gains from remote and digitalised monitoring.

A third argument for the application of RBF is the introduction of real change by holding the agent (grant recipient) accountable to the principal (donor/funder), especially when RBF conditions and disbursements are openly reported [33]. This enhances project

progress monitoring in a way that maximises impact but raises the question of how open RBF agreements should be to improve effectiveness, since transparency is a key determinant for accountability [12]. An important consideration in accountability relationships is that of the information accessible to the principal to guarantee that he/she can keep the agent accountable [36]. A donor who invests in a grant project or programme would want to know how well the funds have been utilised by looking at several performance indicators and metrics [37]. The quality of performance data, particularly performance indicators (at output and outcome levels), will influence the decisions made by the relevant actors [38], including the ability to hold them accountable. It is impractical for the principal to constantly look over his/her shoulder to gauge how much effort is being expended on the project/programme. The principal therefore includes accountability mechanisms to incentivise the agent to put in maximum effort, because the asymmetric information can open up an opportunity for the agent to slack off (or act in a way that only maximises his/her utility) without the principal knowing. The imposition of a MRV is one technique to indirectly evaluate the agent's degree of effort.

A fourth theoretical approach that supports the application of RBF is the theory of recipient discretion [33]. This theory relates to the extent to which recipients are allowed to use their discretion to achieve pre-agreed results as well as how they apply the funds. Critics of conventional aid programmes have argued that most of the programmes have aimed to drive programme effectiveness in countries that present highly complex and idiosyncratic settings [39–41]. According to them, in these settings, traditional aid programmes, which stick to pre-planned interventions, obstruct the regular process of debating, negotiating, implementing and modifying public policies. RBF programmes, on the other hand, allow funders to demonstrate that funds have been properly utilised by attaching payments to outcomes rather than pre-planned inputs and activities. This allows recipient entities to pursue a variety of strategies and approaches that are more likely to succeed, depending on their local knowledge anchored in local political and social dynamics. Even among the implementing partners, there are varying degrees of complexities that make it infeasible to implement a 'one-size-fits-all' approach requiring recipients to adhere to a pre-defined way of executing programmes. This theoretical approach thus posits that RBF programmes that give recipients greater flexibility to leverage their local knowledge to advance their own set of activities and strategies stand a better chance of success [33]. One known example of when recipient discretion was factored into the RBF design is the World Bank's East Asia and Pacific (EAP) Clean Stove Initiative (CSI) implemented in Indonesia. This programme aimed to catalyse the transition to clean cooking using electric stoves [42], allowing selected distributors to design and adapt their cookstoves based on customer preferences, local cooking habits, as well as maintenance and repair capacity of the supplier [42]. This contributed to the high rates of adoption and satisfaction levels among users [42].

#### *2.4. RBF Literature Review: Central Narratives and Research Implications*

The literature review reveals that the status of research reflects the novelty of RBF approaches for CCS in the energy sector, which creates a significant research gap. While RBF programmes and outcomes in these sectors have been documented to some extent in technical and programme reports, normally issued by the funders or implementers of such programmes, critical and systematic research reviews of RBF practices in the electricity and clean cooking sectors are largely absent, albeit with a few exceptions [43–47].

As the overview in Appendix A Table A1 shows, peer-reviewed evaluations of RBF programmes that go beyond technical, or single-case, studies have largely focussed on the healthcare services sector, which corresponds to the global evolution of the approach within donor programmes. Nevertheless, these studies provide important findings on key success factors and challenges of RBF in the respective sectors which point towards the critical importance of efficient and adequate monitoring and evaluation procedures [44]. This specifically includes incorporating the end-user perspective [48] and a substantial

degree of flexibility of the programme to react to changing market structures or unforeseen external events, including natural disasters [44].

While the literature documents positive results and impacts of RBF programmes mainly in the healthcare sector, such as improvement in the supply and coverage of healthcare services [21,49], increased access to certain services or appliances, better value for money [50] and enhanced workers' performance [51], the research literature also highlights some documented negative or unintended impacts. These unintended consequences point towards potential trade-offs between qualitative and quantitative implementation targets in terms of services or appliances [43,48], including so-called 'cherry-picking' or 'cream-skimming' [21], the creation of excessive consumer demand which can overload the programme delivery [52], concerns about gaming and distortion, especially in healthcare RBF programmes [49], and the general challenge of promoting long-term adaptation of end-user behaviour towards new or improved services or appliances—a critical factor for the long-term sustainability of a programme [21]. The research thus suggests the importance of critically acknowledging and documenting such unintended impacts of RBF programmes and anticipating them during the design phase [53].

Although the opportunities of integrating modern energy cooking solutions into electricity access programmes and strategies have been highlighted in the past [11], and most recent clean cooking RBFs are part of wider energy access programmes, the actual level of integration for scaling clean cooking into electricity access projects, for example through renewable MGs [54], in relation to the scaling-potential of MECS remains an open question, also due to the nascency of modern energy cooking RBFs and their evaluation.

## 2.5. Research Approach and Methods: Landscaping Current RBF Initiatives and Critical Questions

The limited independent and systematic research on RBF programmes in the clean cooking sector to date means there is a gap in understanding of the function, logic and impacts of RBFs, including unintended and undesirable consequences, which might minimise or undermine the impact of the programme. Technical reports issued by RBF agents usually document such unintended impacts to a very limited extent (if at all) as they often lack mechanisms instituted within their RBF framework to capture these effects [55], or may be biased towards reporting positive outcomes to demonstrate the success of the RBF programme to their funders.

The rise of CCS RBF programmes over the last decade provides an opportunity to close these research and knowledge gaps with a systematic impact evaluation of these programmes. Given that most clean cooking markets of interest to funders are highly dynamic and largely comprised of enterprises with unproven business models, the goal of this paper is to analyse under which market conditions RBF is the most appropriate instrument to achieve sustainable scale-up of appropriate CCS [56]. Our analysis is guided by the following core research questions:

- Under what circumstances are RBF programmes an effective form of development impact funding for achieving impact at scale in the clean cooking and broader modern energy access sectors?
- Are the balance sheets of clean cooking companies strong enough to raise the required bridge financing under an RBF scheme?
- To what extent are local capital markets able to cover such bridge financing, and at what cost?
- Are RBF programmes flexible enough to incentivise the distribution of emerging improved cooking technologies and account for fast-paced technological changes in the market?
- How could RBF programmes facilitate the integration of CCS into electricity access projects?
- Under what circumstances can RBF (including carbon credits) accelerate the scaling of the clean cooking markets?



These complex and multi-dimensional questions have been approached through a systematic, empirical and multi-disciplinary methodology, which is comprised of three stages:

1. The first stage involved a comprehensive literature review and an in-depth evaluation of three case studies of current and/or previous funding programmes (see Appendix A Table A2). The programme case studies have been selected according to their scope (specifically the promotion of clean cooking and/or energy access), data availability and programme logic (RBF).
2. Secondly, two rounds of online surveys with closed questions were completed by 40 clean cooking companies and 28 capital providers, supported by Energy4Impact, a project partner of the MECS programme.
3. Thirdly, 26 semi-structured interviews with clean cooking companies and capital providers were carried out to explore specific issues identified in the previous stages.

This mixed-methods approach enabled the triangulation of key findings. The desk review offered both breadth and depth by capturing a wide variety of RBF programmes across various geographies and diving deep into the three specific case studies. While the focus was on RBFs in the clean cooking sector, experiences from RBF programmes in other sectors were also included; in particular, electricity access RBFs, in order to understand how integrating electricity access and clean cooking programmes might enable a more holistic approach to energy access. The detailed literature review and case studies were complemented by quantitative data from the online surveys to assess to what extent the issues identified were affecting the sector as a whole. Finally, the semi-structured interviews were designed to understand the reasons behind the trends observed in the quantitative data from the surveys, dive deeper into specific issues and understand the direction that the sector is moving in.

This evidence-based research is intended to distil essential learning lessons from previous and ongoing RBFs in the clean cooking sector to inform the MECS programme's efforts to scale-up modern energy cooking solutions such as LPG, ethanol, biogas and electric. Importantly, this can facilitate the integration of clean cooking into the wider energy access agenda and identify how it can connect into other sectors, such as carbon financing and humanitarian relief.

### 3. Clean Cooking RBF in Action: Programme Evaluation Results

#### 3.1. Overview: Clean Cooking RBFs in Africa and Asia

Appendix A Table A2 provides an overview of ten major clean cooking RBF programmes that have been implemented in the recent past or are still ongoing in Africa and Asia. The comparative evaluation, which synthesises desk-based research and stakeholder interviews, shows that the investment volume of the RBF programmes reviewed varies significantly, ranging from \$266,000 for the Global LEAP EPC in Kenya to around €20 million for the Energy Environment Partnership Trust Fund Africa (EEP Africa).

Four RBF programmes in the clean cooking sector focus specifically on rural areas where access to electricity is a challenge, while five programmes have no specific focus in terms of urbanisation level but focus more broadly on low-income households.

Most RBF programmes focussing on clean cooking include a range of technologies and fuels (although most have a strong focus on ICS) and set technological requirements in terms of CO<sub>2</sub> outputs and indoor-pollution levels of the appliances based on the World Bank's Multi-Tier Framework [18]. Market approaches for improved biomass stoves still dominate the market. With regard to eligibility, to date, there is only one RBF programme that specifically targets electric cooking—the Global LEAP Awards RBF as part of the EnDev 2.0 programme in Kenya. Consequently, electric cooking solutions and the incentivisation of modern energy cooking into electricity access RBFs is an as yet largely untapped potential.

The bidding mechanisms of past programmes have usually been based on a system where the incentive provided to encourage sales is set at up to 50% of the selling price of the stove. However, in more recent times, programmes such as the BRILHO programme in Mozambique and Global LEAP in Kenya have introduced reverse bidding processes,

whereby companies see a reduction in the subsidies per unit with increasing quantities supplied. While this strategy appears to increase the value for money of a programme from a donor perspective, it may have financial implications for the companies as they may resort to an overly aggressive bidding strategy. This could potentially affect both their ability to deliver and compete with larger companies as most larger companies already benefit from cost savings due to economies of scale.

Looking at the financial incentive, most RBF programmes follow a tiered approach where a higher incentive is given to firms that develop or manufacture more modern and cleaner cooking technologies, reach underserved areas and target low-income groups. Most clean cooking RBF programmes also provide catalyst grants to these firms to cover their upfront costs of market setup and research and development (R&D) activities to avoid a situation where quality is sacrificed for quantity [26]. It is also important to note that although there is evidence to suggest that financial incentives improve programme effectiveness in the short run, there is no evidence of its long-term effectiveness [57]. Most of the programmes are purely output-based, focussing on a certain number of approved appliances to be distributed, with some of the programmes adding a regional/county component where they incentivise service delivery to consumer groups, such as economically marginalised households in very remote areas.

Although Kenya has been the recipient of most historic RBF programmes, in recent years, other African countries such as Malawi, Mozambique, Rwanda and Zambia have been gradually receiving attention with regard to CCS RBF programming. The World Bank for example is currently considering the implementation of clean cooking RBFs in Ghana, Niger and Uganda, with the Swedish International Development Corporation (Sida) funding a new RBF programme targeted at Burkina Faso and Liberia, USAID is developing their 'Alternatives to Charcoal Programme (A2C)' in Malawi and Zambia, while BGFA is in the process of scoping a clean cooking RBF for Zambia and other countries.

Although it is as yet too early for most programmes to derive specific learning lessons, the comparison of the programmes points towards certain critical key areas: timeline of the programme, approval of technology and market dynamics, as well as the MRV process.

To extract more specific key learning lessons, three RBF programmes: EnDev 2.0 Kenya, Global LEAP Kenya and the BRILHO programme for Mozambique, have been evaluated in a case study approach for this article.

### 3.2. Kenya Clean Cookstove Market Acceleration Project—EnDev 2.0 Clean Cooking RBF

The EnDev programme is a European multi-donor initiative, implemented by the German agency GIZ. It aims to promote sustainable access to modern energy services for households, social institutions and small- to medium-sized enterprises in 24 developing countries across Africa, Asia and Latin America. EnDev 2.0 has extended the programme's first stage in Kenya, which was originally focussed on SHSs and solar lanterns supported with €3.9 million funding volume, with a €1.6 million RBF for ICS and modern cooking fuels, and was implemented between 2009 and 2019, constituting one of the first clean cooking RBF programmes in Africa.

The rationale for choosing an RBF programme for off-grid solar and clean cooking in Kenya was to overcome barriers for scaled sectoral commercialisation in an emerging market and enhance the uptake of CCS, especially in peri-urban and urban areas [58]. The programme thus aimed at driving overall market maturity toward self-sustaining levels through temporary incentives linked to specific KPIs. Although the volume of resources provided for the ICS sector was much smaller than for the electricity access part of the programme, the programme set ambitious targets for the cooking sector and aimed to incentivise 80,000 product sales through a flat incentive rate based on the performance Tier of the stove. The programme supported a wide range of clean cookstoves, including charcoal, wood, ethanol and gasifier cookstoves, of performance Tier 2 and above [18], which were tested at the Kenya Institute of Research and Development (KIRDI) and were required to achieve fuel savings of at least 40%.

Due to the nascent market status for charcoal cookstoves, charcoal ICS below Tier 2 standard in terms of CO<sub>2</sub> were also included at a later stage. Similar to the technology itself, the ICS incentives which were initially based on the county development index rate (based on the market development status and dynamics, including poverty rate, population density, development index and proportion of rural/urban population within a county) were also adjusted during the programme. The low initial uptake among beneficiaries and sales made and the pressing timeline triggered the implementation of an incentive rate based on the cookstove Tiers and aimed to boost sales of higher-efficiency stoves, and consequently ranged from €8 for ICS below Tier 2 up to €10 for Tier 2 and €13 for appliances above Tier 3, which amounted to around 60–70% incentive for Tier 2 and around 65% to 75% incentive for higher Tier appliances.

The incentives were regularly revised to enhance distribution in underserved counties and account for a fluctuating currency exchange rate. The broad eligibility criteria of EnDev 2.0, which included local financial institutions, cookstove manufacturers, retailers, community-based organisations and NGOs, as well as private distributors of cookstoves selling on either credit or cash, resulted in 29 programme beneficiaries for the ICS sectors, of which 20 were distributors and 9 were financial institutions. Financial institutions, however, experienced significant difficulties delivering the desired outcomes of the programme due to the sectoral risk perceptions of these institutions, which then focussed more on their core business and the limited competitiveness of their credit procedures in comparison to Pay as You Go (PAYG) models.

According to the RBF logic, incentives were disbursed as ex-post-payments upon independent verification of pre-agreed results, which were the sales of pre-approved cookstoves above the pre-agreed baseline, which was determined through historical sales performance to ensure actual business growth. Incentives were capped at €100,000 bi-annually and limited to a total of €500,000 per beneficiary. Parker Randall Eastern Africa (PREA) were contracted through GIZ as an Independent Verification Agent (IVA) to provide independent validation of the performance and deliverables—the process which is outlined in Figure 3 and which included verifications via phone interviews, field visits and document review.

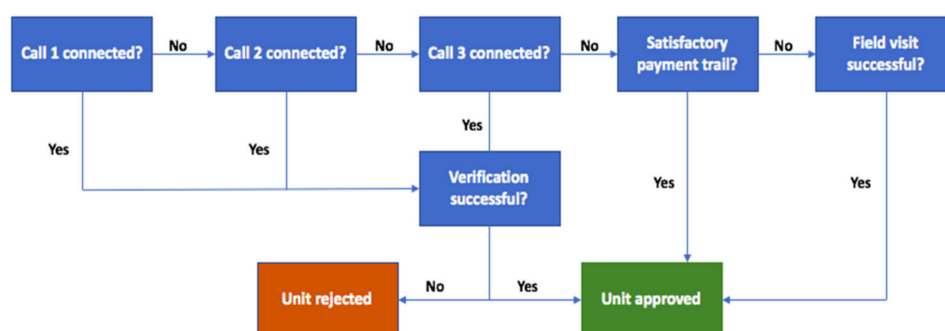


Figure 3. Verification process for EnDev 2.0. RBF in Kenya [19].

In the final programme review, the programme was reported to be highly successful in terms of units delivered as it exceeded its target of incentivised cookstoves supplied to Kenyan households by roughly 20,000 [19,58], as Table 2 illustrates. Apart from the quantitative success, it was reported that the 20 cookstove distributors who participated in the programme managed to extend their operations into new counties, ensuring coverage for clean cookstoves in all 47 Kenyan counties as of 2019.

Table 2. Results of EnDev 2.0 [19,58].

Cookstove RBF (Phase 2)	
Total number of units sold/Target	110,796/80,000
% of units sold by distributors/manufacturers	77%
% of units sold by financial institutions	23%
Units sold in marginalised counties	6%
Product type	Improved Cookstoves (73%), LPG (21%) and Ethanol (3%)
Tonnes of CO <sub>2</sub> eq. avoided	65,600

Despite the reported quantitative successes, the comprehensive evaluation of the programme based on the collaborative research approach described in Section 2.5 highlights six key learning lessons. The first is related to the selection of the IVA. The interviews with the IVA revealed capacity issues, a significant fluctuation among staff of the IVA and problems with regard to data quality. The resource-intensive and complex verification process was not well-understood among all stakeholders, and additional technical support had to be introduced to operationalise the processes. All these issues led to delays in the verification processes and the disbursement of funds to the distributors, which was reported to be the main concern among the participants of the programme who have been interviewed for the analysis.

Secondly, the uptake of clean cookstoves in marginalised counties at only 6% was very low, as official EnDev reporting data revealed. The high costs in terms of logistics and distribution due to poor infrastructure conditions, security issues and a lack of skilled staff in these counties significantly exceeded the profit margins of the cookstoves sold, as some of the participants reported in the interviews, even under higher incentive levels, and made it highly unattractive for companies to serve these counties. This generally bears the risk of a further detachment of marginalised counties in terms of socio-economic development and health benefits from more central counties. This should be given special attention in future programmes.

Thirdly, the programme indicated the importance of flexibility with regard to the incentive structure. During the course of the RBF programme, the incentive structures were adjusted and modified several times for various reasons, as interviews with the implementer revealed. The focus of distributors, for example on the sales of lower-tier systems in more central markets at the beginning of the programme, triggered the change of the uniform incentive structure into tiered incentives based on the level of the cookstove technology, and regional outreach positively impacted regional and technological diversity in distribution and was revised regularly.

Fourthly, due to the nature of the RBF, funding is only disbursed upon delivery, which leaves it to the programme participants to acquire working capital and upfront investment, which is generally challenging in emerging markets. Consequently, working capital and financial constraints were reported by the EnDev 2.0 programme participants in the closed surveys as central challenges which were then exacerbated by the delays in incentive disbursement. This in turn made financial and operational planning extremely difficult for some participants, especially local companies, and slowed down working processes as well as outcome achievements, particularly for smaller companies. This suggests that options for bridge funding, especially for smaller companies, can potentially enhance the efficacy of CCS RBF programmes.

With regard to the eligibility and quality of the cookstoves, it was reported by the implementer that a number of companies supplied stoves that did not perform well in terms of emission reductions, which also reflected the nascency of the market. As a result, the RBF eligibility criteria were adjusted, and companies were required to improve the quality standards of the stoves. Although the positive impact of the process was the adoption of these higher quality standards in other programmes such as the KOSAP clean cooking RBF, these quality issues delayed the disbursement of funds in the EnDev 2.0.

programme for more than two years. This issue illustrates the importance of defining rigorous quality standards for the products incentivised at the outset of the programme as a fifth key learning lesson.

Finally, although it must be noted that the EnDev 2.0 clearly targeted rural areas with no grid-connection, which usually comprises the socio-economically most disadvantaged groups of the population, the relation between the type of cooking technology and the volume distributed illustrates the challenges of the deployment of higher Tier cookstove technologies in these markets, as shown in Table 2. It indicates that the level and type of financial incentive provided might support the distribution of improved lower Tier cookstoves, but also that slightly higher incentives do not necessarily correlate with a higher uptake of more advanced technologies. Consequently, and in order to promote scaling of higher Tier and modern energy cooking solutions, the results suggest that a more targeted approach is needed. This could include the deployment of resources to support specific responses to identified uptake barriers, which could aim towards consumer education and technical assistance, the fuel supply chain analysis, including electricity, or an adjusted incentive scheme that specifically focuses on higher Tier cooking solutions.

Although the EnDev programme focused both on increasing clean energy access through SHS and pico-systems and the uptake of improved cooking technologies, these components were not integrated, which establishes a yet untapped potential to foster local innovation and incentivise cross-sectoral collaboration.

### 3.3. EnDev/CLASP Kenya EPC RBF

The Global LEAP RBF is a tried and tested formula developed and implemented by the US-based NGO, CLASP, which combines quality assurance with RBF. Through this mechanism, they have managed the distribution of over 270,000 off-grid TVs, fans, solar water pumps and refrigerators across Bangladesh, Kenya, Rwanda, Tanzania, Uganda, Senegal and Zambia in other Global LEAP RBF rounds since 2006 [32]. The Global LEAP Awards is an international competition to accelerate innovation and market development by identifying the best-in-class energy-efficient appliances. In 2020, the first competition for e-cooking appliances was launched, focusing on electric pressure cookers (EPCs), which MECS research had identified as one of the most energy-efficient appliances available on the market [54]. The competition results in the production of a *Buyer's Guide* [59], which lists a set of quality-assured appliances which then become eligible for future RBF schemes.

The EnDev/CLASP EPC RBF programme was the first-ever RBF solely focussed on electric cooking in a developing country. In contrast to the other components of the EnDev RBF Facility in Kenya reported above, which was mainly focused on improved cookstoves and SHS, the Kenya EPC RBF which was launched in 2020 was solely dedicated to the promotion of EPCs and was of much smaller scale. The programme volume was set at \$226,000 and followed an ambitious timeline, allocating four months for the programme launch plus six months for the implantation, with the final reporting to be due in November 2020. The EPC models eligible for the RBF were originally intended to be those appearing in the EPC Global LEAP *Buyer's Guide*. However, the timeline of the competition and the RBF did not align, so eligibility was decided based upon certification via established quality standards (e.g., Conformité Européenne (CE) for importing into Europe) and/or safety and performance testing carried out by the MECS programme [60] at the Centre for Renewable Energy Systems Technology (CREST) at Loughborough University [61]. MECS research showing the compatibility of Kenyan cooking practices with EPCs was a key driver for the selection of Kenya as a pilot country for the e-cooking RBF.

E-cooking is still very much in its infancy in Kenya, with less than 3% of the population owning an electric cooking appliance [62]. Several Kenyan suppliers had recently started selling EPCs, with promising results, however, the availability of these new appliances is still very low, as the market review revealed. The selection of eligible participants, including distributors and financiers, was based on a reverse-auction scheme. The applicants submitted their bids that were comprised of the incentive funds requested based



on the percentage of the EPC retail price and the anticipated volume of EPCs to be distributed. The selection process also included a strategic component where bidders had to outline their plans in terms of scaling up their business under normal market conditions. The grants awarded to six companies covered approximately 30–50% of the retail price and were intended to be disbursed within three tranches: 20% at the time of purchase, another 20% at the time of shipment and 60% upon verification of sales of the product. The target of the RBF was to sell 5300 EPCs by the end of October 2020. 60 Decibels, a globally active lean data management company, acted as an independent contractor to not only verify the results, such as the disbursement of the stoves, but also to evaluate end-consumer behaviour and adaptation after 3 months of the sale through random calls.

The programme did not set a baseline or distinguish incentive levels for a certain regional distribution like the rest of EnDev 2.0 Kenya. Instead, the distributors were encouraged to determine their regional and customer outreach strategy. The logic behind this was to give suppliers the maximum freedom to develop their sales strategy in a market that is of greater nascency than the ICS market in Kenya. Still, from a regional perspective, Kenya appeared to be the most attractive market for an EPC trial in comparison to other countries in the region. Consequently, suppliers mainly focused on urban and peri-urban customers who were connected to the grid and belonged to slightly higher income groups, although household spending levels were not recorded during the sales process, which some companies would have seen as a valuable insight with regard to potential consumer focus groups.

As revealed in the interviews among programme participants and implementers, the COVID-19 pandemic negatively impacted the RBF scheme in two ways. In the first months after the programme launch, the demand for EPCs was increasing due to strict local lockdown measures and rising charcoal prices. Consequently, some of the participating companies experienced a higher demand, exceeding the supplier capacity, which became limited due to the pandemic and the distortion of overseas supply chains. As a consequence, many suppliers faced serious delays in their product delivery, which was intensified in some cases due to customs issues in Kenya. In reaction to these issues, the incentive disbursement was changed from 40% subsidy emitted upon sales to 70% subsidy emitted upon order. The remaining part of the incentive, which was initially planned to be issued three months after a verified sale, was then distributed immediately upon the verification of sales. The EPCs distributed through the programme had a price range of \$70 to \$120, with the RBF covering between 30% and 50% of the unit costs, as EnDev reporting revealed. The ambitious sales targets could not be achieved within the strict programme timeline, which could not be extended by the donors, and due to reported issues with regard to technology verification at the beginning of the programme. As in-stock sales are still ongoing, however, the programme implementer expects that the RBF will achieve the original target.

Based on the interview data and EnDev reporting data, a number of important learning lessons about the first EPC RBF and the promotion of a new and higher advanced cooking technology in an East African market can be generated. The first is that this RBF was successful in drawing together actors from the electricity access and clean cooking sectors, who would previously have participated in separate RBFs, as the overview of successful bidders shows. It enabled MG developers to explore adding e-cooking to the array of energy services they offer to their customers, whilst simultaneously allowing cookstove manufacturers to venture into the world of electric appliances. One programme participant reported that his business would probably not have moved into the EPC space without the RBF programme, while another participant confirmed that the RBF significantly supported the uptake of EPCs among consumers. As a consequence, both companies reported that as a result of the programme, EPCs became a central future business component, although both respondents could not confirm that they secured additional investment to finance a further expansion strategy at the time this research was conducted. The RBF supported the uptake of EPCs in the emerging Kenyan market mainly by enabling participants to order

and distribute EPCs in bulk, although smaller companies reported difficulties in securing upfront bridge funding due to high local interest rates of approximately 20%. It must be noted, however, that similar to BRILHO and EnDev 2.0, the RBF for EPC was not integrated in the wider energy access programme by combining the deployment of MGs and the distribution of EPCs, for example, as the scope of the programme was quite limited.

Secondly, while the distributors reportedly mainly targeted grid-connected consumers at medium to higher income levels as the EPCs were distributed mainly as a one-off cash or credit purchase, participants stated that the future introduction of PAYG—or ‘pay as you cook’ (PAYC)—models could further enhance the uptake of EPCs as one-off purchases are a challenge for many potential customers due to the price of the EPC.

An interesting observation made by the implementer during the EPC RBF in Kenya was that women showed a higher ability for purchasing EPCs through one-off payments, while men preferred to purchase the EPCs through a credit option. While specific data on payment behaviour in relation to the gender of the purchaser is currently unavailable, these observations have provided important information for the EPC companies with regard to their distribution strategy and limiting payment default risks. One respondent expressed the wish that more data on customer profiles should have been collected and provided to the EPC companies which would allow them to improve their marketing and sales strategy.

Thirdly, promoting consumer awareness and the adaption of the technology by overcoming deeply embedded and often false perceptions of the high cost of e-cooking or charcoal providing ‘tastier’ meals still require significant effort and resources among the distributors to further scale the adoption of electric cooking. Participants and implementers of the programme reported that MECS consumer research data and market awareness creation was a significant push towards the increased use of EPCs. The incentives through the RBF reportedly helped the distributors to develop and implement consumer outreach and sales strategies. While the data reporting on ongoing usage of the EPCs is still outstanding and the programme implementer has clearly admitted challenges in capturing consumer behaviour, the future integration of tracking mechanisms to gather data on usage of the device can provide important insights on the continued usage of the devices over a longer-term perspective and could simplify reporting duties on the supplier side as well as verification processes within the programme, which have mainly been performed via telephone interviews. The cost of such tracking systems, however, is still a challenge in the EPC market. As one respondent reported, a usage tracking system would cost him around \$450 per month, while phone tracking and verification stand at approximately \$110 for his volume in the programme. Another respondent indicated that early prototypes of the hardware required for energy metering and device lockout to enable usage tracking and PAYG for e-cooking appliances is currently of the same order as the cost of the appliance itself. However, substantial cost reductions are expected once a mass-market product has been developed.

Finally, the promotion of electric cooking must also be understood in the context of the energy tariff settings. Kenyan on-grid energy tariffs, for example, provide for a price increase from \$0.17 to \$0.23 per kWh above for usage of 100 kWh or more per month. Even though at the higher tariff e-cooking is still five times cheaper than charcoal for heavy foods [54], many consumers still perceive the relative costs to be the other way around. Hence, the impact of an RBF programme in the electric cooking space can potentially be increased through the implementation of a consumer awareness campaign. It could be further strengthened by the integration of national energy policy consultations and cooperation with the utility to develop dedicated tariffs targeted at cooking and utility-enabled finance options.

MECS has acknowledged these opportunities and is driving a consultation process with the Ministry of Energy in Kenya and Kenya Power to enhance the policy framework and market perspective for electric cooking in the country. The Ministry of Energy has recently indicated the high priority that it attaches to expanding the market for electric

cooking, particularly in grid-connected areas, whilst the possibilities for a coordinated promotional campaign involving innovative approaches to consumer finance are currently being explored with the utility, appliance manufacturers and distributors, and key donors in Kenya.

### 3.4. BRILHO RBF Mozambique

BRILHO Mozambique is a FCDO-funded 5-year nationwide energy access programme that runs from 2019 to 2024 and seeks to expand the energy market for ICS in Tier 2 and above performance categories, such as improved biomass cookstoves, biogas, ethanol, LPG and electric stoves. It is complemented by an electricity access target through SHS and renewable energy MGs. The programme is led by the SNV Netherlands Development Organisation and implemented in cooperation with Practical Action Consulting (PAC) and MARGE as partners and Greenlight and Catalyst Power as service providers. It aims to achieve its intended objectives by blending catalytic grants, RBF grants and technical assistance (TA) for electricity access and CCS, as well as through information sharing, implementation of quality standards and advocacy on policy and regulations. For its clean cooking RBF programme, BRILHO applies a reverse auction bidding system and a multitier incentive structure. The RBF incentive is conditional on the sale of a pre-agreed number of units intended to benefit 750,000 consumers, with incentives up to 200% depending on the level of development and extent of the remoteness of communities served. The disbursement of funds is linked to independently verified sales and other qualitative measures, such as employment of key personnel and completion of a market assessment report.

In addition to the RBF component, the BRILHO programme is providing a Milestone-Based Payment (ex-ante), a form of a catalytic grant, to de-risk market entry, product development and/or scale-up activities for smaller firms in particular. The maximum available catalytic grant per company is £750,000, and it is contingent on 100% match funding of the amount, either cash or in kind. The total budget for the entire programme is £22.8 million, with the clean cooking budget estimated at £6 million. Although the programme was originally planned to take off in 2019, issues surrounding the reorganisation of the UK Department for International Development (DfID) Mozambique and the incidence of COVID-19 pushed the start date to mid-2020. At the time of writing this paper, there were 10 awardees: 7 SHS companies and 3 clean cooking companies. Although it is still early days, one of the participating companies of the BRILHO RBF programme, originally operating in the electricity access sector, describes the programme as a “gamechanger for scaling up the distribution of clean cooking technologies in underserved areas”. It is doing so through the TA component of the RBF, specifically with market entry strategies, which have facilitated market entry of this company into the CCS market in Mozambique. During the interview, the company revealed that the bonus incentive component of the programme also encouraged them to serve the ‘marginalised’ segments of the population. As a company describing itself as aiming to improve the lives of marginalised groups, they view this extra incentive element of the programme very favourably.

One of the interviewed companies participating in this programme focuses on SHS, ICS, MG and appliances. The company confirmed that the initial cost of digitalising the monitoring and tracking systems for their SHS and MG prior to the receipt of the BRILHO RBF was fairly high. They note that with the BRILHO RBF, they are now able to bring that initial cost down, enabling the scaling up of their digitalised SHS and MG, which they claim is yielding significant cost-savings—relative to the costs of phone and field visit monitoring and tracking processes—to the extent that they are planning to develop PAYG-enabled clean cookstoves. According to them, if a component of the RBF programme directly targets the development of such smart technologies for CCS, it could potentially offer companies a more cost-effective form of verifying outcomes, which can help them to scale-up their businesses. This will be particularly important for early-stage and smaller clean energy and clean cooking companies who may not have access to such technologies to even

contemplate developing PAYG-enabled cooking solutions. With the gradual emergence of such digitalised CCS, e.g., ACET (biogas), Koko Networks (ethanol), BURN Manufacturing (EPC) and African Clean Energy (cookstoves), there is a big opportunity for output-based RBF programmes in the clean cooking sector to thrive. In the interview, the company admitted that they have successfully leveraged PAYG technologies to improve access to finance for SHS and MG customers while also ensuring better repayment rates. From their experience, they envisage that if such smart technologies are deployed to CCS, with the support of RBF programmes, they could efficiently serve multiple goals in the clean cooking sector in the near future, expand access to consumer finance via affordable digital payment plans, better streamline MRV processes and ultimately attract additional donor funding in the form of RBF into the sector. With these emerging smart technologies, there is scope for future RBF programmes based on digitally verified outcomes, with concomitant cost savings in the MRV process.

#### **4. Discussion: RBF Cross-Sectoral and Regional Evidence on CCS Funding Landscape and Market Size**

The evaluation of clean cooking RBF programmes in developing countries illustrates that, despite the sector being a comparatively new subject for RBF programming, the interest in supporting the scaling of clean or improved cooking solutions is gaining traction among the international donor community, with a number of clean cooking RBFs being at the planning stage, mainly in SSA.

Historically, the focus has been on Kenya, a more advanced clean cooking market, but the regional scope is increasing, with Malawi, Zambia, Mozambique, Liberia and Burkina Faso being potential future recipient countries, among others.

Currently, clean cooking RBFs remain mainly donor-driven. National governments only play a minor role in developing and implementing RBFs, as seen by the limited focus on modern energy cooking solutions in SSA's national policy agendas compared to overall energy access [9]. The political awareness for supporting cleaner cooking frameworks and an enabling environment has not yet reached the levels of overall energy access, despite the severity of the negative health impacts created by cooking with 'dirty' fuels at the current scale, nor is it yet largely embedded within wider energy access strategies pursued by governmental stakeholders or foreign donors (although there are growing efforts to see clean cooking gain greater priority on international agendas, which is reflected, for example, in the preparations for this year's High Level Dialogue on Energy. Bundling energy access and modern energy cooking strategies in combination with a political agenda that creates an enabling environment and limits certain investment risks offers significant potential to scale clean energy access, clean cooking and the improvement of livelihoods for around 3 billion people, globally [11].

The evaluation revealed that the key learning lessons from the use of RBF in clean cooking as well as other sectors are related to financing, market and end-user dynamics, as well as the verification process. These are presented in Table 3, which establishes key risk factors for an RBF programme.

##### **4.1. Financing**

RBFs are usually focused on markets that present a significant growth potential for certain sectors or technologies (e.g., energy where access is low) but also significant barriers for businesses to grow (e.g., affordability/customer ability to pay). Consequently, RBF incentives need to be designed to enable companies to grow their business or expand into new technologies by reducing market barriers, incentivising bulk procurement and supporting market exploration.

Table 3. RBF risk matrix.

Risk/Barriers	Explanation	Severity	Impact	Observed in (Country/Programme)	Mitigation Approach
Pre-financing challenges	Upfront financing required; high national interest rates in Africa (20–40%), pure RBF does not provide pure concessionary upfront financing	Medium	Potential market distortion; local players without international financing access disadvantaged; limits R&D/Innovation; insolvency of RBF participants; risk of project failure	Rwanda SHS RBF programme and Global LEAP EPC Kenya (partially)	Due diligence: access to financing = pre-selection criteria. Provide bridge funding; % of grant disbursement upfront
Inflexibility	Market development faster than RBF programme (RBF-approved appliances overtaken by newer/cheaper models)	Medium	Lower distribution rates; targets cannot be fulfilled; creates irritation among consumers and disadvantages RBF participants over other players; RBF players lose trust	EnDev Kenya; EnDev-III Nepal	Keeping RBF design and implementation flexible, allowing a wide range of CC technologies
Short timeline	Short RBF implementation periods and unforeseen events (e.g., COVID-19/national disasters, etc.).	High	Speed before quality; no/limited consumer information; long-term uptake, use and overall sustainability; default/financial risk for RBF participants (cannot sell all units obtained)	Global LEAP EPC	Flexibility in the RBF design and implementation so that timetable for award and implementation can always be adjusted to accommodate any unforeseen events, while also ensuring that technologies do not go obsolete
End-user/community dynamics	No differentiation of incentives between products and end-user market. Varying levels of community acceptance	Medium	No differentiation of incentives between products and end-user market. Varying levels of community acceptance	EnDev Kenya and KOSAP CCS	Introduce tiered incentives based on energy service levels; periodically incentivise participating firms to sell in underserved areas. Increase community and end-user awareness
Transaction costs/results verification	Delays in monitoring and verification (M&V); M&V costs too high; finding right M&V agent sometimes difficult	Medium	Delays in the disbursement of funds to companies	Endev Kenya	Proper due diligence so as to find right M&V agent. Where possible, introduce remote monitoring technologies to reduce cost and delays
Transition from RBF to market-driven business models	Given the relatively nascent industry, firms may find it difficult to transition to market-driven models beyond RBF	Medium	Financial sustainability issues; risk of using RBF grant for inventory rather than sales	Global LEAP EPC RBF Pilot Kenya	Provision of upfront financing plus capacity building and TA support, especially for seed and early-growth businesses as they move along the growth curve
Currency depreciation/fluctuation	Procurement of technology in hard currency' (\$); customer payments in local currency	Medium	In case of significant currency depreciation and fixed incentive rates, margins lower/capital contribution of participants higher; especially challenging for smaller companies and for longer disbursement timelines	Kenya	Regular review of incentive rates; adaptation to currency fluctuations

The evaluation for the clean cooking sector has shown that RBFs are usually most helpful for companies that have already gained essential market experience, have successfully overcome the seed and early-growth stages and are transitioning to further consolidate and grow their business. Smaller companies who are at an earlier stage would need more support to achieve given milestones within a funding programme, as well as other types of financing to scale-up their business model. Hence, the targets and scope of an RBF can bear

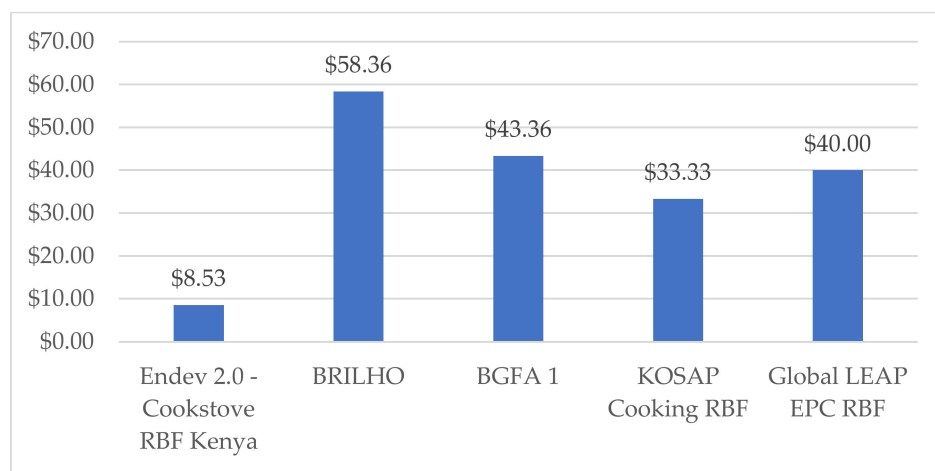


certain trade-offs between ambitious distribution targets linked to supporting late-growth companies and more targeted approaches that include supporting the development of smaller businesses and innovators. The work of MECS in Kenya has shown that pre-RBF innovation and prototyping support can also help local companies to branch out into promoting new technologies.

The support for smaller, often mostly local companies, within an RBF framework can be two-fold [12]. The first is an evaluation and categorisation of RBF beneficiaries with regard to their institutional capacity and the design of an incentive structure for different categories, allowing for the bundling of participants. Secondly, a market analysis and segmentation could be the basis for an incentivisation of operation areas for smaller companies, whereas bigger players are expected to service more complex and capital-intensive markets.

Another challenge is the acquisition of upfront financing for bulk orders in programmes that are purely based on RBF, especially for smaller or local companies with limited access to international finance as the cost of capital in developing markets is high, with local currency interest rates for debt capital ranging between 20% and 25%. The inclusion of an up-front grant within an RBF programme to support the pre-financing and cashflow of the participants has been identified as a major opportunity in previous RBFs to diversify the spectrum of participants. This, coupled with specifically targeted incentive rates, can help to overcome barriers that limit market outreach in less attractive regions.

The incentive structure and hence the overall cost of an RBF is directly linked with the technology it aims to support. Clean cooking technologies of higher Tier standards [18] require higher incentives, with modern energy cooking solutions such as EPCs ranging in the highest group of incentives per item, as illustrated in Figure 4. The EnDev 2.0 programme, for example, mainly targeted improved charcoal stoves, while BRILHO and Global LEAP focused on e-cooking and other higher Tier solutions.



**Figure 4.** Average incentives paid per item in different RBF programmes in Kenya, Mozambique and Zambia [19]. Values are based on total RBF incentives for clean cooking/target number of stoves deployed.

Since RBFs are aimed to scale the market penetration of certain advanced technologies, distributors and distribution structures are key drivers for the success of an RBF programme. Smaller or early-stage companies with limited distribution capacity might either need extra support in setting up these facilities or RBF might not be the most appropriate instrument to support their business growth. The experience in Kenya has also shown that although incentives were set to encourage local medium enterprises (LMEs) to engage with financial institutions, the actual RBF engagement of financial institutions was very limited. Hence, the suitability of RBF to support LMEs needs to be further evaluated in the specific local context of an RBF and it needs to be discussed whether LMEs

might benefit more from other supporting mechanisms [58]. The limited collaboration between LMEs and financial institutions has meant that the intended goal of improving customer affordability, especially for rural consumers through credit and other payment plans, is threatened. Notwithstanding, clean cooking RBF programmes, such as BRILHO Mozambique, are providing extra incentives to participating companies for selling modern energy cooking solutions to underserved rural communities. These extra incentives are expected to be transferred to these segments of the population, thus making clean and modern energy cooking solutions and fuels accessible and affordable to users. Future clean cooking RBF programmes are now also incorporating the provision of extra bonuses to companies that provide payment plans for end-users into their design. RBF procurement incentives can also stimulate large-scale product buying by reducing real and perceived financial risk. These volumes enable distributors to launch and scale new product lines more quickly than in typical market conditions. Bulk purchase also aids suppliers in achieving economies of scale and lowering production costs, which then translate into low-priced products for the end-user [32]. In Table 3 and Appendix A Table A1, we present a host of risk factors and limitations associated with clean cooking RBF programmes, which donors/implementing agencies must be aware of.

With regard to financing the S-curve (in this context depicts the nature of firm growth over time), as illustrated in Figure 5, the successful completion of the RBF is not a guarantor for businesses to maintain the growth path and attract additional financing for further scaling, as other market factors and externalities as well as internal capacity and resource development of businesses have a decisive influence. The participants interviewed for this study have not yet been able to secure additional financing to progress growth in their RBF-supported business streams, which is also partially due to the COVID-19 pandemic, the recentness of the programmes, as well as macro-economic challenges including currency depreciation leading to hesitation among international financiers to further invest in that specific market. It must also be noted that access to financing is continuing to be a key challenge in the clean cooking sector [18].

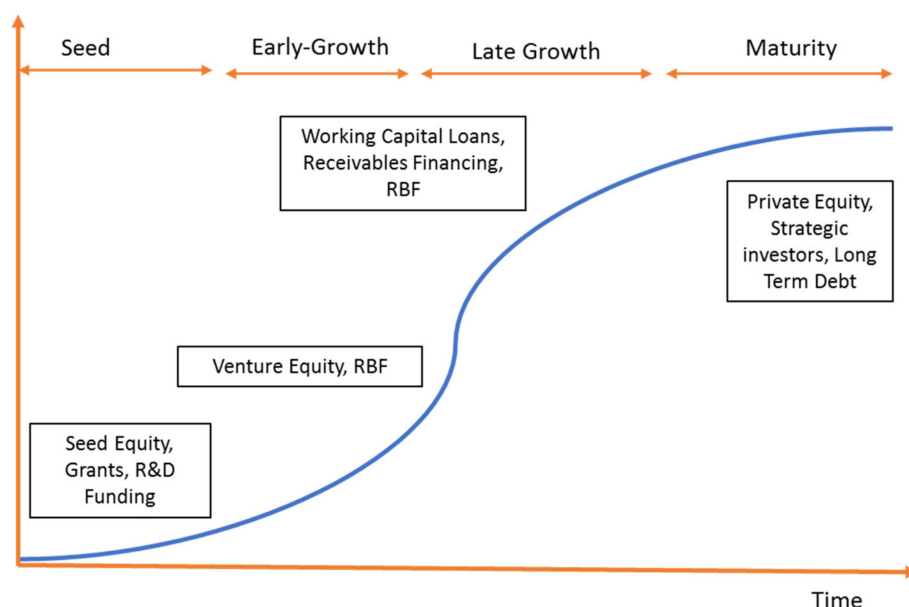


Figure 5. Required CCS financing options in relation to company growth stage [22].

Currency risks are generally a key challenge for project financing in developing markets [9]. This is especially valid for RBFs if the disbursement of the incentive is staggered and stretched over a certain timeline as it is connected to the achievement of certain milestones. A number of African countries, including Kenya and especially Zambia, have seen significant losses of local currency values against international currencies, which directly

impact RBF participants as they often import their products in hard currency, but consumers pay in local currency. Our research revealed that companies participating for example in the Beyond the Grid Fund Zambia (BGFZ) have stated that the Kwacha depreciation has been a massive problem for their business operation and the losses incurred seriously hamper further growth of the company. Hence, the incentive structure needs a constant review and incorporation of these dynamics can lead to regular adjustments, as practised during the EnDev 2.0 Kenya programme.

The above financing constraints faced by clean cooking companies mean that the end-user ultimately bears the consequences in the form of low affordability. Affordability of clean cooking solutions has remained one of the most significant barriers to adoption and usage. Although some stove sales have been financed by local financial institutions, lending volumes have not been encouraging: the bulk of clean cooking solutions are still sold for cash [63], making them less affordable. Clean energy traditional financing for low-income consumers, especially in rural areas, is characterised with high loan transaction costs and difficulties of assessing and predicting consumers' repayment risks. However, there is growing evidence that microfinance and informal lending by savings groups are expanding the adoption of clean cooking solutions in resource-poor settings [64]. Even though microfinance plays an important role in reaching consumers in rural areas who are in need of financial services but often excluded from formal finance, it comes at a cost—effective interest rates of microfinance can go well over 100% [65]. Fortunately, the emergence of mobile technology (see the case of 'Chaguzi' in the subsequent section) and other innovative financing models (see [63]) for the end-user in the clean energy sector are providing opportunities to expand access to clean cooking solutions for low-income consumers at more affordable rates.

#### 4.2. Verification Process

An efficient verification process based on effective data collection and monitoring is a key component of an RBF programme and has a decisive influence on the overall outcome of the RBF. Difficulties during the verification process have been a major challenge for RBF beneficiaries who usually pre-finance their activities in capital-critical markets and hence rely on the timely disbursement of funds. Consequently, partnering with an experienced IVA that understands the local market and acts as a bridge between the companies participating in the RBF coupled with sufficient resources to provide technical communication can support frictionless communication at eye-level and efficient reporting processes. The inclusion of impact-focused KPIs, such as gender, the distribution to economically disadvantaged households or delivering in underserved areas, requires additional data collection and verification resources which must be balanced with the desired outcome, scope and timeline of the RBF.

The friction in the verification processes that occurred in some of the programmes has led to delays in the disbursements of funds, which can create serious cashflow problems, especially for smaller companies. This again illustrates the substantial need to develop standardised KPIs for different clean cooking technologies in the future, which should also include a standardised data collection and verification approach (development impact data such as tracking health benefits or environmental impacts are particularly difficult and resource-intensive to track). Potential trade-offs between the inclusion of local, technologically less-advantaged players or more sophisticated and complex reporting requirements—which can usually be fulfilled more easily by international players who are already more established—however must be acknowledged in this regard. Consequently, stakeholders of RBF programmes can significantly benefit from TA with regard to data management and reporting, which would also support a sustainable enhancement of business operations of the participating partners.

Overall, and with regard to financing mechanisms of RBF programmes, it can be concluded that while it is theoretically desirable to connect grant payments to specific outcomes and therefore have a higher potential to generate certain desired impacts, this type

of programme requires higher-level administration and verification resources compared to output-based programmes or those that provide upfront grant financing. Furthermore, the measurements of specific outcomes, including the longer-term uptake of the new technology, are still challenging, but might benefit from technological progress, especially with regard to smart data collection. This technological progress could include the current trend towards developing PAYG cooking solutions, with PAYG LPG in particular, but it also applies to ethanol and electricity. This process is led by companies and based on the lessons learnt from the off-grid solar rural electrification. The use of PAYG technology pretty much ensures that data collection is inbuilt into the operations, thus addressing the data challenge, in addition to having many other advantages, including increased affordability, convenience and better service provision.

Allied to the smart data functionality that new technologies such as PAYG offers [66,67], mobile technology can also be leveraged to improve clean cooking financing for low-income consumers by breaking barriers—such as collateral requirement, high loan transaction costs and other operational costs associated with screening customers and assessing repayment risk levels—associated with accessing traditional forms of consumer finance. An example of such a promising mobile technology is Micro Energy Credits Corp's (MEC's) mobile platform, Chaguzi, which utilises machine learning, big data and predictive modelling to build risk profiles for different low-income customers of clean energy products [68]. This can potentially facilitate the provision of tailor-made loan products to this segment of the population, thus helping to bridge the affordability gap while also opening up new markets for RBF recipients to serve profitably. The currently limited availability on business models, financial performance, consumer uptake and financial data in relation to cooking technology is still a challenge, and there is a significant opportunity for research impact programmes, such as MECS, to step in to provide data in cooperation with local and international partners.

#### 4.3. Technology, End-User Acceptance and Market Dynamics

End-user awareness and acceptance are decisive for the success of an RBF, especially in the clean cooking sector, as cooking habits are deeply culturally rooted [6,69]. The adoption of new CCS requires behavioural changes to achieve the desired socio-economic or environmental impacts, for example with regard to fuel stacking, which is a well-known problem in urban and rural developmental contexts [70,71]. As a result, simply supplying an appliance cannot be considered sufficient to guarantee the intended development outcomes, and future CCS RBF schemes need to establish effective ways to link payments to the sustained use of the cooking appliance. The scaling of a new technology, such as, for example, EPCs, requires significant time and resources to create consumer awareness, acceptance and adoption, as participants of the Kenyan EPC RBF programme confirmed.

A continuous end-user contact, the collection of end-user feedback and usage tracking have been described as key components by EPC and ICS distributors in this context. In relation to the programme implementer and the funding partner, a substantial understanding of the business processes as well as efficient and open communication processes with the recipients are key to translate 'messy' market dynamics into a working business model, as one RBF stakeholder pointed out. The distribution of technologies verified to be eligible for the RBF is not isolated from wider local market dynamics. This means, for example, that technological progress, which is currently rapid in the clean cooking sector, might produce appliances that are cheaper or more advanced than the appliances that have been approved at the outset of an RBF programme. Consequently, RBF programme implementation should not only contain flexibility with regard to incentives, as discussed earlier, but also acknowledge technology market developments and adoption. The appropriateness of the device in terms of local cooking habits and the availability of certain energy and fuel sources are key factors needed to facilitate it and to ensure sustained use of the chosen solutions.

The research shows that most of the RBF programmes are technology agnostic but exhibit a strong tendency towards ICS, with e-cooking being significantly under-represented

due to the nascency of the e-cooking market in many developing countries. This gap underlines a significant untapped potential of reducing the use of biomass, especially charcoal, reducing carbon emissions and creating positive health impacts, particularly in the on-grid sector. It is estimated that between 80% and 90% of grid-connected SSA households still cook with charcoal or other biomass, although figures vary significantly from country to country [72]. The following calculation illustrates the market potential for e-cooking solutions in the on-grid sector of SSA alone: out of 1.107 billion people in SSA, currently, 47.6% have access to electricity [73], which translates into around 526 million people or roughly 87 million households in SS applying an average household size of 6 people. Applying an average of 15% of these households currently using electricity for cooking leaves around 74.6 million households still cooking mostly with biomass in SSA. Consequently, around 447.9 million people remain exposed to cooking-related pollutants in urban- and peri-urban areas of SSA alone. An average household cooking with charcoal or firewood emits around 5 tonnes of CO<sub>2</sub> per year [73]. These figures are averages and vary depending on the type of stove used, food type or cooking habits. Applying this baseline data, the equation presented in Appendix A Table A3 shows that promoting e-cooking solutions in the SSA on-grid sector alone could potentially save around 400 million tonnes of CO<sub>2</sub> emissions per year. This also presents a significant potential for carbon credit financing, which is discussed in the following section.

#### 4.4. Beyond RBF: Towards Outcome-Focused Finance, Impact Funding and Climate Finance

As illustrated previously, discussions on RBF have tended to focus on public sector interventions by multilateral agencies, such as the World Bank and EnDev, whereby incentive payments are made to projects delivering pre-agreed targets. However, other forms of impact funding such as carbon credits and co-benefit payments can also be considered as RBF as these also involve grant payments provided by donors, dependent on pre-determined objectives being achieved. These are an as yet largely underdeveloped opportunity in the clean cooking sector [55] due to a number of market and implementation barriers.

Carbon credits have historically been an attractive source of funding for cooking projects, especially for ICS projects executed by NGOs and humanitarian organisations [47,56,74], but these have still represented a small niche market compared to other carbon credit investments [75]. There have been two main sources of carbon credits. The first is the Clean Development Mechanism (CDM) which is managed through the United Nations Framework Convention on Climate Change (UNFCCC). This has been the main source of funding for compliance purposes under the 1997 Kyoto Protocol and is now under review after the 2015 Paris Agreement. Secondly, the 'voluntary market', which has operated in parallel as an alternative source of carbon credits for clean cooking projects, where mainly private firms can voluntarily offset their emissions. Over the past few years, interest in carbon crediting has surged, and as of 2020, in all sectors, around 61 carbon pricing initiatives and more than 14,500 registered crediting projects globally have been scheduled and implemented, with around \$45 billion in carbon price revenues generated in 2019 [27]. The majority of these crediting activities are still focused on the power and fugitive emission sectors, with an increasing share of investment in forestry projects, which now account for almost half of the investment.

Despite a significant growth of the carbon pricing sector, the application of carbon credit financing in the clean cooking sector has faced significant challenges. Markets have often been frustrating for project developers with prices fluctuating, complex procedures, high certification costs and projects sometimes finding it hard to attract funding at all. Carbon market prices, especially in the voluntary market, are highly variable and ranged from an average of around \$2 to \$12 t/CO<sub>2</sub> in 2019, with an average of \$3.5 t/CO<sub>2</sub> paid in the clean cookstove market [75]. Furthermore, the concept of offsetting has itself been very controversial, with commentators querying whether these incentives were really working to reduce emissions and how rigorous procedures were [76,77].

The majority of clean cooking companies surveyed for this study reported significant challenges when applying or implementing carbon credit financing for their respective



businesses, leading to either giving up on pursuing this option or a much slower take-off than anticipated. Besides complex bureaucratic and organisational hurdles, which are especially challenging for smaller businesses located in the Global South, the pricing of the credits, repayment schemes and monitoring have been significant challenges for the sector. Although carbon prices have increased in various jurisdictions over the past years, they are still substantially lower than needed to achieve consistency with the Paris Agreement objectives. As of 2019, it has been estimated that emissions have been priced at less than \$10 t/CO<sub>2e</sub>, while the International Monetary Fund (IMF) calculated the global average carbon price at only \$2 t/CO<sub>2</sub> [78], which sharply contrasts with the estimated \$40 to \$80/per tonne of CO<sub>2</sub> by 2020 and \$50 to \$100 per t/CO<sub>2</sub> by 2030 required to effectively reduce emissions in accordance with the Paris Agreement [79].

The move to modern energy cooking solutions has offered the chance for a simplification in calculating emission reductions using a smart data approach. The consultancy group ClimateCare has worked with MECS to develop a new methodology that simplifies the process of taking electrical and metered cooking appliances through the process of accessing carbon credits. In the past, the method for calculating emission reductions was based on quantifying emissions resulting from the quantum of fuel used in a sample of households and then calculating emission savings by comparing this with emissions similarly calculated after the project. The kitchen surveys, both baseline and follow-ups, had to be detailed and accurate, so they were typically carried out in 100 households or more and then repeated at least every two years. The process was time-consuming, expensive and open to errors in data collection. The new approach calculates emission savings for each unit of energy used in cooking, and so with actual usage monitored, calculations can be made simply and accurately. The installation of metering devices that monitor actual usage (and hence the equivalent of carbon reduction under the new procedure) may be technically challenging for ICS that still rely on biomass but should be manageable and economic for electrical and metered devices. Although the total volume in the voluntary carbon markets for household devices, including cleaner cookstoves and switching fuels, only had a share of around 1.3% of the total market revenue in 2019, the volume of carbon credit financing in this sector more than doubled from an estimated \$15.1 million to \$36.7 million between 2017 and 2019 [75].

Given the strong global commitment to support climate change initiatives, the prospects for carbon credits arising from different sources appear very positive at the present time, which provides a strong incentive to identify opportunities to simplify procedures and reduce costs.

Climate-related funding is directly related to GHG emission reductions and is provided from sources dedicated to promoting these objectives. Clean cooking projects promote other strong positive SDG impacts, in particular for health improvements, gender impacts, environmental benefits from reducing black carbon emissions and biomass depletion, and livelihood benefits. These may provide opportunities for clean cooking projects to solicit support from other donors. Development Impact Bonds (DIBs) or outcome purchase programmes are one mechanism whereby such opportunities can be realised. DIBs extend debt capital to clean cooking companies in exchange for ownership rights to the outcomes created by the sale of the appliances or services. These outcomes or benefits are then verified and sold to outcome buyers (donors), thereby enabling the repayment of the debt, and effectively converting the loan into a grant for the clean cooking company. This form of RBF is at a very early stage but has the potential to scale significantly if it can be shown to be cost-effective and reliable in meeting donor objectives. MECS is supporting the completion of the first DIB in the modern energy cooking space with Cardano Development, which is piloting this financing structure with an initial project.

#### *4.5. CCS RBF in the Humanitarian Context*

De-risking finance mechanisms such as RBF have successfully been used to incentivise companies to enter markets outside of their regular scope of operations, including not

only low-income, rural areas but also displacement settings, which represent an even more uncertain environment. Displacement settings are complex, with both displaced and host populations who need access to energy at household and community levels. Energy projects in displacement settings have tended to focus on refugees in rural camp settings who may have limited or unpredictable income streams, making them a marginal market segment with limited ability to pay for energy services [15]. As a result, energy access projects in displacement settings have predominantly been funded through grants rather than traditional debt and equity investments, due to the associated risks. However, grant funding is often limited in scope and has a relatively short lifespan, which does not align with the long-term nature of the energy access challenge [80].

Projects targeting displaced populations have also been relatively scarce as compared to the energy access efforts in rural and remote parts of countries still working towards the achievement of universal access. Two notable examples of the application of RBFs to displacement settings include the RBF for MG development in Kalobeyei settlement, Northern Kenya, and the use of carbon credits to support the distribution of solar cookers for Sudanese refugees in Chad. In the case of the latter, the carbon credit scheme was set up to mitigate the environmental degradation of the refugee-hosting areas and the exacerbating conflict between the refugee and host communities due to firewood collection among both groups to satisfy their cooking needs [81]. To address these challenges, the CookKit Solar Cooker project [82] was launched in 2005 to help transition six camps hosting Sudanese refugees to cleaner cooking. Since 2019, the FairClimateFund has supported the project, which has sought Gold Standard certification for CO<sub>2</sub> emission savings resulting from the reduction in firewood consumption.

The carbon credits obtained have been used to continue the distribution of solar cookers. In the Kalobeyei Integrated Settlement in Kenya, which comprises of three villages located just outside of the Kakuma refugee camp, two solar-hybrid MG, one in the settlement and one in the host community, have been commissioned under the €1.5 million GIZ and Barclays Bank of Kenya programme [15]. The programme has been funded by FCDO (previously DfID) and hosted by EnDev in partnership with UNHCR and has provided incentives for the private sector by alleviating the costs associated with the production and distribution of solar power, particularly across the more remote and challenging parts of Northern Kenya. Offering funding of up to 50% CAPEX and an RBF subsidy for each household connection made, it has supported one developer to enter Kalobeyei and provide electricity connections to households and business alike, particularly given the limited capacity to pay among the households, with only approximately 34% able to pay the average \$15 required per month. To address the needs of the remaining 66% of households, the programme will seek further funding to extend the subsidy and ensure the project is operational over the contracted period of 20–25 years.

While the FairClimateFund approach benefits from the potential to address the need for clean, modern energy cooking for Sudanese refugees over the long term, as the introduced carbon credits mechanism will continue to support ongoing solar cooking kits' distribution, it perpetuates the reliance on freely distributed products, which can have a detrimental effect on the development of market-based approaches in displacement settings in Chad. On the other hand, the example of the RBF in Kalobeyei has a higher potential to support local market development, yet so far, there is no clear exit strategy for the programme. This leaves the MG provider with a level of uncertainty about the long-term feasibility of their operations, particularly if a sufficient number of customers, including productive users of energy, is not reached before the current end date of the programme. The examples from humanitarian contexts thus demonstrate that projects and programmes should carefully consider innovative financing mechanisms and evaluate their advantages and disadvantages, as well as long-term implications for the local clean cooking sectors and the end-users themselves.

## 5. Discussion and Conclusions

This paper has explored the adequacy of RBF programmes for the modern energy cooking sector based on the evidence from the wider energy access sector, as well as other relevant sectors where RBF is more established, such as healthcare. The review of existing literature and the primary data collected through stakeholder interviews have offered critical insights into both the challenges and the advantages of RBF schemes to promote innovation and facilitate the scale-up of modern energy cooking, particularly in low- and middle-income countries. We acknowledge that a more holistic approach to evaluating RBF programmes for the clean cooking sector should place emphasis on the end-users' perspectives as well. However, due to scope and COVID-19-related constraints, no demand-side data was collected for this research. This limitation opens an avenue for future research on this topic to consider the evaluation of RBF programmes exploring end-users' perspectives. The lack of demand-side data and the scope limitations of the paper have also meant that no cost-benefit analysis of the reviewed RBF programmes has been carried out. As seen in the literature review, such cost-benefit analyses are key to understanding the overall effectiveness of RBF programmes and should also be considered in future research.

Nevertheless, the analysis has shown that RBF can promote the uptake and scaling of clean cooking solutions if it is designed to match the requirements of a market that is not too nascent and if it offers an incentive scheme that balances the needs of the programme participants, for example with regard to upfront financing and the overall targets of the RBF in terms of impact and technologies.

A certain degree of flexibility to react to changing circumstances or market developments is key to achieve the desired objectives and longer-term impacts of an RBF programme in the energy sector, which includes clean cooking in this context. The optimal design of an RBF programme requires a substantial understanding of target sectors and market dynamics among the RBF stakeholders, an efficient verification system that is understood and practicable by the participants and the comprehension that transition processes to clean cooking and market growth are longer-term developments. Qualitative key performance indicators, such as consumer acceptance, as well as longer-term monitoring, are critical long-term success factors for RBF to ensure the continued uptake and use of CCS but securing the inclusion of these indicators within programmes remains challenging and can be seen as a limitation that needs to be addressed. RBF's effectiveness is maximised in a clean cooking market that is characterised by a certain degree of consumer awareness, a functioning supply chain and an existing distribution infrastructure for modern energy cooking fuels. With regard to fiscal incentives, blending an RBF with upfront grants to companies for market setup and development costs bundled with TA for applicants and local public institutions, for example to set-up testing protocols, can enhance the potential longer-term benefits for sectoral market players as the programmes are intended to kick-off the scaling of a certain technology and market growth.

The upfront cost of modern energy cooking appliances, including e-cooking devices, is often a major barrier for many consumers. If an RBF can help overcome this challenge, it can unlock a much more convenient and cheaper form of cooking. Despite the perception that electricity is 'too expensive for cooking', MECS research has shown that the cost of cooking with electricity is often much lower than current expenditures on cooking fuels in the on-grid sector.

With the focus of CCS RBF programmes being on ICS in the past, there is now also a growing shift to all clean cooking technologies, including modern cooking solutions, which include EPCs and other electrical cooking appliances.

The technology and incentive scheme most favourable for an RBF programme is largely determined by the local energy market conditions and overall programme goals. An RBF focussed on the further uptake of EPCs and other electric cooking solutions is currently most appropriate for urban and peri-urban on-grid customers, as energy tariffs are often subsidised and affordable, income levels are higher than in rural areas and free

firewood consumption for cooking is low. These factors allow for a positive economic equation, making e-cooking usually the more cost-effective solution for a transition away from biomass. Addressing specific uptake barriers such as availability of good-quality products, consumer awareness, cooking preferences leaning towards charcoal and the misperception that e-cooking is generally more expensive as part of an RBF programme can enhance the programme impact. One option to tackle these barriers is through supporting local distributors with TA, integrated innovative funding as well as multi-partner programmes including governmental and non-governmental stakeholders. Targeting e-cooking for the on-grid consumer market has a significant charcoal-reduction potential and can substantially help to reduce deforestation and carbon emissions.

The off-grid energy market establishes different requirements for RBF programmes and the scaling of clean cooking solutions. The mostly rural settings in the off-grid energy market are often characterised by low- and seasonal-income levels, high consumption levels of firewood that is collected for free, low levels of access to technologies as well as potential high outreach costs to remote areas. Although most clean cooking RBF programmes are part of wider electricity access programming, the clean cooking component stands often as a separate lot or programme component detached from MG deployment, such as in the discussed KOSAP Kenya programme, the Global LEAP EPC RBF or BRILHO in Mozambique. The closer integration of modern energy cooking with electricity access programming such as renewable energy MGs is a desirable strategy with a significant potential impact on improving health and reducing deforestation. The BGFA, round three for Uganda, is currently approaching that integration by incentivising clean cooking solutions among productive uses of energy as part of electricity access projects to some extent, but it remains a subsidiary element in the electricity access programme.

Ideally, modern cooking programmes could ‘piggyback’ on the outreach strategy of electricity access programmes using the introduction of improved cooking technologies as a first step on the ladder of modern cooking solutions and benefit from bundling efforts in serving rural markets or potentially bypassing such steps completely by the use of much more strongly targeted market interventions, drawing on the lessons from successful targeted subsidisation schemes utilised in the growth of LPG in Latin America.

The integration of e-cooking solutions into MG development requires a careful local assessment to match local affordability and the cost of energy levels. Most MGs are already struggling in recovering their operational costs through their generated revenue, and rural consumers are facing cost-reflective tariffs that are challenged by local affordability levels. Hence, the household level uptake of e-cooking solutions on MG settings in rural areas is still often restrained by affordability gaps as well as MG load limitations. Consequently, an innovative RBF element in this regard could be the shift from the sole appliance financing through the RBF component to subsidising the energy used for electric cooking as an ‘e-cooking tariff subsidy’. The national on-grid tariff could serve as a potential benchmark in markets where on-grid energy tariffs are subsidised and hence lower than in the off-grid space. While MG developers confirmed the feasibility of this instrument for their metered customers, such a subsidy would generate a number of direct benefits. Firstly, the uptake and actual usage of the clean cooking device would be incentivised instead of the sole acquisition of the appliance, which does not always result in its usage due to fuel-stacking behaviour and energy affordability problems. Secondly, more targeted support of lower-income customers would be easier as the subsidy could be directly coupled with certain existing MG tariff bands. Finally, the tariff deployed during certain times of the day could help to balance MG energy loads and demands, for example by incentivising daytime cooking, and support the overall energy utilisation and sustainability of MG. MG developers could then utilise the tariff subsidy to acquire, distribute and promote the e-cooking device.

The productive use of energy for clean cooking in commercial settings, such as local restaurants, or in institutional settings such as rural schools, such as the e-cookstove project by SOWTech, supported by MECS [83], also bear currently underexplored opportunities for

e-cooking solutions in rural contexts, but require the inclusion of local context parameters in clean cooking scaling strategies.

Overall, innovative RBF approaches bear a significant potential to start the longer-term transformation from biomass-based to modern energy cooking, which would reduce indoor air pollution and save lives. Essential components for the success of such programmes are local awareness for new solutions and their acceptance, socio-cultural adaption and technological innovation, which are key areas of the MECS programme.

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## Appendix A

Table A1. Literature review—main RBF findings.

Source	Country of Study	Intervention/ Financing Type	Sector	Approach Measurement Indicators	Methodology	Main Findings/ Conclusion	Key Success Indicators for RBF
Abagi et al., 2020 [45]	Africa, Asia, Latin America	RBF procurement incentives	Energy access and cooling	Number of appliances sold	Case study; meta-data evaluation; technology focus	Programme not focused enough on local innovation; consumer data collection and evaluation key before selecting appliances for RBF	Product design must be suitable for consumer needs.
Vigdor (2012) [84]	USA	Teachers’ performance incentives	Education	Average test score gains	Experimental evaluation— regression discontinuity design	Improvement in average test scores	Questions about cost-effectiveness of the scheme; needs-based approach necessary; simplification of scheme necessary.
Bonfrer et al. (2014) [48]	Burundi	Healthcare services—PBF	Health	Antenatal, postnatal, family planning	Non-randomised study	Quantitative improvement of healthcare access but no qualitative improvement of care provided	RBF needs to incentivise serving poorer and vulnerable households, otherwise RBF will widen inequality gaps
Cohen and Patel (2019) [15]	North Kenya, including displacement settings	Mini-grid RBF	Energy	Number of connections provided	Case study	Pre-feasibility study showed that 34% of the local population can afford to pay \$15/month for electricity, meaning that 66% cannot afford that rate and will require further subsidy. Post-implementation findings are yet to be published	While the RBF scheme supported by GIZ is an important factor to facilitate improved access to electricity in the Kalobeyei settlement, it will not be sufficient to connect all households and therefore additional funding to offer further subsidies will be needed
Grittner (2013) [21]	13 developing countries in Africa, Asia and South America	Healthcare supply and coverage—PBF	Health	Quality and coverage of healthcare services	Qualitative and quantitative methods	Improvement in supply and coverage of healthcare services. Evidence on quality and efficiency not sufficient.	Cannot cleanly associate these healthcare improvements to only the PBF. Rigorous evaluation methods are needed.
Hufen and de Bruijn (2016) [85]	Netherlands	Energy conservation— performance-based contracts	Energy	Energy savings	Case study	Energy savings realised; adverse effects (e.g., complex contracts, with financial consequences for the agent)	Performance-based contracts (PBCs) should be tailor-made. Flexibility and simplicity in the design of PBCs required.
Johnstone (2020) [86]	Malawi	Improved cookstove; RB; Carbon Credits	Clean cooking	No. of stoves distributed; Emissions reductions	Case study	Delays in RBF payments; uncertainty about who funding provision for future stove replacements; carbon credits’ verification time-consuming and expensive; credits subject to price volatility	Rigorous verification

Table A1. Cont.

Source	Country of Study	Intervention/ Financing Type	Sector	Approach Measurement Indicators	Methodology	Main Findings/ Conclusion	Key Success Indicators for RBF
Kalk et al. (2010) [49]	Rwanda	healthcare services—PBF	Health	Quality of healthcare services; health workers' motivation and performance	Semi-structured interviews; desk reviews	Higher worker performance and motivation levels. Issues such as 'gaming' threaten the provision of quality health care services.	To maximise impact the RBF design should be adapted to the local context.
Lambe et al. (2015) [43]	Kenya	Improved cookstoves; RBF (carbon finance)	Clean cooking	Usage and after-sales service	Semi-structured interviews	Carbon finance can facilitate better follow up on customers' usage and satisfaction levels, and after-sales service. Risks of perverse incentives.	Carbon finance schemes need be meticulously designed and carefully implemented.
Ngo and Bauhoff (2021) [87]	Rwanda	Healthcare services—PBF	Health	Institutional deliveries and antenatal visits	Difference-in-difference regressions; secondary data	Positive effect on institutional delivery and visits in the short and medium term; Qualitative effects not significant	Alignment of national reforms and local policies with RBF key to success.
Petross et al. (2020) [52]	Malawi	Healthcare services; PBF	Health	Intended and unintended consequences.	Focus groups	Intended and unintended effects for Service Delivery Integration; issues with overcrowding of the health facilities	Design of RBF/PBI programmes needs to consider the cultural expectations of end users.
Rietbergen and Blok (2013) [88]	Netherlands	Reduction in CO <sub>2</sub> emissions—Performance Ladder (CO <sub>2</sub> PL)	Energy	CO <sub>2</sub> emissions	Desk reviews	Application of the CO <sub>2</sub> PL incentive scheme can lead to significant reduction in CO <sub>2</sub> .	Other energy and climate policies may have contributed to the RFB effects. Aligning RBF programmes with local policies can optimise impact.
Shen et al. (2017) [89]	Zambia	Healthcare services; PBF	Health	Job satisfaction, motivation and attrition rates	Mixed methods	RBF led to significant increase in job satisfaction amongst health workers, decreasing attrition rates; but effect on job motivation was insignificant	RBF not very effective in improving intrinsic values, e.g., motivation is intrinsic and cannot be induced by financial incentives, consistent with Lohmann et al. (2018).
Turcotte-Tremblay et al. (2017) [90]	Burkina Faso	Maternal healthcare—PBF	Health	Workers' satisfaction, patient confidentiality, patients and family members' fears and apprehensions during community verification	Longitudinal (multiple) case study; Semi-structured interviews, informal discussions and non-participant observation	Unintended consequences associated with community verification—workers' dissatisfaction, breach of patient confidentiality, fears and apprehension amongst patients and family members.	Only focused on short-term effects. RBF should aim to evaluate long-term impacts as well.

Table A1. Cont.

Source	Country of Study	Intervention/ Financing Type	Sector	Approach Measurement Indicators	Methodology	Main Findings/ Conclusion	Key Success Indicators for RBF
Turcotte-Tremblay et al. (2020) [91]	Burkina Faso	Healthcare services; PBF	Health	Unintended consequences: dissatisfaction with health services, quality of health services	Innovation theory and multiple case study; semi-structured interviews and observations	Unintended consequences (e.g., long delays with payments resulting in dissatisfaction and demotivation) outweighed intended impact (i.e., provision of quality primary healthcare services.)	Without accounting for unintended effects, we may be overstating the effectiveness of RBF programmes.
Widijantoro and Windarti (2019) [44]	Indonesia	ICS—RBF	Clean cooking	Quantity of cookstoves sold	Single case study based on empirical data analysis including consumer satisfaction and distribution	M&E key for RBF—challenging to implement and operate; RBF timeline too short; qualitative achievement but continued usage of stoves problematic.	Consumer awareness and training; maintenance; timeline must allow unforeseen events; incentivise continued usage
Zeng et al. (2018) [50]	Zambia	Healthcare services; RBF	Health	Coverage and quality effectiveness of maternal and child health services	Cluster-randomised trial	Increased use and enhanced quality of maternal and child health services. RBF found to be a cost-effective mechanism from the value for money perspective.	Evaluation of RBF needs to be more rigorous (e.g., RCTs) to get the full picture.
Zhang and Adams (2015) [91]	China and Indonesia	ICS; RBF	Clean cooking	Number of stoves delivered, number of stoves used, stove-use training of households, actual usage levels.	Pilot studies	Led to the manufacture of high-quality stoves, and subsequently frequent usage among users. improvement in after-sale service in China	To maximise impact, timely disbursement of incentives, especially for smaller firms is essential. RBF design needs to be as flexible as possible.
Zhang and Knight (2012) [92]	China, Lao PDR, Mongolia, Indonesia	Clean biomass stove; RBF	Clean cooking	Number of stoves delivered, number of stoves used, stove-use training of households, actual usage levels.	Pilot studies	Indoor air quality improved; cost savings derived; increased user satisfaction	Role of both government and the private sector essential. If not well-designed, verification costs and lack of pre-financing for smaller firms may lead to undesirable effects.
Zhang et al. (2018) [42]	Indonesia	Clean biomass stove—RBF	Clean cooking	Stock, actual sale, satisfaction, level of performance after 3 months	Pilot study (case study)	Number of stoves sold increased; better performing stoves were made; customers reported of cost-savings.	Wider community level engagement needs to be considered more.

Table A2. Clean cooking RBF programme evaluation.

Programme	RBF Programme Management	Pre-Defined, Output-Based Targets	Investment Volume	Consumer Focus	Technology	Bidding Mechanism	Financial Incentive	Monitoring and Evaluation	Region/Country	Results Achieved (Y/N)	Major Issues Reported	Positive Impacts
Beyond the Grid Fund Zambia (BGFZ) 2016–2021	Renewable Energy and Energy Efficiency (REEEP)	Output-based; 300,000 connections target; 150 RE MGs	Overall budget of €69 million; clean cooking component €25.25 million	Rural areas; non-electrified customers	SHS; mini-grids; ICS	Reverse auction	Incentives for sales of stoves and installation of SHS	Third-party verification of stove sales and SHS installation, disbursement upon third-party verification of achieved pre-agreed results.	Zambia	Ongoing/partially on-track	Ambitious RBF distribution targets; expansion plan not well-managed	Provided off-grid electricity and/or clean cooking to 150,000 households in Zambia
BRILHO Mozambique 2019–2024	SNV Netherlands Development Organisation	Predefined: in terms of specific target areas + number of units sold; target is to serve 750,000 households	Budget for whole programme is £22.8 million, with the clean cooking budget estimated at around £6 million	Underserved areas: rural poor and peri-urban	ICS, LPG, SHS, mini-grids and electric stoves	Reverse auction	Multi-incentive structure: Base incentive set at £10 per electric stove; £5 per advanced improved cookstove + catalytic grant + bonus incentive for serving remote areas	Third-party verification of stove sales, recruitment of key staff, completion of market assessment reports	Mozambique	On-track despite the original programme start date being delayed by the COVID-19 pandemic	Application process and procedures quite lengthy and somewhat overly bureaucratic	Expanded outreach to more challenging market segment
Clean cooking fund Rwanda 2018–2023	Rwandan Development Bank	Output- (number of stoves sold), outcome- and impact-based (health benefits, gender equality and reduction in black carbon)	\$20 million	Rural areas; low-income customers	Tier 2+-cookstoves	Not decided yet	Multi-tiered incentives	Third-party verification of inventory, sales, adoption, as well as climate, gender and health impacts.	Rwanda	On track	Programme still nascent	Anticipated impacts include reduced ADALYS, improved gender equality, reduction in black carbon and carbon emissions
EEP Africa 2018–2023	Nordic Development Fund (NDF), supported by KPMG	Output-based: (number of units sold and % of units sold to marginalised rural areas)	€20 million	Rural bottom of the pyramid customers	ICS, LPG and Electric stoves	Fixed incentive (up to 50% of price of stove)	Incentives for sales of stoves	Third-party verification of the sale of improved cookstoves, proof of serving the bottom of the pyramid customers and training for buyers on how to use the cookstoves.	Botswana, Burundi, Kenya, Lesotho, Mozambique, Namibia, Rwanda South Africa: Swaziland, Tanzania, Uganda, Zambia	Tba	COVID-19 negatively impacted on sales; supply chain challenges	Increased uptake among bottom of the pyramid customers

Table A2. Cont.

Programme	RBF Programme Management	Pre-Defined, Output-Based Targets	Investment Volume	Consumer Focus	Technology	Bidding Mechanism	Financial Incentive	Monitoring and Evaluation	Region/Country	Results Achieved (Y/N)	Major Issues Reported	Positive Impacts
Endev 2 Kenya 2009–2019	GIZ	Output-based: number of units sold, and % of units sold in underserved rural areas	€3.9 million/€1.5 million	No exclusion or inclusion criteria for consumers served during first phase. Underserved rural areas during the second phase.	SHS; solar lanterns/ Tier2+ cookstoves (intermediate, advanced and non-biomass)	Fixed incentive based on Tier 2 stove/region (€8–10)	Multi-tiered incentives based on the performance tier ratings of the stoves. Periodic modification of incentives to encourage increased uptake in underserved areas	Third-party verification process for the sale of ICS included phone and field visits, plus review of project documents	Kenya	Yes	Issues with quality of stoves; problems and delays in the verification process; limited off-take through financial institutions	Increased uptake in underserved counties; 110,807 units of cookstoves sold under the RBF programme
Global LEAP EPC 01/2020–11/2020	CLASP	Output-based: volume of EPCs sold	\$266,000	No specific target/supplier-driven but mainly grid-connected clients in urban and peri-urban areas	EPC	Reverse auction	Multi-tiered incentives	Third-party verification involving random sample of phone calls to check if the purchases of EPCs were made	Kenya	No	Call for proposal and implementation period too short; supply-chain problems due to COVID-19	Serving underserved areas; RBF had funded cf. 500 sales and 3400 as inventory
Indonesia Clean Stove Initiative 2012–2016	Indonesia Ministry of Energy and Mineral Resources and World Bank	Predefined in terms of target areas to serve plus output-based (sale and usage)	\$490,000	First pilot focused on urban areas; second round focused on rural poor customers	ICS	Fixed incentive—up to 50% of stove cost (~US\$20 max)	Multi-tiered incentives for sales and usage of stoves	Third-party monitoring/verification of pre-agreed results (70% following verified sale/30% after verification of actual usage of the stove after 3 months). M&V involved phone calls and field visits	Indonesia	Partially (~80%). Target was 10,000 stoves	Relatively longer time to implement the pilot. High cost of monitoring and evaluation. Issues with missing data, cultural sensitivities affecting the M&V process	Technical assistance to participating entities; greater capacity building of stove suppliers leading to high quality stoves; 7900 stoves sold
KOSAP 2 2020–2023	SNV Netherlands Development Organisation/SunFunder Inc.	Output-based (sales target of 150,000 clean stoves)	\$5 million	No specific target so far as consumers were resident in a particular county.	ICS and Liquified Petroleum Gas (LPG).	Fixed incentive—37% of product selling price	Incentives for sales of stoves	Third-party verification of number of units sold. Process involves a combination of desktop work, phone calls and field visits	Kenya	Tba	Programme still nascent; calls for proposals just ended February 2021	Programme still nascent



Table A2. Cont.

Programme	RBF Programme Management	Pre-Defined, Output-Based Targets	Investment Volume	Consumer Focus	Technology	Bidding Mechanism	Financial Incentive	Monitoring and Evaluation	Region/Country	Results Achieved (Y/N)	Major Issues Reported	Positive Impacts
The REACT Kenya Results-Based Financing program (REACT RBF) 2021–2024	AECF	Output-based (verified sales) plus predefined in terms of serving poor households (25% or greater of verified sales should be towards poor households)	\$4 million	Rural poor; off-grid households	Tier 2+ cookstoves	Fixed incentive—up to 50% of stove price	Incentives for sales of stoves	Third-party verification of the sale of improved cookstoves, performance and quality of the stoves, as well as the provision of after-sales support service.	Kenya	Tba	Programme still nascent	Programme still nascent
Universal Energy Facility 2020–2023	Sustainable Energy for All (SEforALL)	Output-based (number of ICS and SHS units sold)	Aspires to be a \$500 million facility by 2023 (\$100 million by 2021)	No specific target consumers	Mini-grids (first wave), SHS and other clean cooking solutions (second wave)	Tba	Multi-tiered incentives for SHS and incentives for sale of ICS	Third-party verification of proof of the delivery and deployment of mini-grids, SHS and other clean cooking solutions.	Sierra Leone, Madagascar, Benin (more to follow)	Tba	Programme still nascent	Programme still nascent

**Table A3.** Baseline calculation of carbon emissions through biomass cooking in sub-Saharan Africa and mitigation potential through e-cooking promotion in the on-grid sector.

#1	1,107,000,000	Total SSA population 2021
#2	526,932,000	46% estimated energy access *
#3	79,039,800	Estimated 15% of population who currently use electric-cooking **
#4	74,648,700	Households without e-cooking but with energy access (average household size 6) **
#5	87,822,000	Overall number of households with electricity access *
<b>Baseline: Average cooking emissions in t/CO<sub>2</sub> per year ****</b>		
	Firewood	Charcoal
#6	3.42	5.4
#7	4.4	7.4
#8	3.9	7.5
#9	3.91	6.77
#10	5.34	t/CO <sub>2</sub> total average value for firewood and charcoal
#11	398,375,229	Total CO <sub>2</sub> emissions in t per year for electrified # of households that don't use e-cooking (= #10 × #4)—Estimation

\* World Bank Data. \*\* MECS estimation/[93]. \*\*\*\* <https://www.cleancookingalliance.org/assets-facit/Comparative-Analysis-for-Fuels-FullReport.pdf> (accessed on 1 March 2021).

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