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Research article

The case for a clean cooking green bank

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Abstract: The socio-economic and climate benefits of a transition to clean fuels and technology for cooking are gaining prominence on the global policy agenda. However, investment volumes fall critically short of those required to achieve Sustainable Development Goal 7's universal clean cooking access target, while available forms of finance often do not match demand. We investigated the value in creating a specialised public bank, modelled on green state investment banks, to address the clean cooking investment challenge. In so doing, we introduced the green bank concept to the academic literature on clean cooking and provided original data and analysis. Expert interviews revealed a desire for public banks to assume greater risk in their financing activities in clean cooking markets, and to adopt a broader array of financial instruments and structures. Interviewees also recommended that public banks act as pathfinders and first movers in these markets, play a more prominent role in market building, and educate and organise the aggregate funding group. These attributes displayed notable similarities with the roles historically undertaken by green banks. Our findings suggested that a dedicated public bank for clean cooking, modelled on green banks, would be additional to the sector and potentially play a catalytic role in leveraging private investment.

Keywords: green banks; climate finance; development finance; energy transition; clean cooking; sustainable development; SDG7

JEL Codes: F33, F35, O13, O19

Abbreviations: CEFC: Clean Energy Finance Corporation; DFI: development finance institution; GIB: green investment bank; SIB: state investment bank; UK GIB: UK Green Investment Bank

1. Introduction

Researchers have critically assessed development finance institutions' (DFI) delivery of climate and development finance to support the transition to clean fuels and technology for cooking (Coldrey et al., 2024). We build on that work by interrogating the institutional design features considered necessary to more effectively deliver such finance. We investigate the suitability of the green bank institutional model for clean cooking by exploring the following research question: What value exists in creating a specialised public bank, modelled on green banks, to address the clean cooking investment gap?

1.1. Evaluating green banks in a clean cooking context

Green banks, also known as green state investment banks (SIB), green investment banks (GIB), national development banks, and government owned banks (Geddes, 2020) are, like DFIs, a type of public bank inasmuch as both are majority owned and controlled by one or more state entities, and serve a mandate issued by a state entity (Steffen et al., 2020). DFIs' mandates are distinguished by their focus on supporting private sector development in developing countries (OECD, 2024), with funding made available to the public and private sectors through the institutions' sovereign and non-sovereign lending operations, respectively (Peitz, 2022), Typically, governments play a limited decision-making role in relation to non-sovereign projects, and have little influence over, for example, which economic sectors or companies will be funded (Molinari & Patrucchi, 2023). DFIs are the principal institutional channels of climate and development finance for clean cooking (Sustainable Energy for All and Climate Policy Initiative, 2021). While some targeted, publicly capitalised funds exist, chiefly the Clean Cooking Fund managed by the World Bank's Energy Sector Management Assistance Program, the Spark+ Africa Fund, and the Modern Cooking Facility for Africa, no DFI or other public bank exclusively funds clean cooking.

In previous research, experts articulated a set of activities that the existing clean cooking funding group, especially DFIs, could undertake to foster and grow clean cooking markets. These activities are summarised as funders demonstrating greater risk tolerance in their financing activities, an increased propensity to offer tailored financial solutions through a streamlined funding approach, deep engagement with local market actors in target countries, and a leadership role in knowledge sharing (Coldrey et al., 2024).

By comparison, green banks have historically undertaken the roles of investment de-risking, capital providers and mobilisers, first movers in transactions, accelerators of the enabling investment environment, education and capacity building, market signalling, and lead arranger of the funding group (Geddes et al., 2018; Whitney and Bodnar, 2018).

In responding to the research question, we show the alignment between experts' views of the attributes that a public bank focused on clean cooking could manifest to most effectively carry out the identified activities and green banks' established roles. We note at the outset that primary data collected for this study were explicitly analysed and interpreted through the lens of green banks. In other words, the author group, comprised of energy poverty researchers, used the recognised roles and characteristics of green banks to evaluate and critique the data.

1.2. Access to clean fuels and technology for cooking

Since the Sustainable Development Goals (SDG) were promulgated in 2015 (United Nations, 2015), there has existed a consistently large deficit between the uptake of affordable, reliable, sustainable and modern fuels and technology for cooking against SDG7.1's universal access target. More than 2 billion people lacked access in 2022 and, as of 2023, they were distributed across 128 low and middle-income countries (IEA et al., 2024; IEA, 2023). On the current trajectory, 1.7 billion people globally are predicted to remain without access in 2030 (IEA, 2024b). The data show a high correlation between lack of clean cooking access and low socio-economic development. In 2022, of the twenty countries with the largest access deficits by total area (IEA et al., 2024), fourteen were among the twenty lowest ranked countries in the Human Development Index (UNDP, 2024).

Among the combinations of fuels and equipment used to meet household cooking needs, the World Health Organization deems a fuel or technology "clean" if it falls within emission rate targets for fine particulate matter and carbon monoxide. Biogas, liquid petroleum gas, electricity, ethanol, natural gas, and solar fuels produce low levels of harmful pollutants and are considered clean fuels for this purpose, while "improved" cookstoves burn solid or liquid fuel more efficiently than traditional stoves (World Health Organization, 2021; Bhatia and Angelou, 2015).

The negative health, gender, and climate impacts of cooking poverty are costed at USD 2.4 trillion per year (World Health Organization, 2023; ESMAP, 2020), with household air pollution from the use of open fires and inefficient stoves powered by kerosene, charcoal, and other solid fuels giving rise to an estimated 3.2 million avoidable deaths annually (Puzzolo et al., 2024). Many studies highlight the fact that women and girls bear a disproportionately negative burden of lack of clean cooking access (Ngum and Kim, 2023; Ramachandran, 2022; Njenga et al., 2021; ESMAP, 2020; Sciences Po and ESMAP, 2020; ENERGIA et al., 2018). Conversely, expanding the use of clean cooking solutions gives rise to co-benefits that span multiple SDGs (60 Decibels, 2024; Mperejekumana et al., 2024; Osiolo et al., 2023; Gill-Wiehl and Kammen, 2022).

An April 2024 G7 commitment (G7 Climate, Energy and Environment Ministers, 2024) to promote clean cooking technologies, the IEA-sponsored May 2024 Clean Cooking Declaration (IEA, 2024a) and the SDG7 data custodians' calls to elevate clean cooking to "the top of the sustainable development agenda" (IEA et al., 2023) all reflect increased prioritisation of the issue in influential policy circles. However, this ambition is curtailed by an enormous, chronic funding shortfall for clean cooking companies and projects, with a notable unmet need for concessional and higher-risk funding from public sources, and limited engagement from local financiers.

1.3. Funding gap

Less than twenty percent of clean cooking policy roadmaps in countries with large access deficits are backed by clear financing schemes (IEA, 2023), and empirical literature that examines the link between clean cooking access and foreign direct investment has been described as "barely existent" (Kwakwa et al., 2021).

Based on current policies, the World Bank Energy Sector Management Assistance Program forecasts that USD 148–156 billion per annum to 2030 is required for universal access to modern cooking services that rely on cleaner fuels (ESMAP, 2020). In contrast, the IEA tracked USD 2.5 billion in clean cooking investment globally in 2023 (IEA, 2023) and the Clean Cooking Alliance identified

USD 215 million invested in enterprises in 2022 (Clean Cooking Alliance, 2023). Sustainable Energy for All and Climate Policy Initiative found that finance commitments for clean cooking averaged approximately USD 130 million per annum in aggregate between 2015 and 2019, in twenty low and middle-income countries in sub-Saharan Africa and Asia that are home to more than eighty percent of the global population without access ("High Impact Countries (HIC)") (Sustainable Energy for All and Climate Policy Initiative, 2021).

Low volumes of private, domestic investment were recorded in HICs between 2013–2019, while public spending from national sources is chronically underrepresented in sectoral analysis (Sustainable Energy for All and Climate Policy Initiative, 2021). The latter is partly due to difficulties in data collection and challenges with double counting (Sustainable Energy for All and Climate Policy Initiative, 2021) but is more fundamentally a function of lack of domestic financial resources, constrained national public budgets and substantial fiscal deficits in developing countries with large clean cooking access deficits (Bernard Meka'a et al., 2024; Sennoga and Balma 2022; Singh and Ru, 2022). Such limited volumes of domestic finance available for clean cooking have led to calls for targeted policy initiatives to encourage local capital market participation (IEA, 2023).

1.4. Green banks

Green banks are "mission-driven institutions that use innovative financing to accelerate the transition to clean energy and fight climate change" (Coalition for Green Capital, 2024). They are typically publicly owned, commercially operated entities designed to use limited government funds to stimulate capital markets and crowd in private investment to expedite the transition (Hundt, 2019; Schub, 2015). Green banks take different forms with respect to their underlying policy frameworks, mandates, funding sources, ownership and governance structures, scope of activities, and toolkit of financial instruments (Brown, 2021; Mazzucato and Penna, 2016; Schub, 2015). However, all are motivated by the public purpose to accelerate low-carbon-, climate-resilient and sustainable development (Whitney et al., 2020). When used to instigate renewable energy investments, green banks participate in financial markets and act as instruments of energy policy (Waidelich and Steffen, 2024).

Green banks are distinguished from the practice of green banking, where a bank's financing activities are responsible, sustainable and consistent with environmentally sound outcomes. Green banking in this broader sense applies to the financial sector as a whole and has informed a growing academic literature (Khan et al., 2024; Debrah et al., 2023; Aslam and Jawaid, 2023; Rahman et al., 2022; Ozili, 2022; Akomea-Frimpong et al., 2021).

SIBs, of which green banks form a subset, are not new institutions but their roles have expanded since the 1990s to include a wider range of financial interventions, including investing to address complex, structural issues such as climate change (Mazzucato and Penna, 2016). Indeed, nearly all green banks were founded in the 2010s, with the catalyst for most being government directives to increase flows of climate finance (Whitney et al., 2020). Driven by their policy mandates and by acting in accordance with their missions, SIBs can act as patient investors in markets and take greater risks with no or lower expected returns relative to other types of investors (Rainero and Modarelli, 2019). As such, they have proven an important policy tool to make novel technologies investible (Egli et al., 2022) and, when used as an instrument of innovation and industrial policy, can have economy-wide benefits (D'Orazio and Valente, 2019).

As of 2020, there were nearly thirty green banks globally, some at the national level and many at the subnational level (Whitney et al., 2020). Most were in high income countries, three in upper-middle income, one in a lower-middle income, and none in low-income countries. Most are standalone entities, but some are constituted as specialised financing facilities within existing financial institutions. Being creatures of government policy, albeit commercially operated, green banks seek to achieve the policy objectives of the country or state in which they are established. Accordingly, they typically do not finance projects across national borders (Whitney & Bodnar, 2018; Schub, 2015). The concentration of green banks in developed countries reflects the relative novelty of the institutional model, long time frames to establishment and capitalisation, and typically more mature legal and financial systems in high income countries (Whitney et al., 2020). Longstanding green banks include the United Kingdom Green Investment Bank (UK GIB), now owned by Macquarie Corporation and known as the Green Investment Group (National Audit Office, 2017), Australia's Clean Energy Finance Corporation (CEFC) (*Clean Energy Finance Corporation Act 2012* (Cth)), both established in 2012, and the New York Green Bank established in 2013 (New York Public Service Commission, 2013). Commentators have noted the strong political commitment that underpinned the creation of the UK GIB (Matthew, 2011) and the tendency towards bipartisanship when policymakers focus more on the economic opportunities that green bank activity generates than their costs (Geddes et al., 2020).

Recent years have seen notable momentum to establish green banks in developing countries, for example, the Mongolia Green Finance Corporation (Green Climate Fund, 2020) and the African Green Banks Initiative, which aims to create an ecosystem of green banks in Africa (African Development Bank Group, 2024). This reflects the replicability of the institutional model to different country contexts and its adaptability to a range of policy objectives (OECD, 2016). More specifically, green banks can help address individual countries' distinct low-carbon transition challenges by providing an alternative to the current climate finance system dominated by large international structures and funds. In so doing, they shift problem-solving, agency and control of climate finance to the national level, and build local capacity (Whitney et al., 2020; Whitney and Bodnar, 2018). They have been described as "the ultimate form of national ownership for financing the energy transition to meet the goals of the Paris Agreement" (Whitney et al., 2020).

In the period of little more than a decade since the first green bank was established, they have contributed notably to accelerating clean energy deployment. For example, as of March 2017, a few months prior to its sale, UK GIB had committed GBP 3.4 billion of its own capital to 100 projects, leveraging GBP 8.6 billion of private capital at a ratio of approximately GBP 2.50 for every GBP 1 invested (National Audit Office, 2017). In the ten years since CEFC commenced operations, it invested AUD 12.7 billion in over three hundred transactions, and in financial year 2022–2023 achieved record private sector leverage of AUD 5.02 for each AUD 1 invested (Clean Energy Finance Corporation, 2023). However, notwithstanding these outcomes and despite an improved theoretical and practical understanding of renewable energy support policies, little attention has been given to the role that green banks have played in advancing the clean energy transition (Waidelich and Steffen, 2024).

This study's contribution is to introduce the green bank concept to the academic literature on clean cooking, provide original data and analysis, and evaluate the potential of the green bank institutional model to accelerate the deployment of clean cooking solutions.

2. Methods

Methods for this study comprise a literature review and primary data collection through expert interviews.

2.1. Literature review

An initial literature search was conducted on 8 July 2024 in the Scopus and Web of Science electronic databases. The search incorporated articles published from 1 January 2010 to date. The search queries, used to identify relevant studies, consisted of terms related to green banks and clean cooking in the article title, abstract, and keywords.

The search strings "clean cook*" AND "green bank*"; (clean OR improved OR modern) cook* AND "green bank"; (clean OR improved OR modern) cook* AND (green OR state) AND "investment bank"; and (fuel* OR tech*) W/2 cook* AND (green OR state) AND "investment bank" yielded no results.

A broader search relating to green banks and SIBs generally, and green finance and investment for clean cooking was then carried out. The search strings (clean OR improved OR modern) cook* AND green AND (fund* or financ* or invest*); "state investment bank"; "green investment bank"; green AND "state investment bank"; and "green bank*" returned 450 results after filtering for subject areas considered to be out of scope, specifically those relating to engineering; physical and biological sciences; computer sciences; mathematics; art and communications; education; and religion. Citations were imported and managed with the EndNote reference management software. A screen was then performed to remove duplicate articles, non-English language publications and those considered inapplicable to the present study. The latter included articles relating exclusively to private sector finance; environmental, social, and governance disclosure regimes; Islamic banking; and green finance in the broad sense of public and private capital for projects that mitigate the effects of climate change and give rise to financial returns and social benefits (Bhattacharyya, 2022). To the resulting 44 articles, eight key, frequently cited studies from academic journals and the grey literature were added. These were missing from the database searches but generated from a review of the reference lists (backward snowballing) and citations (forward snowballing) of relevant, primary review articles (Greenhalgh and Peacock, 2005). A total of 52 articles were included in the final analysis.

2.2. Primary data collection

Primary data collection via in-depth, semi-structured interviews supplements the literature review. This method was selected in view of the research question; the dearth of academic literature addressing the nexus of clean cooking and green banks; and the small number of practitioners familiar with the intersection of clean cooking, climate and development finance, and green banks. Semi-structured interviews permitted the research themes to be explored systematically, notably using open-ended questions aligned with the research objective that gave an experienced interviewee group the opportunity to share their insights and experiences (Booth et al., 2016).

Twenty-three interviews were conducted between August 2023 and September 2023. To the best of our knowledge, the interview process is the first to date to inform an academic study investigating the nexus of green banks and clean cooking, and the interviewee sample the largest yet assembled to inform academic research on climate and development finance for clean cooking. Participants were

selected based on their institutional affiliation and experience of clean cooking markets, climate and development finance, and/or green banks. Of the interviewee group, three were identified using the snowball method and were therefore nominated by individuals who had already agreed to participate in the research (Johnson, 2014). The referral process that underpins snowball sampling is subject to selection bias since it depends on the researchers' initial cohort of contacts. This creates a risk of distortion in the data collected and therefore ultimately the representativeness and generalisability of the research findings. On the other hand, as a research method, snowball sampling can be beneficial in recruiting individuals from hard-to-reach populations; for example, where there exists a limited pool of potential participants who meet the research criteria, or individuals who may be reticent due to a desire to remain anonymous and who therefore place a premium on trust (Parker et al., 2019). Those characteristics apply to this study in view of clean cooking being a relatively small energy sub-sector with a finite number of funders, the small number of companies that have achieved scale, and few green bank practitioners with exposure to clean cooking.

In addition to entrepreneurs, the interview sample comprised a diverse range of funders: international financial institutions, development agencies, commercial bank and impact investors, and philanthropies. Additional perspectives were sought and obtained from individuals within multilateral organisations active in clean cooking markets and experts in climate finance policy and practice. Interviewees were in fifteen countries, spanning five continents. Nineteen of the total interviewee group were affiliated with organisations that carry on activities mostly or exclusively in low- and middle-income countries. Interviews took place in English via online videoconference, ranging in length from thirty-two to seventy-four minutes, with an average duration of approximately fifty minutes. Data collected through interviews were recorded electronically and transcribed using Zoom and Microsoft Teams, and were then analysed by the lead author to identify common themes.

Table 1 sets out the composition of the interviewee group by type (and number) of organisation.

Table 1. Interviewees by stakeholder group.

Category	Identifier code	Number of participants
Clean cooking company	CC	7
Climate finance	CF	3
Development agency	DA	3
Impact investor/private fund/foundation	PF	6
Multilateral organisation/international financial institution	MO	4

All interviewees gave their informed, written consent to participate in the study. The study was conducted according to the ethical review guidelines and processes of The University of Queensland and complies with the National Statement on Ethical Conduct in Human Research (Australia) (2007, current revision).

We note the research methodology's limitations: while generating detailed insights about a given topic, relying on semi-structured, in-depth interviews with a finite interviewee group as the principal method of primary data collection creates a risk of subjectivity and bias in the data collected, and, therefore, research findings and recommendations that are not readily generalisable (Queirós et al., 2017). Data collection and analysis were conducted by the lead author, which also carries a risk of excessive subjectivity and bias in the reporting of results. The authors attempted to mitigate these risks by each being involved in designing the study's methodology and by co-authors undertaking a review

of the key themes arising through the interview process, as identified by the lead author. Moreover, the interviewee recruitment strategy sought to capture a sample of expert interviewees with diverse subject matter expertise and institutional affiliations, representing favorable geographical and gender balance.

3. Results and discussion

Interviewees were asked to describe their experiences with green banks and their funding models, and then to nominate the most important roles that a public bank dedicated to the clean cooking transition could play.

Of the twenty-three respondents, ten confirmed that they were either aware of the green bank institutional model or had substantive dealings with green banks. Most notably, those respondents whose work is exclusively or principally focused on clean cooking were least likely to be familiar with green banks. Of seven clean cooking company respondents and three development agency respondents, none had substantial transactional experience with them. Two of four respondents from the multilateral organisation group reported some familiarity with green banks while three of six interviewees from the private finance group had either co-financed or worked directly with them. In contrast, each of the three interviewees from the climate finance group demonstrated a strong understanding of the green bank institutional model and had undertaken substantial work in or with them. Underscoring the results of the literature search, it can be inferred that to date there has been little crossover between clean cooking and green banks.

Responses to the substantive interview questions capture interviewees' views of the ideal features of a dedicated, public bank for clean cooking and are reported through a green bank lens. Those respondents more familiar with green banks made observations of how these institutions operate in practice and the attributes that have contributed to their success.

3.1. Risk mitigation

Investments in support of the structural change inherent in the energy transition entail high risk and require patient capital (Clo et al., 2022; D'Orazio and Valente, 2019; Schub, 2015). In developing countries, the actual and perceived risks involved in clean energy investment remain more significant than in developed markets. They include macroeconomic instability, governance and policy risk, the absence of deep and established credit markets, information asymmetries between investors and other market participants, and a relative lack of long-term data as a basis for risk assessment (Waidelich and Steffen, 2024; Singh and Ru, 2022; Whitney et al., 2020; Steffen et al., 2020; Kalirajan and Chen, 2018; Polzin et al., 2017). This creates a "climate investment trap" where investors apply higher risk premiums to any capital they might make available, increasing the cost of the energy transition in developing countries relative to countries with lower perceived risk and leading to foregone investment (Ameli et al., 2021). In this context, while public finance cannot ensure the world's emissions reduction targets and, by extension, the SDGs, are met (Donastorg, 2017), it can make targeted investments to reduce investor risk perceptions and thereby catalyse private sector finance. This comes with the caveat that an outsized focus on de-risking, to create financing terms that benefit large institutional investors and asset managers in developed countries, may reduce scope for alternative socio-economic development strategies. On this view, developing country governments experience reduced agency in policy formulation due to an expectation that they will prioritise the allocation of resources to create conditions agreeable to private investors (Gabor, 2021).

Against this background, risk mitigation can be understood as policy to redirect capital towards low-carbon investment by lowering financing costs in two principal ways. First, through financial de-risking by transferring the financial impact of a negative event to a different party. Second, through policy de-risking by reducing the likelihood of a negative event through removing barriers in the investment environment (Schmidt, 2014). In respect of the latter and reflecting that investment decisions are informed by a combination of risk, return and policy, the policymaking challenge is to influence private investors' strategic choices and change their behaviour to better align with the green transition (Steffen, 2021; Wüstenhagen and Menichetti, 2012).

To effectively mitigate risk, public banks must have an intimate knowledge of the markets they operate in and an acute awareness of the financing risks and barriers in those markets.

If you're getting involved in a market early, you need to be going in identifying the risks, mitigating the risks and then bringing the private sector with you. You really have to understand the market in terms of what it's going to take. It might be a venture risk. It might be a financial risk. But you need to know why the market is not moving and then be laser focused on creating financial products that are going to solve that particular problem. [CF3]

In clean cooking markets, interviewees considered that public funding is essential from a policy de-risking perspective. This includes raising the profile of the issue among policymakers and building local institutional capacity to provide technical assistance to improve companies' investment readiness, and to raise consumer awareness of solutions (Coldrey et al., 2024). As one interviewee from a multilateral organisation explained, this is especially relevant in light of limited public sector financial capacity in target countries.

The experience that we've had is that the countries with the largest clean cooking deficits are the ones where the public finances are in the most woeful shape. The fiscal space is not sufficient to do many of the things that they like to do across the economy. And when they look at their priorities like schools, housing, defence, health care – cooking tends to be the invisible one. [MO3]

In terms of financial de-risking at the transaction level, public banks can assume relatively greater risk by providing capital in the early stages of company growth and project development (where risks are highest) to prove concepts and increase investment pipeline. Further, by financing the demonstration of innovative technology or business models, where the gap between capital intensity and availability of private capital tends to be greatest, public banks provide evidence to otherwise hesitant private investors that investments they may not have considered due to lack of knowledge or risk profile may be commercially viable (Marbuah et al., 2022; Whitney et al., 2020; Schub, 2015). These actions can help achieve a critical mass of investable enterprises and projects and, in due course, economies of scale.

So there's no way that there'll be enough public money available to do all the deals, but certainly public money can be used to kickstart, or to do a lot of demonstration investments. [MO4]

Despite this, interviewees from all groups expressed that public banks are not, in aggregate, taking sufficient risk in their financing activities to sustainably grow clean cooking markets. In view of demand for finance vastly exceeding supply and high underlying perceptions of risk, one entrepreneur mentioned that public banks that provide concessional and higher risk funding potentially have a role in funding "everything, until it is no longer needed to be publicly financed" [CC3]. Another suggested that public banks should be more proactive in understanding private investors' risk perceptions in clean cooking markets, to "be more aggressive about it, open up to the private sector and say 'what do you want from us to be able to come in?'" [CC1].

Interviewees endorsed a more expansive public bank approach to risk assumption in clean cooking markets that reflects and prices in the social and climate impacts of their funding activities as well as recognises their role in crowding in private investment: "you've got to look at public money as a catalyst rather than as the solution" [CC7]. In this context, one respondent from the climate finance group added that commercial financiers might shy away from markets that are awash with public funding, which can serve to heighten their risk perceptions [CF1].

When you think about the state of the market, the nascency, there's a lot of risk associated with all of these deals, even if it's a project that's more de-risked than others. An institution that's really fit for purpose is looking at those risks and figuring out how can they participate alongside other actors and fill the gaps that exist. You know, what can they bring that's additional given their size, their backing, the creditworthiness of their balance sheet. [PF1]

Consistent with the literature that describes investment de-risking through a range of financial instruments as a core function of green banks (Geddes et al., 2018), respondents familiar with the institutions emphasised their role as more than capital providers, but risk mitigators [CF1]. They added that green banks' mandates to be financially self-sustaining implies both the efficient use of operating capital and prudent risk management in individual transactions.

In carrying out their de-risking function, green banks build finance sector capacity by co-financing with private investors to help them understand and manage actual or perceived risks. This leads investors to become more attuned to the risks and in turn increases their appetite to fund projects without public funding (Geddes and Schmidt, 2020). As they become more willing to assume what are at the outset relatively novel risks, greater leverage is created and the market gap in commercial finance narrows. One climate finance expert described the process of green banks transferring knowledge to co-financiers through the transaction process:

To build capacity, I think there's nothing better than learning on the job. So the bank or the fund itself is going to lend via the local institutions. And it becomes a blended facility with the credit coming from both the bank and the green bank. The banks always want to do more, and the people inside the banks want to do more. So having the expertise and the capital alongside them as they take the step was really important. [CF3]

3.2. Flexible financing

A recurring theme in the interviews was a call for all financiers active in clean cooking markets, but especially public banks, to more effectively tailor their financial solutions to individual transactions. This demands a bottom-up approach to capital provision that responds to market needs rather than a supply-driven model. "In [market x], everybody was basically running after donor money to initiatives rather than responding to a certain demand in the market. Those are two very different things." [MO4] Respondents felt that in many cases, tailored financing lends itself to a broader range of financial instruments and structures than those public banks currently use, and adapting and making better use of existing tools to meet investees' needs through the value chain (Coldrey et al., 2024).

So I asked [existing grantee]: 'so if we were to organise another [results-based financing (RBF)], what should we take into consideration?' And he said, "we don't want another per unit RBF subsidy agreement. But if you could find a way to provide us with a guarantee, to guarantee certain carbon income, that would be fantastic". [DA3]

When questioned about the financial instruments and structures the sector needs, interviewees frequently mentioned guarantees, especially first loss guarantees under which a guarantor agrees to bear losses incurred up to a set amount or percentage in the event of a borrower's default (World Bank, 2024a), as an instrument that public banks have not widely deployed for clean cooking but that has significant potential to catalyse private finance. This reflects momentum towards the greater use of publicly backed guarantees within the broader climate and development finance ecosystem (The Green Guarantee Company, 2024; GuarantCo, 2024; Gautam et al., 2023).

In aggregate, interviewees also volunteered that public banks operating in clean cooking markets expand their solution set to include more concessional debt; equity and quasi-equity, especially early in companies' growth cycles; well-priced, wholesale funding and lines of credit to local financiers; local currency financing; instruments to help companies manage foreign exchange risk; financial solutions tailored to burgeoning voluntary carbon markets; funding for project feasibility studies; and policy-based lending. Thoughtfully designed, targeted consumer subsidies were also considered a critical component of public banks' financial toolkit. A common response from interviewees was the desirability of public banks structuring financing vehicles to aggregate critical volumes of the small, individual transactions that define clean cooking markets.

An impact investor with substantial experience of transacting with green banks noted the institutions' ability to select from a menu of financial instruments at their disposal [PF5], and this is reflected in the operational evidence. The literature records a broad financial toolkit that green banks have drawn from, which can be applied to address risks in individual transactions at different points along the innovation chain (Geddes et al., 2018). Commonly used financial instruments and structures include grants; equity; concessional, subordinated, mezzanine and market-rate debt; green bonds; guarantees; and insurance. Green banks have also provided technical assistance in the form of training and advice in due diligence processes and standards setting, as well as targeted programs and funds that align with individual institutions' mandates and are fit for local market conditions (Lyons and White, 2023; Geddes, 2020; Steffen et al., 2020; Schub, 2015). Such technical assistance is especially apposite to small and medium-sized enterprises, which can face multiple funding "valleys of death" as they move through the stages of company growth and whose personnel may be less skilled and experienced than those of larger, more established businesses (Global Distributors Collective, 2022; MECS & Energy4Impact, 2022). Notably, green banks have helped overcome a significant barrier to investment in low-carbon assets by creating warehousing and securitisation instruments that bundle small projects to reduce transactions costs and achieve scale (McInerney and Bunn, 2019).

In the clean cooking sector, in addition to offering a broader range of financial solutions, interviewees considered that public banks could carry out their role as capital providers more effectively by taking steps to streamline their funding processes. "There could be benefits around just innovation and speed and adapting to the market versus asking the market to adapt to you" [CC3]. Ideally, this would result in lower transactions costs for companies seeking finance and place greater emphasis on outcomes and impact arising from funded activity.

I talked to [unnamed DFI] who wanted to do small [clean cooking transactions]. And I think they must have spent two years and half a million Euros on legal, to set up a [funding] structure. When you work with a Nigerian company that wants to import two hundred stoves, or they want to introduce clean cooking in a mini grid, or they want to produce improved cookstoves, it's about 'do you have the right woman or man and are they able to pay back the loan?', as often there is no collateral. It's not whether you've done your legals in Europe. That doesn't determine whether you get your money back. [DA3]

For their part, public banks that fund clean cooking are acutely aware of the need to transact quickly and acknowledged that, in many cases, their processes could be improved. One interviewee from a multilateral development bank reflected as follows: "We are not doing. We are talking a lot of things" [MO1]. This is tied to the view expressed by several respondents that in the case of larger DFIs specifically, clean cooking is not an easy fit for existing "funding buckets" or departments within the institutions, or for staff competencies. From an operational point of view, they suggested that DFIs break down silos within their own institutions to align clean cooking-related activities with those of adjacent funding departments, such as those concerned with energy access or gender equality. A development agency funder highlighted the importance of adapting its financing activities to market needs through the company lifecycle:

We have public finance resources, we have aid, we have grants, and we also have guarantee instruments. One way to look at it is as the different types of finance that a sector, and particularly companies, need to scale and grow and establish themselves. [DA2]

Interviewees' calls for more efficient funding processes in clean cooking markets are mirrored in the internal reform processes underway in major climate and development funding institutions. For example, the Green Climate Fund's intention to expedite project review and approval times and refocus operations to prioritise systems-scale programs over individual projects (Green Climate Fund, 2023). Similarly, the World Bank's target to reduce project review and approval times by one-third by mid-2025 (World Bank, 2024b) as part of its plans to achieve greater development impact by increasing external engagement "to enable private sector solutions, mobilize private capital, and strengthen private sector development to achieve impact at scale" (Development Committee, 2023). These reforms take place in the context of current efforts, led by developing countries, to improve the global financial architecture to better support responses to climate change (African Heads of State and Government, 2023; French Presidency, 2023; United Nations, 2023; Government of Barbados, 2022).

A public bank funding approach that focuses more on outcomes than process also lends itself to mutually beneficial relationships with investees and co-financiers, grounded in collaboration and trust, that promote agility and flexibility in investment and portfolio management, and a more regular flow of information. In several interviewees' opinion, this should be underpinned by appropriate incentive structures that guide individuals within public banks, such that they are rewarded less according to the absolute number of transactions they approve or administer and more according to the quality of outcomes achieved.

Each of the investees has a dedicated program manager, and that program manager is in constant communication with them. We try to keep in touch with them all the time, to see what we can do to support. We can change milestones. We want companies to deliver clean cooking. We're not there to exit or terminate the contract at the first opportunity. [MO2]

A relationship-centred approach is exemplified by the green bank practice of creating or enabling financing structures that include commercial funders as co-financiers or delivery channels, which has led to them perceiving green banks not as competitors but as funding partners and knowledge agents (Steffen et al., 2020; Geddes, 2020; Geddes et al., 2018). This perception is enhanced by green bank personnel being drawn from within their commercial banking peer group. A climate finance specialist with knowledge of the UK GIB explained:

Do you know the thing we took great pride in at [UK] GIB? We were all private sector people. There was one government person among the 120 staff, and the pace at which we moved was private sector pace. [CF3]

3.3. Pathfinding

Related to their role as risk mitigators, interviewees for this study spoke to the need for public banks to show initiative in their funding activities and to play a pathfinder role: "public finance needs to move first and needs to take the risk. It needs to pave the way." [CF3] This was considered critical in emerging clean cooking markets.

It's about getting hands dirty and being able to play that role in the very first, early consolidation stage of companies, and the whole ecosystem that supports these companies at country level. [MO4]

In respondents' view, these pathfinding actions go beyond capital provision and risk-taking. Rather, they speak to public banks showing ambition in the markets they operate in, a willingness to assume risk commensurate with their mandates, and a proactive approach to identifying and filling market gaps. It was felt that they should be at the cutting edge of what a market needs, playing a leading role in borderline transactions at the margins of viability and taking "first risk" in these transactions, as well as fostering an ecosystem conducive to private investment. Respondents felt that public banks active in clean cooking markets are not playing those roles to the extent they could be.

The [public] institutions in the market are not well suited structurally or tactically, and also at a very on the ground detailed level, to take risk and be nimble and fill gaps rather than say to the market 'here's what we can do, this is how we work, this is our timeline, and this is our offering.' And then the market wants to meet those demands but can't. And so everyone just kind of sits there. [PF1]

In contrast, and consistent with the view that SIBs' actions extend beyond addressing market failures to shaping and creating markets (Mazzucato and Penna, 2016), an impact investor noted the role that UK GIB and CEFC played in transforming the markets they were mandated to operate in.

One thing I would say is that they are actually pushing the market forward. So as they see new opportunities, as they recognise there's more pieces to the puzzle to decarbonise, they seem to have the ability and flexibility to start to move into those spaces. [PF5]

A climate finance specialist concurred, noting the UK GIB's focus and targeted financial interventions designed to attract private investors.

That was something new to investors. So the government, committing its own resources alongside investors, was a really interesting way to build confidence in the market very, very quickly. [CF3]

By stimulating markets, coordinating the funding group, and sharing knowledge, green banks "stretch and transform" the finance sector (Geddes and Schmidt, 2020), challenging norms and acting as a powerful source of market pull. In clean cooking markets, respondents considered that moving first entails public banks supporting less proven technologies and business models and funding the scale-up of successful strategies, in each case intervening where other financiers are unwilling to. Low transaction volumes and limited investment opportunities in these markets (Coldrey et al., 2023; MECS & Energy4Impact, 2022) also led interviewees to underscore the importance of public banks priming a pipeline of transactions, especially given the high "sweat equity" [CF1] costs of doing so to a level that would attract potential co-investors and improve their returns.

An impact investor suggested that public banks' pathfinding role may encompass activities that are initially loss-making but that nevertheless contribute to market transformation:

Stand up a new financial institution, capitalise it and underwrite its losses. In the places where you prove that there's a viable market that can be served without subsidy, once you start to see competition or start to see other banks clamouring that they want to provide capital, start pricing more

towards market. So a much more problem-centric approach to capital which will absolutely create some losses, but on an absolute basis those losses will not be huge. [PF6]

The corollary to a pathfinder role, and a point emphasised by interviewees from multiple groups, is that public banks should step back once their intervention has succeeded in transforming a market, through driving down the cost of capital, removing the need for concessionality and placing it on a self-sustaining path. "[Public banks] should be solving problems as quickly as possible and then unleashing the private sector so they can go and solve other problems in other locations." [CF3]. In other words, when commercial finance is appropriately servicing a market, public banks should have "the humility and courage to say, 'we're no longer doing this'" [CC3]. This was considered important in view of constrained public budgets in developing countries that experience cooking poverty.

[DFIs] can go in, they can take risk which they are supposed to take in terms of the development role and then they can scale, and then they can step away once private finance is comfortable that they can participate. The key is that they do step away. [PF5]

There is scant evidence of green banks crowding out private investment in the markets they operate in. On the contrary, experience from Australia, Germany, and the UK suggests that private investors welcomed the institutions' presence in those markets, and, therefore, that green banks are operating in accordance with their market gap mandates (Steffen et al., 2020). It is also open to policymakers to underscore this by requiring green banks to withdraw their support once novel technologies have reached sufficient maturity in any given market (Waidelich and Steffen, 2024). In practice, the UK Department for Business, Energy & Industrial Strategy concluded that the market failures UK GIB had been established to address had largely been addressed, which informed the Department's decision to privatise the institution (National Audit Office, 2017). Other green banks have refocused and redesigned their tools and strategies to target other areas in need. For example, in Australia, the CEFC created an innovation fund and added equity to its financial offering in response to dynamic local market conditions (Geddes, 2020).

3.4. Market makers

"It's a confidence thing." [CC6]

Allied to their pathfinding role, respondents described a more intangible benefit of public banks bringing gravitas to the transactions they are involved and, in so doing, adding credibility to funding consortia. While several interviewees referred to the potential for an expanded clean cooking funding base, high perceived investment risks and private investors' resulting trepidation demand leadership and investment signals from public funders.

There's a lot of funding, you know, a lot of sources of funding that aren't necessarily convinced of the proposition. Of the impact that can be achieved. There's certainly many funders that are convinced that this is something we need to address. But then the question is, if I throw a bunch of money at it, will it actually fix the issue? [PF1]

Respondents believed that many public banks operating in clean cooking markets are too reactive to market developments and participating too late in individual transactions. They considered that these markets are precisely those in which public banks should be proactively finding market gaps and acting to address them by demonstrating the viability of specific technical solutions and business models. Put another way, by indicating to private investors that transactions are investable, public banks increase their confidence and narrow financing gaps.

These reflections are consistent with the observation that respected green banks engender trust among private investors by signalling their willingness to invest in projects early in the transaction cycle, reducing perceived investment risk and attracting co-finance (McInerney and Bunn, 2019; Geddes et al., 2018). An impact investor reflected on their experience of financing with green banks:

I think there's a big role in being able to mobilise private capital and a big role in being able to bring institutional capital as well. I know one [transaction] in the making, where the institution wouldn't be looking at it but for [green bank's] money. And I think that's really important, that with public financing we think about the 'but for' question. Would this happen but for the work of the public institution? I mean, that's the role they should be playing. It's the risk they should be taking. If it can be done in the private financing market, my perspective would be public finance should be moving away and should then go to where the harder problem is. [PF5]

Published research suggests that multilateral DFI participation in a public private partnership for renewable energy infrastructure, through funding, technical assistance, and policy support to host countries to create an attractive investment environment, increases the likelihood of a successful project and of private investors' willingness to engage (Fleta-Asín and Muñoz, 2021). Similarly, two interviewees for this study cited the Infrastructure Development Company Ltd as a public bank that was pivotal in making a market for solar home systems in Bangladesh through a combination of providing wholesale funding at favourable rates, financially supporting local technical service companies, refinancing the portfolios of microfinance institutions that lent money to households, and undertaking sector coordination and knowledge building (Cabraal et al., 2021). An interviewee from the climate finance group expressed an analogous potential role for green banks in clean cooking markets, describing two aspects of the legitimacy they could bring to them.

I think they're a huge risk mitigation for new sectors like cookstoves, if you can get them involved, because all of a sudden all these other potential funders, whether they're philanthropies or DFIs, they're taking the risk of not understanding the market. And if something goes wrong, you have somebody else who has skin in the game. The other piece of risk mitigation I think green banks can bring in developing countries for emerging sectors is credibility. Because in cookstoves you're relying so much on concessional money, philanthropic money, grant money. These are groups that are very wary of things blowing up in their face from a reputational standpoint. [CF1]

3.5. Fostering the ecosystem

A key theme arising in interviews was public banks' critical role in nurturing the growth of emerging clean cooking markets and of educating market participants. In this regard, respondents emphasised a role for public banks in addressing information asymmetries, collecting and sharing data, and sponsoring efforts to monitor and evaluate projects (Coldrey et al, 2024). They also referred to the fragmented nature of clean cooking markets and saw a need for public banks not only to act as financial arrangers in individual transactions, but also of the aggregate funding group. According to this view, they should be a central organising point, drawing on local expertise, knowledge and networks, on the proviso that they are aware of how they relate to others within the broader financing ecosystem.

One of the real institutional challenges at the moment in most fields is the integration question. So in addition to solving something specific, which may be the delivery of finance in a particular area, the critical factor is going to be how the institution and others around it dock in. [CF2]

An impact investor concurred, noting:

There's a real risk of duplication of effort and how you facilitate cross learning between various initiatives not only at the ground level, of the operating businesses themselves, but also at the financing level and between the various financiers. Having the same overarching financing objective is important, because the challenge is that everyone has a tendency to believe that their way is the best way and sometimes the common objective is forgotten in that. So that's really important, to keep the overarching objective in sight. I know that sounds obvious but it's so often forgotten as people start to jostle, to work out where they fit, within the jigsaw puzzle of solutions. But understanding what others are doing and not recreating the wheel is just so important, because resources are constrained. And to make sure we're using those resources efficiently is important, as is taking lessons, being willing to call out failure, and learning from that. [PF5]

To contribute to market building through education and coordination, respondents from all groups stressed the importance of public banks having the market standing to do so. This entails appropriate human capacity, with the right skills mix including finance and policy expertise, to build trust with market participants, to be able to credibly influence them, and to champion the sector. With the notable exception of certain highly skilled individuals and teams, respondents considered that the human resources of many DFIs are not yet optimally tailored to clean cooking market needs. "The cross disciplinary competence level that's required to actually solve these problems just ain't there" [CC7].

In contrast, respondents with experience of successful green banks emphasised that one of their most important features is that they are staffed by individuals with specialist skills and commercial experience. As a climate finance specialist noted, this can help address distrust among commercial financiers of government-sponsored funding initiatives.

When you're trying to set up a green bank, the people who most resisted were the local finance community. Usually green banks come out of government initiative, and I think they tend to be allergic to that. So this is why we made a point that we do not pay government scale, no one's a civil servant. We look and feel like a commercial bank. [CF1]

Specialist expertise was felt to lead in turn to financial interventions that resonate with the private sector:

If you're creating a finance facility for clean cooking, you have to staff it with professionals from the private sector who understand the dynamics of the market, who understand the risks and can design a facility which is for the private sector. [CF3]

This has led to green banks being perceived by market participants as trustworthy centres of excellence in the markets they operate in. Published research shows that this is important in establishing the institutions' credibility, with positive flow on effects for investor confidence and market transformation (Lyons and White, 2023; Geddes et al., 2018). As two interviewees explained:

The other thing that's really quite appealing about the green bank model is that you create a centre of expertise, and you do it in a way, if it's government-funded, that is non-competitive. So non-experts can come and find out how they become experts. [CF3]

Green banks are arrangers with the local finance community. The key is you have to be seen as a serious player by those other members of the community. And you have to build those relationships so that you can then pull them into sectors that they're a little bit uncomfortable with, because they know the green bank is here as a partner. And they can take more risk from a concessional standpoint. Over time the hope is, if these things really work commercially, that at some point people are complaining that the green bank is distorting the market or over subsidising. That's great! That's success. When

people are complaining to politicians about the green bank, take that as a badge of pride, and move on. Figure out where you should be going next. [CF1]

Several respondents stressed the importance of public banks, whether constituted as DFIs or otherwise, maintaining their independence from political interference, especially to minimise the risk of bias or preference among donor governments that capitalise them. A failure to maintain such independence can distort the investment decision-making process and markets, undermining trust in the institutions.

If you're creating a new institution, who's funding it? And what are their interests? There are all kinds of political dynamics that make it more or less functional or that influence its mandate. [PF1]

The green bank literature emphasises the institutions' independence as a critical success factor (Lyons and White, 2023; Brown, 2021; McVicar, 2014), and this was underscored by multiple interviewees with green bank experience.

It's vitally important that any institution is independent from government. We were able to do that because we were an independent organisation with an independent board. It's really important that everything is free from political interference. You cannot overstate that. [CF3]

A positive effect of financial institutions operating at arm's length from their government owners is that it puts them in a unique position to furnish data, evidence, and experience to inform the policymaking process. This can in turn engender a positive feedback loop and continuous improvement in translating policy to financial transactions to achieve policy objectives.

We had a really constant feedback loop. Part of it comes from the analysis of the market. Part of it comes from the fact that we had all private sector people who had experience in the market already. We know what's happening elsewhere in the world. We know what good looks like. We know what's not working here. So we're going to be very active in terms of helping you shape that policy. But it's about that trust element as well. And I think there's a role for building the capacity around policy and government. All the different levers that meant the success of the [UK] Green Investment Bank, and policy was one of those big levers and government understanding the right policy to facilitate. [CF3]

Respondents were divided in their opinions about whether the clean cooking sector would benefit from a new, supranational public bank that embodies certain attributes of green banks, or whether it could be better served by a reformed, existing institution that exhibits those attributes. Some interviewees suggested that individual countries may have an inherent mistrust of any new institution that did not work specifically for them. Others expressed that the necessary financing and ecosystem building activities could most effectively be carried out in-country by a local institution with market knowledge and capacity.

I don't think that the likes of the World Bank and the bigger multilaterals are the right entities to run and operate these programs. I actually think that they need to find a good home and a more localised way to find a flow for their funds and then be able to deliver impact. [PF4]

This view, of shifting the historical focus of climate and development finance from multilateral DFIs and climate funds as the traditional channels of such finance, to national level ownership, decision-making, and responsibility, also describes the rationale for green banks (Whitney et al., 2020).

4. Conclusions

Persistently high rates of cooking poverty globally, the associated costs of inaction and chronic funding gaps suggest that a disruptive approach to delivering the finance necessary to increase clean cooking access is required. Public banks can play a catalytic role in clean cooking markets by providing

concessional funding, by assuming risks in their financing activities that private investors are unwilling to and by facilitating market transformation.

Expert interviewees for this study identified important functions that a public bank dedicated to the clean cooking transition could carry out to address investment gaps and accelerate the uptake of solutions in the field. These are summarised as mitigating risk for private investors, efficiently providing fit-for-purpose financial solutions, playing a pathfinding role in markets, moving first in individual transactions, and taking the lead in fostering the ecosystem through educating and coordinating the funding group. Notably, these roles are interlinked and complementary, moving beyond public banks' core functions of capital provision and risk mitigation to encompass the process of building and shaping markets.

Green banks are a relatively new policy instrument that have demonstrated success in blending public and private capital to transform clean energy markets and facilitate the low-carbon transition. Comparing interviewees' views of the ideal features of a dedicated, public bank for clean cooking with historical green bank roles reveals some striking similarities. The correlation suggests, and we recommend to policymakers, that a public bank for clean cooking that embodies green bank characteristics would appear to be a good fit for the types of financial interventions that clean cooking markets require.

In introducing the green bank institutional model to the academic literature on clean cooking, this study contains limitations. First, successful green banks have an opportunity to share learnings with the clean cooking sector and to transfer their knowledge of how to appropriately intervene in, and transform, highly localised, context-dependent markets. Put another way, public banks active in clean cooking markets could learn from the green bank institutional model, and we suggest that research into the key elements of such knowledge transfer could add to theory and practice. Second, this study has left open the thought of whether the clean cooking sector needs a new, supranational institution that displays certain attributes of green banks, or whether it could be best served by a reformed existing institution or by appropriately mandated and resourced local institutions. This, and the related question of how establishing any new institution would affect prevailing financial systems, create opportunities for further enquiry considering current momentum to improve the global financial architecture to better respond to the climate challenge. Last, any new or reformed clean cooking funding institution modelled on green banks would require an investment strategy, informed by a comprehensive map of the financing landscape that accounts for differences in individual markets, identifies market gaps, and sets out how the institution intends to fill them. The strategy would include consideration of the specific financial instruments and structures that could be deployed to address identified market failures. An interesting avenue of further research would be to investigate the core elements of such a strategy.

Author contributions

Conceptualisation, O.C.; methodology, O.C., P.L. and P.A.; investigation, O.C.; writing—original draft preparation, O.C.; writing—review and editing, P.L. and P.A.; supervision, P.L. and P.A.; project administration, O.C.; funding acquisition, O.C. All authors have read and agreed to the published version of the manuscript.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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