

Clean Impact Bond: Mobilizing Finance for Clean Cooking



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About this brief

This IFC brief introduces the Clean Impact Bond (CIB), a results-based financing (RBF) instrument that Cardano Development, IFC, BIX Capital, the Osprey Foundation, and Sistema.bio structured to mobilize finance based on the sales of certified health and gender credits in the modern energy cooking sector for the first time. Along with the context for the CIB, this brief presents evidence that clean cooking can achieve measurable health and gender benefits, and summarizes lessons learned from structuring the CIB. Findings are drawn from IFC's technical assistance, through the process of the CIB structuring, desk research, interviews with market leaders, and analysis of survey data collected from rural households in Kenya. The target audiences of this brief are investors, financial intermediaries, multilateral/development finance institutions, outcome buyers, clean cooking companies, and other market players that have an interest in increasing the availability of clean cooking solutions, supporting inclusive businesses that are serving the base of the economic pyramid, addressing climate change, and advancing gender equality.

^a All of this assessment's procedures and protocols were approved by the Amref Health Africa Ethics and Scientific Review Committee (<https://esrc.amref.org/faq/>) in Kenya, and all participants gave their informed consent prior to the collection of data.

Abbreviations and Acronyms

aDALY	averted disability-adjusted life year
ALRI	acute lower respiratory infection
CIB	Clean Impact Bond
COPD	chronic obstructive pulmonary disease
DFI	development finance institution
DIB	development impact bond
GHG	greenhouse gas
GS	Gold Standard for the Global Goals
HAPIT	Household Air Pollution Intervention Tool
IFC	International Finance Corporation
IHD	ischemic heart disease
LC	lung cancer
LPG	liquefied petroleum gas
LSM	Living Standards Measure
$\mu\text{g}/\text{m}^3$	micrograms per cubic meter
N	sample size
PE	personal exposure
$\text{PM}_{2.5}$	particulate matter smaller than 2.5 microns in diameter
RBF	results based financing
SIB	social impact bond
SD	standard deviation
SDG	Sustainable Development Goal
SME	small and medium enterprise
WHO	World Health Organization

All dollar amounts are US dollars unless otherwise indicated.

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Introduction



Biodigester in a garden

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Introduction

Clean cooking fuel, stoves, and related technology have great potential to improve households' health and livelihoods, empower women, and reduce negative climate and environmental impacts. However, worldwide, more than 2.4 billion people lack access to clean cooking technology. Annually, this costs our society more than \$2.4 trillion globally, driven by adverse impacts on health, climate, and gender equality,¹ and contributes to 3.2 million premature deaths.^{2,3}

Clean cooking solutions⁴ (such as ones that use biogas, ethanol, liquid petroleum gas, or electricity) are proven solutions for addressing these problems in low-income countries; however, they are often too expensive for poor households. For this to change, business models to manufacture, sell, and/or distribute clean cooking solutions must be scalable. Unfortunately, lack of financing is a major barrier to scaling up the production of existing solutions. Research suggests that \$25 billion is needed annually to achieve universal access to clean cooking by 2030 – yet only \$133 million has been committed towards clean cooking investment.⁵

To address the finance gap in producing clean cooking solutions for consumers at the base of the economic pyramid,⁶ Cardano Development, International Finance Corporation (IFC), and partners (BIX Capital, the Osprey Foundation, and Sistema.bio) launched the Clean Impact Bond (CIB) in 2022. This development impact bond (DIB) is designed to mobilize finance from a variety of partners to support scaling up the production of clean cooking solutions, by quantifying and selling health and gender co-benefits to outcome buyers (organizations that commit to purchasing development impacts such as gender equality and health benefits).

The fundamental objectives of the CIB are:

- 1) Provide a results-based finance (RBF) instrument to finance clean cooking solutions that achieve development impacts – improving health and women's empowerment (health and gender co-benefits) – in the households that use these solutions.
- 2) Develop a replicable approach to monetizing health and gender co-benefits, in the same way that carbon credits are available to willing buyers.
- 3) Demonstrate the potential for health and gender outcome markets, which could attract development funders and impact investors that could provide financing to scale up the production of clean cooking solutions that low-income consumers can afford.

This learning brief, which shows **how an innovative RBF instrument can be structured**, illustrates how issuing and selling tradable and verifiable health and gender certificates can generate additional cash flow for the small and medium enterprises (SMEs) that manufacture and distribute clean cooking solutions (the underlying investees of the RBF instrument).

The brief summarizes the findings of a study assessing **the measurable health and gender co-benefits** from using a clean cooking biogas system. This study found that a biogas cooking system can reduce women's risk of illness from cooking-related air pollution, as well as increase time saved that women would spend on cooking-related tasks, which they can then spend on income generation and education.

This brief concludes with a summary of lessons learned from the CIB to inform future RBF projects and generate interest among key stakeholders, such as impact investors, outcome buyers, and the SMEs that manufacture, sell, and distribute clean cooking solutions.

About the Clean Impact Bond (CIB):

The Clean Impact Bond DIB is a partnership among Cardano Development, IFC, BIX Capital, the Osprey Foundation, and Sistema.bio. BIX Capital, as the investor, provided upfront working capital financing in the amount of \$300,000 to Sistema.bio, the cooking enterprise, which used the financing to scale up operations to reach low-income customers. Outcomes of the CIB aimed for an improvement in averted ill health and mortality, and an increase in women's Quality Time⁷ through the use of the biogas digesters, provided by Sistema.bio to rural families across 10 regions of Kenya. The Osprey Foundation, as the outcome buyer, committed up to \$500,000 to pay for health and gender outcomes after they had been independently verified and certified to have been achieved. The outcome payments from the Osprey Foundation will cover delivery costs of the CIB, including measurement, reporting, and verification, and the repayment of BIX Capital's investment. The Clean Impact Bond was officially launched in 2022, when Cardano Development, the impact manager, and the Osprey Foundation signed an outcomes contract, and BIX Capital and Sistema.bio signed a loan agreement. The launch of the Clean Impact Bond was announced in Accra, Ghana, at the Clean Cooking Alliance's Clean Cooking Forum in 2022.

Context



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Context

Despite the increased focus on Sustainable Development Goal 7 (SDG 7 - Affordable and clean energy), 2.4 billion people worldwide lack access to clean cooking. SDG 7 aims to achieve universal access to affordable, reliable, and modern energy services by 2030.

Annually, the lack of access to clean cooking costs more than \$2.4 trillion, driven by adverse impacts on health, climate, and gender equality, and contributes to 3.2 million premature deaths.^{8, 9} The lack of access to clean cooking is greatest in Sub-Saharan Africa, where only 10 percent of the population has access to such clean cooking systems.¹⁰ As a result, traditional cooking practices – using open fires or stoves fueled with wood, charcoal, or kerosene – are a major source of toxic air pollution.

Transitioning to clean energy for cooking, including using biogas, ethanol, liquid petroleum gas, or electricity, provides several benefits. First, the use of clean cooking solutions can substantially reduce the use of non-renewable biomass and the emission of greenhouse gases (GHGs). Second, because clean cookstoves combust fuel at a high temperature, they emit much less lung-damaging fine particulate matter (particulate matter smaller than 2.5 microns in diameter – PM_{2.5}). Third, because these stoves cook food faster, with less fuel, women and girls spend less time cooking and gathering fuel and have more free time available (see Box 1). Thus, not only can clean cookstoves contribute to achieving SDG 7, but they can also provide co-benefits¹¹ for health and gender equality that contribute to achieving SDG 3 (Good health and well-being) and SDG 5 (Gender equality).

Box 1: The Impact of Traditional Cookstoves on Women and Girls

Using a traditional stove is time consuming, due to factors such as inefficient stoves, slow-to-light fuels, and fuel collection and preparation times. In many low- and middle-income settings, women perform the tasks of cooking and fuel collection¹², which is unpaid time they could otherwise be spending on education, income generation, rest, and/or recreation¹³. Around the world, women spend between two and ten times more time on unpaid care work than men.¹⁴ Traditional stoves also have negative health impacts. Because women and girls do most of their household's cooking, they experience the highest exposures to the household air pollution that traditional stoves produce. Studies show that women and children account for more than 60 percent of all premature deaths from household air pollution.¹⁵

Lack of financing hinders progress in scaling up the production of clean cooking solutions

Clean cooking appliances are in high demand in low-income countries, but their price point remains a barrier for low-income customers. This is due to challenges faced by the SMEs that manufacture and distribute these appliances. They cannot afford to scale up and produce their products for a lower price.¹⁶ These manufacturers usually neither earn enough to finance their expansions themselves, nor have access to affordable working capital,¹⁷ because they lack the credit history and collateral that lenders usually require.¹⁸ Of the \$25 billion required annually to achieve universal access for clean cooking by 2030,¹⁹ only \$133 million was committed by bilateral/multilateral development finance institutions (DFIs) and international donors, private capital sources, carbon markets, and multilateral climate funds in 2019.²⁰ An innovative financing solution is required so that the clean cooking sector can access financing to enable expansion.

A development impact bond can mobilize finance for the clean cooking sector

Cardano Development, IFC, and partners launched the Clean Impact Bond (CIB) in 2022. It is a development impact bond (DIB) designed to mobilize finance from a variety of partners to scale up the production of clean cooking solutions, by quantifying and selling the health and gender co-benefits to outcome buyers (see Box 2).²¹ A DIB was chosen as the model for the CIB because it allows partners to focus on the outcomes that clean cooking solutions can generate, rather than paying for the inputs or outputs.²² Also, a DIB offers SMEs the working capital they need upfront.

The CIB is a results-based financing (RBF) instrument, which is an emerging solution that companies have begun using to provide energy and clean cooking access for underserved consumers in developing countries. RBF is a form of financing mechanism, and specific applications can evolve over time. Currently, RBF instruments include social impact bonds (SIBs), development impact bonds (DIBs),²³ results-based climate finance,²⁴ clean cooking funds,²⁵ output-based aid, and social impact incentives.²⁶ RBFs²⁷ provide financial rewards to companies after they achieve agreed-upon and verified results. To test RBF mechanisms, IFC has partnered with stakeholders in both the modern energy cooking and the distributed renewable energy (DRE) sectors (see Box 3).

“When you use wood, the pots get sooty, the chimney gets sooty, and the kitchen becomes full of ash – all of which take a lot of time to clean.” – Biogas-using participant

Box 2: Unlocking Outcome Market Opportunities

In recent years, the types of outcome markets available for the impacts of clean cooking have been evolving. The relevant ones include voluntary carbon markets, potential markets for social impacts, and capital markets where buyers are seeking environmental-, social-, and governance-related returns. Outcome buyers are the critical enablers for RBF instruments, because they will pay for the pre-agreed outcomes that companies commit to achieving. For example, it has been estimated that the volume of voluntary carbon credits will grow to \$50 billion by 2030.²⁸ Carbon buyers, which include corporations, donors, and foundations, are also interested in high-quality carbon projects that achieve social benefits (co-benefits) such as gender equality.^{29,30} However, work on gender outcomes is still at an early stage, because few projects have applied any of the available methodologies for assessing their gender impacts in a way that monetizes them in outcome markets. Since 2010, the market for impact bonds has been steadily growing. By early 2023, more than \$460 million had been invested in 239 SIBs and DIBs in 39 countries.³¹ However, only 17 DIBs were issued in emerging markets. Thus, there is an opportunity to leverage these outcome markets to address the significant financing gap³² for businesses that produce and distribute climate-smart household appliances, including cookstoves, for low-income consumers. As noted, such financing could not only improve households' health (SDG 3), but also advance gender equality (SDG 5).

Box 3: IFC's Experience with RBFs

In 2018, IFC invested in BIX Capital, which provides financing for SMEs that manufacture or distribute clean cookstoves.³³ These SMEs then repay their loans by selling the carbon credits that households generate by using their clean cookstoves. These transactions leverage the existing carbon market infrastructure. The outcome buyers of these carbon credits include governments and international organizations – such as the World Bank's Carbon Initiative for Development (Ci-Dev) – that operate in the compliance market as well as those that operate in the voluntary carbon market. Additionally, IFC is also developing a new verifiable and tradable Distributed Renewable Energy Certificate (D-REC) that will monetize the climate impact benefits from DRE projects, such as small solar home systems and off-grid solar, wind, and small hybrid projects.



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The Clean Impact Bond



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The **CIB** is a financial model that contributes to the wider use of clean cooking technologies through the following three objectives:

- 1) Provide an RBF instrument to finance clean cooking solutions that achieve important development impacts – improving health and women’s empowerment (health and gender co-benefits) – in the households that use these systems.
- 2) Develop a replicable approach to monetizing health and gender co-benefits, in the same way that carbon credits are available to willing buyers.
- 3) Demonstrate the potential for health and gender outcome markets, which could attract the development funders and impact investors that could provide the financing needed to accelerate scaling up the production of clean cooking solutions that low-income consumers can afford.

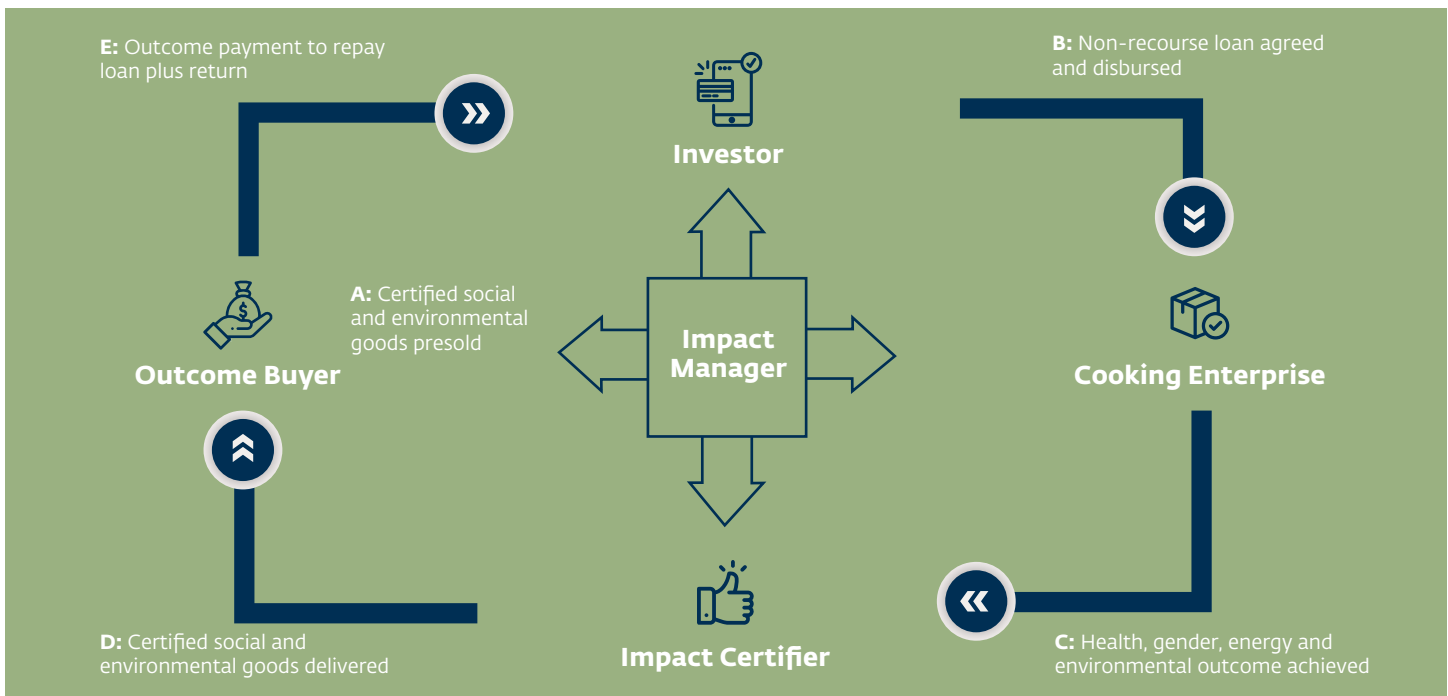
The CIB is the first global initiative to monetize the gender and health co-benefits of clean cooking solutions, alongside the more commonly available carbon credits. The CIB transaction structure has been successfully tested using existing carbon transactions in carbon markets, such as those that fall under the World Bank’s Ci-Dev³⁴ and that provide a solid foundation for replication in health and gender co-benefits. Through the CIB, stakeholders provide financial support to the manufacturers and distributors of clean cooking solutions, by measuring and certifying the outcomes they create.

Structure

The CIB structure comprises five key roles, which are shown in Figure 1. These roles illustrate the five main parties and elements involved in the transaction:

- A) **The impact manager**, which sells at a fixed price the so-called “development impacts” on health using a metric of healthy life saved called aDALYs³⁵ and on gender³⁶ using a metric of Quality Time (see the details in box 4) to an outcome buyer, to be delivered at the future date. Development Impacts are certified by standards such as Gold Standard.
- B) **The investor**, which provides working capital for the cooking enterprise, based on the offtake agreement between the outcome buyer, the cooking enterprise, and the impact manager.
- C) **The cooking enterprise**, which uses the loan to scale up and increase the sale of clean cooking solutions to low-income customers, and monitors the use of these at the customer level.
- D) **The impact certifier**, which certifies the outcomes based on the certification framework that the impact manager and the cooking enterprise jointly develop per the guidance of the Gold Standard.
- E) **The outcome buyer**, which pays for the certified outcome that the cooking enterprise uses to repay its loan.

Figure 1: Clean Impact Bond Structure



Source: Adapted from Cardano Development 2021.

Box 4: aDALYs and Quality Time

- The disability-adjusted life year (DALY) is a metric that combines years of life lost due to premature mortality and years of healthy life lost due to disability/ill health. The averted DALY (aDALY) metric comprises the amount of healthy life saved due to an intervention (including time spent free of illness and avoided premature death).
- Quality Time is the number of minutes per day that a woman spends on income generation, the production of goods that otherwise would be bought, education, rest, and/or leisure.

Partners

Beyond the five main parties, several partners were engaged to develop, launch, and operationalize the CIB. Table 1 outlines the main parties and the partners involved and their functions.

Table 1: Overview of the Main Parties Involved and Their Functions

Role	Name	Function
Impact manager	Cardano Development is an incubator and fund manager for innovative financial sector solutions that accelerate the sustainable development of financial and local capital markets in frontier economies.	Cardano Development initiates the CIB and supplies cash and in-kind funding for its development. Cardano manages the CIB.
Investor	BIX Capital is an \$18 million debt fund for SMEs in Sub-Saharan Africa that supplies low-income people with products that have a high development impact such as clean cooking solutions and water purifiers.	BIX Capital provides loans to Sistema.bio to fund its operations to manufacture and distribute domestic biogas digesters to target customers and refinancing to scale up Sistema.bio operations in Meru and Embu counties in Kenya.
Cooking enterprise	Sistema.bio is a global supplier of biogas products that installs, services, and finances systems for smallholder farmers in Latin America, Asia and Africa.	Sistema.bio borrows working capital and uses the certified health and gender credits as collateral for its loan. Sistema.bio sells the gender and health co-benefits to the outcome buyer (the Osprey Foundation) via the impact manager.
Impact certifier (independent outcome evaluator)	Gold Standard (for the Global Goals) is a non-governmental organization based in Switzerland that has developed a globally accepted set of standards for quantifying and certifying development impacts.	Gold Standard certifies the CIB's health (SDG 3) and gender (SDG 5) impacts, together with the CIB's environmental impact (SDG 13).
Outcome buyer	Osprey Foundation is a philanthropic impact investor based in the United States (US).	The Osprey Foundation purchases the health and gender credits based on the results, against the pre-agreed prices, and pays Cardano Development the pre-agreed purchase price for the respective aDALYs and SDG 5 Impact Statements.
Technical assistance provider and investor	International Finance Corporation (IFC) – a member of the World Bank Group – is the largest global development institution focused on the private sector in emerging markets. IFC works in more than 100 countries, using its capital, expertise, and influence to create markets and opportunities in developing countries.	IFC invests in BIX Capital and advises on the CIB's design, collection, analysis, and reporting of the baseline data, which are used for impact certification.
Impact assessor	Berkeley Air Monitoring Group is a US-based research company with expertise in assessing impacts of cooking energy transition programs in Sub-Saharan Africa and globally.	Berkeley Air Monitoring Group designs the baseline assessment, and gathers and analyzes the initial health and gender data in the project area in Kenya.
Carbon developer	South Pole is a Swiss company that develops and implements carbon reduction projects and strategies worldwide.	South Pole is the project developer and owner of the Gold Standard-certified carbon project with Sistema.bio, and it purchases the carbon credits.
Advisor	Shell Foundation is a United Kingdom-registered charity that supports people living in low-income communities to help them to escape poverty and other hardships.	The Shell Foundation provides strategic advice on the CIB's design and preparations through the foundation's Foreign, Commonwealth & Development Office, and its Transforming Inclusive Energy Markets program.
Advisor	Modern Energy Cooking Services (MECS) is a five-year program funded by UK Aid Direct with a mission to leverage investments in renewable energy by integrating modern energy cooking services into the planning for electricity access, quality, reliability, and sustainability.	MECS provides strategic advice and funding to support the development of the CIB.
Legal advisor	Baker McKenzie is an international law firm that provides advice based on its sector expertise and local market knowledge.	Baker McKenzie reviews all of the CIB's legal contracts (Loan Agreement, SDG Impact Purchase Agreement, Third Party Rights Agreement, and Security Assignment Agreement).



Financial Flows and Terms

Figure 2 gives an overview of the CIB's financial terms and conditions and provides a list of main parties and their roles in the financial flows of the CIB.



Table 2: Overview of the Agreed Financial Terms and Conditions for the Clean Impact Bond

Term	Size	Info	Terms
Outcome payment	Total maximized at \$500,000	The Osprey Foundation purchases the health and gender co-benefits from Cardano Development	<ul style="list-style-type: none"> • Price for health credits: \$1,816/aDALY³⁷ • Price for gender credits: \$1 per added Quality Hour³⁸ • Three-year contract • Disbursed upon reaching the pre-agreed amount of credits
Loan	\$300,000	BIX Capital's loan to Sistema.bio provides working capital	<ul style="list-style-type: none"> • Gender and health benefit revenues are part of the collateral • Three to four years • Market-based interest rate • Disbursement in tranches based on milestones related to distribution and program approval

Co-benefit Certification

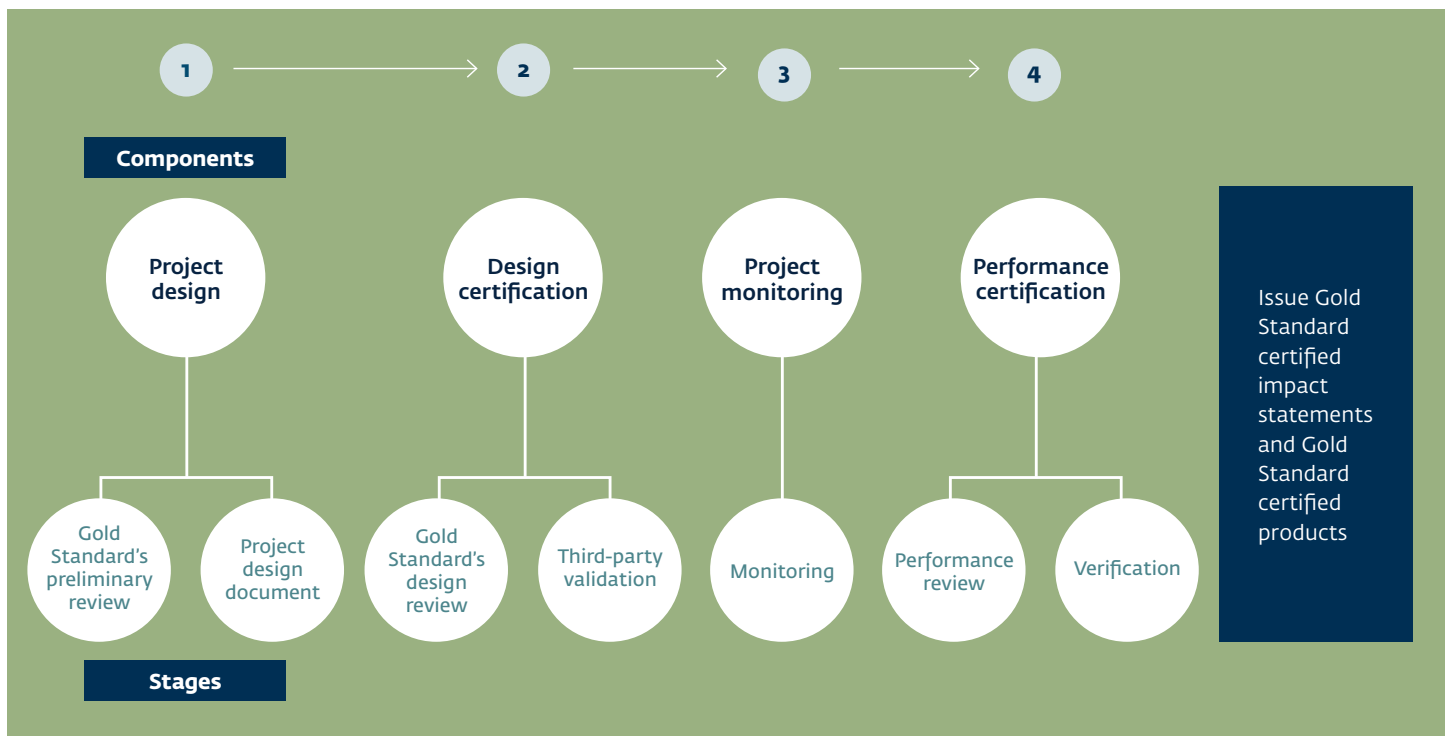
The Clean Impact Bond utilized [Gold Standard \(for the Global Goals\)](#)³⁹ to certify the CIB's health and gender co-benefits. Gold Standard sets standards for climate and development interventions to quantify, certify, and maximize their impact, as well as stringent rules for stakeholder inclusivity. These standards, which create a platform for results-based financing, can be used by project developers and implementers (e.g., cooking enterprises) to assess the quality of their activities, as well as by donors to ensure that they invest in projects that meet their objectives. To make sure that funders are supporting real GHG emissions reductions, and verified SDG impacts, Gold Standard requires local stakeholder

engagement; extensive documentation, including regular field data collection; and the use of independent, third-party auditors. Although originally focused solely on climate impacts through the reduction of carbon emissions (SDG 13), Gold Standard expanded its services in 2017 to provide standards and methodologies for measuring and certifying the impacts of SDGs related to improving health, gender equality, clean water, and renewable energy.

Certification Process

Figure 3 describes the basic process by which health and gender certificates are created for sale and trading (only for aDALYs) using the Gold Standard for the Global Goals.

Figure 3: Process to Be Certified Gold Standard⁴⁰



Source: Adapted from Gold Standard.

Quantifying and Measuring Health and Gender Outcomes



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A key aspect of making the CIB feasible is capturing measurable evidence of biogas users' health and gender outcomes that can be sold to outcome buyers. To obtain Gold Standard's certification of these outcomes for the CIB, an assessment was required to estimate the health and gender outcomes, by comparing the difference between the "business as usual" or baseline scenario (cooking predominantly with wood, charcoal, or kerosene), and the project scenario (cooking with biogas produced by a Sistema.bio digester).

With support from the Government of Japan and the Osprey Foundation, IFC and Cardano Development commissioned the baseline assessment to measure and quantify the health and gender co-benefits from using biogas (see Box 5). The goal was to use Gold Standard's methodologies to translate these co-benefits into clearly certifiable outcomes. (For the methodology of the research, metrics used to measure co-benefits as well as the detailed results of the assessment, see the Appendixes.)

The key outcomes assessed in the baseline assessment were female cooks' health and Quality Time:

- **Health:** Through use of a biogas stove, averted ill health and mortality (associated with reducing cooks' exposure to PM_{2.5}) were estimated.
- **Gender:** Through use of a biogas stove, an increase in the time cooks spent on productive tasks and/or rest and leisure ("Quality Time") was measured.

Key Findings

The assessment confirmed that the health and gender co-benefits of using biogas for cooking are measurable and noticeably positive (see Table 3). It is worth noting that these results fall within the same range as they did in another similar study that was conducted by the World Bank⁴¹ in the same country, with slight differences in specific locations for the same clean cooking intervention.

Health

The personal exposure data gathered in this assessment were appropriate for certifying a positive health outcome. Measured personal exposure to PM_{2.5} decreased to a range that can be associated with important health improvements for the population.



- **Lower PM_{2.5} Exposure:** The personal exposure to PM_{2.5} of female cooks in the project scenario ("**biogas-using households**") was 68% lower than in the baseline scenario ("**biomass-using households**"), averaging **113 µg/m³** in **biomass-using households**, versus **36 µg/m³** in **biogas-using households**.



- **Healthy Life Gains:** The reduction in personal exposure to PM_{2.5} of approximately **77 µg/m³** was estimated to **avert 578 disability-adjusted life years (DALYs) and 16 deaths per year for every 10,000 homes with a biodigester; in other words, for an average household, each year of biodigester**

use would be expected to yield an additional 21 days of healthy life, spread across the lifetimes of the household's members.

Although exposure to PM_{2.5} was lower for the **biogas-using households** than the **biomass-using households**,⁴² the reduced exposure level still exceeds the latest guidelines for global PM_{2.5} air quality established by the World Health Organization,⁴³ suggesting the need to address other sources of air pollution in order to maximize health benefits.

Gender

This assessment is one of the first to define and quantify the gender outcome of a clean cookstove intervention by using shifts in time use toward productive and/or restful activity. If women's saved time is used for more unpaid care work, saving time will not likely lead to improvements in gender equality and women's empowerment. Conversely, a shift from lower-valued to higher-valued activities in terms of income generation may achieve these benefits.⁴⁴

The assessment's quantification of the gender equality outcomes of biogas technology was successful.



- **Time savings: The female cooks in biogas-using households in the project scenario spent less time, on average, on cooking and fuel-related activities than was the case with female cooks in biomass-using households in the baseline scenario, accounting for a total of 99 fewer minutes per day across the assessed activities.**

This amount was more than the estimate in some other studies on cookstove use, but well within the range of time savings observed in other settings associated with biogas adoption.⁴⁵ Saving time has been reported in several studies on improved cookstoves⁴⁶ and Sistema.bio's staff report that customers frequently state that saving time is a key benefit of using biogas. However, saving time does not necessarily improve gender equality and women's empowerment, because the time women save on one chore could then be used for other types of unpaid household work,⁴⁷ with no increase in their Quality Time.



- **Quality Time: When female cooks' Quality Time was assessed, it showed that the biogas-using households in the project scenario spent an average of 47 more minutes of Quality Time per day (285 hours – or approximately 12 days – of Quality Time per year) than the biomass-using households in the baseline scenario.**

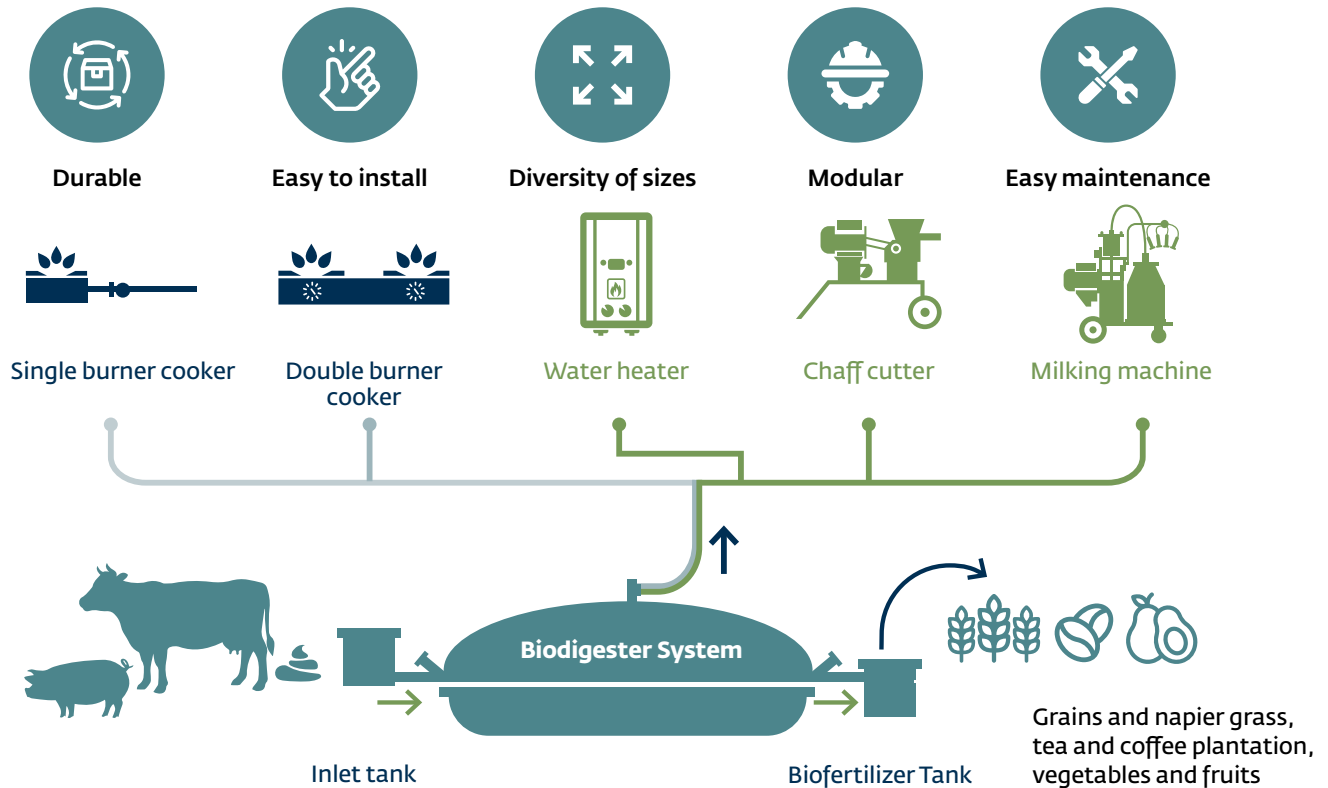
This finding is a novel contribution to the literature on the time-use benefits achieved when women cook with improved cookstoves. The few studies that have attempted to measure increases in women's productive time and/or rest and leisure when women use improved cookstoves have shown both positive and negative results.^{48, 49} However, prior to this study, the "Quality Time" metric was not assessed.

“Since I prepare every meal using the biogas stove, the time spent looking for other fuels like firewood is less.” – Biogas-using participant

Box 5: Biogas Technology

Biogas is a primarily methane-based byproduct when livestock manure breaks down in biodigester systems. To provide households with this clean gas for stoves, water heaters, and other appliances, biogas is transferred from the biodigester via a system of pipes. Biodigesters also produce organic fertilizer that can be used to improve soil for farming.

A technical platform to convert waste to household energy



About 25 percent of the Kenyan population could benefit from the use of biogas technology, yet total market penetration is well below 1 percent of that addressable market.

Sistema.bio's biogas systems ingest climate-damaging animal waste, capture the gas, and deliver the gas to household burners, where it can be used to cook food and heat water in place of traditional climate-damaging biomass fuel. See Box 6 for the impact of biogas on end-customers. Below illustrates the pathways through which biogas interventions produce the co-benefits for health and gender.

Theory of change

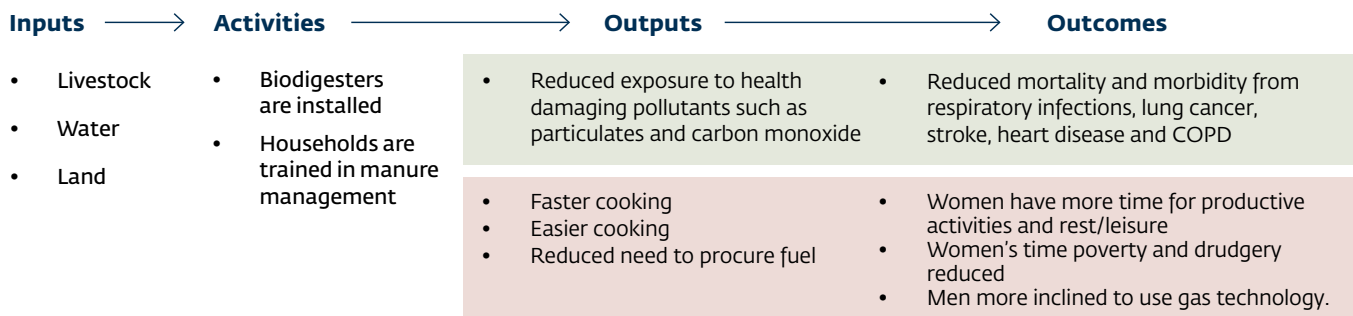






Table 3: Health and Gender Co-benefits of Using Biogas for Cooking

	Outcomes	Achieved per biogas stove, per year	Certified SDG contribution with the Clean Impact Bond	Impact value: dollars generated per stove installation, ⁵⁰ per year (see Table 2)
Health	Averted disability adjusted life years (aDALYs)	 <p>21.2 days (about three weeks) of healthy life added to the household per year of biodigester use⁵¹</p>	 <p>SDG 3 (0.058 aDALYs per household, per year)</p> <p>If the CIB supports the sale of 12,000 stoves,^b this would contribute 696 aDALYs</p>	\$105 per household, per year⁵²
Gender	Increase in women's time used for productive tasks and/or rest/leisure, "Quality Time."	 <p>285 hours (about 12 days) of Quality Time⁵³ added for women and girls in the household</p>	 <p>SDG 5: 285 productive hours of Quality Time freedup for the female cook per household, per year</p> <p>If CIB supports the sale of 12,000 stoves, this would result in the addition of 3,420,000 productive hours</p>	\$285, per household, per year⁵⁴

Note: For the key outcomes and metrics related to health and gender co-benefits, see Table 4 and the Metrics and Standards section in the Appendix.



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^b Projected number of customers added and included in the DIB (for three years).

Both the health and gender equality findings in this assessment met Gold Standard’s requirements,⁵⁵ which confirmed that the quantified outcomes can be sold to an outcome buyer through the CIB. Thus, the quantifiable outcomes for health and gender can be added to the climate benefits that biogas stoves achieve through reducing GHGs. As previously noted, Gold Standard already certifies the GHG emission reductions of

Sistema.bio’s biogas system’s sales in Kenya that contribute to achieving SDG 13 (Climate impact),⁵⁶ as well as impacts related to SDG 7 (Energy access), and SDG 8 (Decent work and economic growth). Also, Sistema.bio has already sold carbon credits to South Pole, the carbon reduction project developer.

Box 6: Impact of Biogas on End-customers

The biogas customers surveyed in this study expressed a high degree of satisfaction with biogas as a cooking fuel. They emphasized the ease and speed of cooking with biogas, and they appreciated feeling less pressure to find and prepare firewood. This is consistent with other studies, which show that biogas is a popular household energy choice in rural areas.⁵⁷ However, biogas technology can present challenges too, which relate to functionality and adoption. To address these potential barriers, Sistema.bio has conducted extensive field monitoring and financed third-party evaluations. For example, 60 Decibels collected data from 278 Sistema.bio customers in Kenya in January and February 2022. This evaluation found that 92 percent of the customers reported saving money with their biogas system, and 88 percent reported improvements in their quality of life. However, some respondents expressed concerns about affordability, the payment plans offered, and how quickly technicians responded to requests for help. Sistema.bio has used this feedback to adjust its payment models, speed up technicians’ response times, and train users to avoid common biosystem problems.⁵⁸

Table 4: Key Metrics for Health and Gender Co-benefits

Co-benefit	Outcomes	Metrics
Health	Averted disability adjusted life years (aDALYs)	<ul style="list-style-type: none"> Personal exposure to PM_{2.5} Population demographics (e.g. household size, number of children under 5, and national background disease rates)
Gender	Increase in women’s time used for productive tasks and/or rest/leisure, which together are termed “Quality Time”	<ul style="list-style-type: none"> Time spent actively cooking Time spent cleaning utensils and the kitchen area Time spent procuring and preparing fuel for use in the stoves Proportion of women’s time engaged in income-generating tasks or rest and leisure Use of any saved time (biogas-using households only)

“Before getting a biogas system, I spent a lot of time searching for wood and dry leaves to burn in the fire. But now I waste no time preparing a cooking fire. Also biogas cooks faster.”

– Biogas-using participant



Sistema.bio's technicians visiting a farm for a biodigester installation. Kericho, Kenya. 2019. Copyright © Sistema.bio.

Lessons Learned

Several lessons were learned from developing and structuring the CIB, and opportunities were identified for improving the design of future RBFs. The key lessons learned were the importance of: establishing effective partnerships to structure the RBF; designing the RBF so that it reaches targeted underserved customers; and effectively assessing, validating, and certifying the gender and health outcomes.



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1. Establish effective partnerships to structure the RBF

i) *Focus on funders and/or donors as outcome buyers that are open to innovation and have a strong interest in supporting projects with social outcomes.*

What we expected: Identifying outcome buyer(s) to purchase health and gender credits would be straightforward, based on emerging evidence and anecdotes that clean cooking solutions benefit health and empower women, beyond their positive impact on the environment.

What actually happened: Because health and gender outcomes from clean cooking solutions had never been transacted before, this initiative proved to be too innovative for many funders/donors. Measuring the indirect health outcomes of clean air required their climate and health departments to internally collaborate. Also, funders/donors usually have long-term programs, so it takes several years for them to add a new program to their budget. Funders/donors with a commitment and openness to innovative approaches to expand health and gender outcomes showed the greatest interest.

Lessons for the future: Focus on emerging outcome buyers such as foundations, corporations, bilateral donors, and multilateral development banks with a strong interest in supporting projects with social outcomes (including health improvement and gender equality), including existing carbon buyers that are seeking high-quality carbon credits that also generate health and gender co-benefits. Now that the potential gender and health benefits of clean cooking solutions have been demonstrated, donors and funders could be persuaded to invest in RBFs that deliver these benefits, rather than just donate money.

ii) *Engage with committed and flexible partners.*

What we expected: This pioneering transaction would require learning by doing, and flexible adjustment during implementation.

What actually happened: As expected, implementing the CIB pilot required a good deal of patience and persistence, a long-term perspective, and sufficient resources from all stakeholders involved. Fortunately, the CIB's partners were strongly committed to launching an innovative financing market that could generate public good. The CIB team was also flexible with regard to the type of outcome buyers, and the types of SDG outcomes to be sold, such as Energy access (SDG 7) and Life on land (SDG 15).

Lessons for the future: Engage with committed and flexible partners and donors when structuring an RBF. It is also key to keep all parties engaged by celebrating small wins, acknowledging partners' commitments in public, encouraging ownership of the tasks led by each organization, and embracing innovation that takes determination for partners involved in an RBF.

iii) *Work with enterprises/project implementers that are at the appropriate stage of business development and meet key criteria.*

What we expected: Identifying the enterprise that could implement the RBF project would be straightforward, as long as it could meet operational and technical criteria including appropriate clean technology and solutions to reach target customers under the RBF.

What actually happened: The investor/project developer approached cookstove producers and/or distributors in a variety of countries; the producers used different clean cooking solutions and were in various stages of business development. Some of the enterprises did not have the capacity to implement the RBF, and others were so mature that they did not need the RBF funding to scale up their operations.

Lessons for the future: Select enterprises/project implementers that are at the appropriate stage of business development and that meet key criteria beyond technology, especially in the following areas:

a. **Business sustainability:** The chosen enterprise should have a strong track record of providing effective, high-quality, and responsive services for its customers, as well as a good financial track record. Enterprises should be operational, have established business goals, and have financing secured to support these goals, so that it is not necessary for the company to depend on the RBF for its initial cash flow. The ideal choices are enterprises that are relatively mature but that still need RBF funding to scale up.⁵⁹

b. **Additionality, scalability, and impact:** The RBF funding should stimulate the type and scale of outcomes envisaged by the project implementer and also leverage private investment. The funding should also increase the breadth and depth of the project implementer's impact, particularly for underserved segments.

iv) *Allow a longer start up period and bring in all project parties early on, so they can budget upstream time and resources.*

What we expected: The CIB team initially expected a one-year preparation phase.

What actually happened: Getting more than eight parties on board, and especially the outcome buyer, took about two and a half years (though the COVID-19 crisis played a big role in the delay) and required a lot of stakeholder management, affecting the allocation of staff, time, and funding resources.

Lessons for the future: Expect the mobilization of outcome buyers for an innovative transaction to take a good amount of time. Allocate adequate time, upfront, to define the roles and responsibilities of each partner, establish an effective framework, align incentives for all stakeholders, and negotiate the project's terms and conditions. Stakeholders need to understand the challenges involved in operating in impoverished, rural areas, and be willing to accept that this could impact the project's timeline and financing.

2. Design the RBF so that it reaches targeted underserved customers

i) *Develop a more sustainable and cost-effective approach while keeping the transaction costs low.*

What we expected: Structuring an RBF using health and gender credits would require a variety of resources and support from different partners.

What actually happened: Because this development impact bond was a pilot, the transaction costs for assessing the health and gender co-benefits were nearly half of the transaction's total costs, exceeding the expectations of what would be required. These were covered by the CIB's various partners, including Cardano Development, IFC, and the Osprey Foundation.

Lessons for the future: Develop a more sustainable and cost-effective approach. When the impact bond scales up, a cost-effectiveness analysis should be conducted to compare the costs of implementing the bond with its expected outcomes. Ways to cut costs include using technology that enables households to measure and monitor their household air quality themselves and developing a module for training local consultants to implement Gold Standard's methodologies. The World Bank recommends reducing transaction costs by combining field work activities (such as data management, logistics and training sessions for enumerators) when the project is pursuing multiple co-benefits.⁶⁰ Although the cost of setting up the RBF is high, as the market develops and the transactions become larger, transactions' assessment costs should decline, and more of the costs could be included in the transaction itself.

ii) *Work with partners to set the right outcome targets and funding level for the health and gender co-benefits.*

What we expected: An important element of the RBF was setting the funding level for outcome targets of the health and gender co-benefits. For health, the aDALY calculation was an outcome quantification tool widely used for primary health care and poverty-related diseases such as malaria, HIV AIDS, and tuberculosis.⁶¹ For gender, setting the outcome targets and funding level required a new calculation for the clean cooking sector. The CIB team expected that this would be the area that required extensive thinking and appropriate expertise.

What actually happened: For health, in order to set an appropriate funding level for the CIB, the team used per capita gross domestic product – a benchmark that changes, annually. For gender, it was generally accepted that “time saving and quality time” is one of the best indicators in this context.⁶² To set fair and reasonable outcome targets and the funding level, the CIB team referred to various studies that explored setting a value on women's time overall, and existing RBFs that used the W+ Standard (the first women-specific standard that measures women's empowerment)⁶³ created by the Women Organizing for Change in Agriculture and Natural Resource Management (WOCAN), and Gold Standard's gender methodology.^{64, 65} The team also obtained advice from gender experts in the World Bank Group and the Clean Cooking Alliance. (See Box 7 for findings from the World Bank's new study on time-use agency to measure women's empowerment and the multidimensional impact of cookstove adoption.)

Lessons for the future: Identify the right partners early on and collaborate with them to set the right outcome targets and funding level for the health and gender co-benefits. The experience we gained through this CIB would be a useful guide for future RBFs.

iii) *Integrate health and gender certification with the existing carbon reduction component from the outset.*

What we expected: Adding health and gender outcomes to the existing carbon transaction might add more complexity for buyers, project developers, and cooking enterprises.

What actually happened: Throughout the transaction, the team found that the added complexity was offset by the advantages that health and gender co-benefits added, including allowing the enterprise to diversify the source of income (e.g., working capital) and mitigate the risks of carbon price volatility.

Lessons for the future: Integrate health and gender certification with the existing carbon reduction component from the outset because health and gender certifications provide added value. Safeguarding the cooking enterprise's ownership of the health and gender outcomes needs to be carried out together with the carbon waiver.⁶⁷

Box 7: Time Use Agency

A new study, “Building Evidence to Unlock Impact Finance: A Field Assessment of Clean Cooking Co-Benefits for Climate, Health, and Gender,” which the World Bank conducted with Sistema.bio in 2022, found that, in addition to time use changes (such as time saving, Quality Time), time-use agency (for example, satisfaction with the time available for rest/leisure) is effective for measuring women's empowerment and the multidimensional impact of cookstove adoption.⁶⁶ Although there were no validated tools to assess the time-use agency, and the results of the World Bank's field survey were not available when the CIB was being developed, the CIB team recommends incorporating this finding into the future project design and the indicators used to measure the gender co-benefit.

3. Effectively assess, validate, and certify the gender and health outcomes

i) *Design indicators that balance the costs and feasibility of data generation and verification, while remaining robust.*

What we expected: The costs and choice of methodologies in gathering and verifying the relevant data would pose challenges.

What actually happened: To ensure accurate and robust results when assessing the health and gender co-benefits of cooking with biogas, the CIB chose Gold Standard's widely recognized methodologies which were also aligned with the requirements of the outcome buyer.

Lessons for the future: Design indicators that balance the costs and feasibility of data generation and verification, while remaining robust in terms of data collection or the quality of indicators. The key outcome metrics should not be complex, because such metrics generally tie repayment to measurable outcomes.

ii) *Balance measurement rigor and the costs of measurement.*

What we expected: Per Gold Standard's methodology, the baseline assessment aimed to enroll lower-income, biomass-using households that are representative of the CIB's future target beneficiaries, which would gain access to biogas technology thanks to additional financial incentives provided by the CIB.

What actually happened: This goal necessitated stringent inclusion criteria, such as low liquefied petroleum gas (LPG) use, which led to more screen-outs and thus a longer-than-expected recruitment phase to onboard both biogas-using households and biomass-using households.⁶⁸

Lessons for the future: For future studies, balance the value of maximizing the representativeness of the baseline study's participants with the extra cost of recruiting them.

iii) *Clearly define the targeted underserved population and their selection criteria at the outset.*

What we expected: The CIB team expected that defining the list of customers and the control group for the baseline data collection would be straightforward and executed in a short period of time.

What actually happened: This assessment reached its findings only after considerable discussion about the characteristics that would be the most suitable to match the low-income households that will be targeted in future results-based financing efforts.

Lessons for the future: Prior to launching an assessment for impact quantification, clearly identify the target population's definition and inclusion criteria—their socioeconomic characteristics as measured by the Living Standards Measure, LPG/stove/fuel use, income level, and ownership of assets.

“Since I installed the biogas, cooking has been so easy, and faster, creating time for other work.” – Biogas-using participant



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Conclusion

With less than a decade remaining to achieve the 2030 Sustainable Development Goals, financing solutions that help achieve universal access to clean cooking – as well as gender equality and health improvements – must be accelerated.

In recent years, the types of outcome markets for the impacts of clean cooking have been growing. These outcome markets include voluntary carbon markets; potential markets for social impact; and capital markets where buyers are seeking environmental, social, and governance-related returns. The Clean Impact Bond's model presents possible avenues for leveraging these markets. The outcome markets represent additional sources of capital that the private sector can use to facilitate access to clean cooking solutions for the underserved, particularly women at the base of the pyramid (BOP).

In conclusion, the authors of this brief hope that it will spur future results-based financing projects; generate interest among outcome buyers, SMEs, and impact investors; and encourage stakeholders across the world's markets to go beyond "business as usual" and be spurred to unlock financing opportunities for those reaching the world's underserved.

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Appendixes



Carrying firewood

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A. Methodology of Baseline Assessment

Assessment Design

The assessment design was cross-sectional and carried out with two groups of participants to compare the project scenario with the baseline scenario. The households assessed in this study were in Meru, Embu, and Tharaka Nithi counties (see Map 1) in rural Kenya, where

Sistema.bio has approximately 700 biodigester customers. This is a productive region where farmers grow cash crops that include tea, miraa/khat, and bananas. They also grow vegetables and raise livestock.⁶⁹

Map 1: Map of the Assessment Area



Sampling Strategy

The biogas-using households (“**biogas-using households**”) in the project scenario were randomly selected from the sales lists of Sistema.bio, and the biomass control households (“**biomass-using households**”) in the baseline scenario were randomly selected from a list of households that

share key demographic characteristics with the CIB’s target population for future biogas system sales. Table 5 lists the eligibility criteria for both the **biogas-using** and **biomass-using households**. The photograph below shows the stove types commonly used by the **biomass-using households**, as well as Sistema.bio’s biogas stove.



From left to right: Three-stove fire, an LPG stove, a Kenyan jiko stove that burns charcoal and a Sistema.bio biogas stove.
Source: Eco Consultancy & Research Ltd.

A total of 126 **biogas-using households** in the project scenario and 115 **biomass-using households** in the baseline scenario participated in this assessment. This met Gold Standard’s minimum for sample sizes—100 households for the survey, and 30 for monitoring personal exposure to fine particulate matter (PM_{2.5}).

households in the project scenario rank as “lower middle class” in Kenya. The **biomass-using households’** average **LSM of 153 puts them in Group 7** of the 12 LSM groups ranked in Kenya, whereas the **biogas-using households’** average **LSM of 224 places them two levels higher, in Group 9**. Both groups’ demographics were well matched on age, household size, children under age 5, and marital status. However, on average, along with a lower score on the LSM, the **biomass-using households** in the baseline scenario had less education, fewer jobs outside the home, and a lower income from casual labor/salaried work.

Socioeconomic Characteristics of Participants

According to the Living Standards Measure (LSM),⁷⁰ both the **biomass-using households** in the baseline scenario and the **biogas-using**

Table 5: Eligibility Criteria for Participating Households

Biogas-using Households	Biomass Control/Biomass-using Households
<ul style="list-style-type: none"> • Sistema.bio biogas system installed at least 6 months prior (earlier than March 2021) • Not delinquent on payments for the biogas system (to avoid a high refusal rate in this group) • No household members are employed by Sistema.bio • Household does not use its stove primarily for commercial cooking • Household has no plans to relocate during the data gathering time frame • Participant is female and the main cook for the household, age > 18 • Participant does not smoke (if selected for personal exposure - PE) • Not cooking for an atypical event/large gathering during PE 	<ul style="list-style-type: none"> • Household has interest in installing a biogas digester, and access to sufficient land and water to support it • Household has sufficient livestock to feed a biogas digester (minimum 2 cows, 16 pigs, or a combination of livestock, or the intent to expand their livestock sufficiently) • No household members are employed by Sistema.bio • Household does not use its stove primarily for commercial cooking • Household has no plans to relocate within the data collection window • Participant is female and the main cook for the household, age > 18 • Participant does not smoke (If selected for PE) • Not cooking for an atypical event/large gathering during PE • Household does not use LPG or household uses LPG less than seven times per week • Participant age and household size within the range of biogas customers

Note, In Phase II, participants also did not have chimneys and did not cook outside.

Data Collection

Recruitment and data collection were conducted in two phases – from September through November 2021, and April through June 2022 – and both phases included dry and rainy months (see Figure 4).

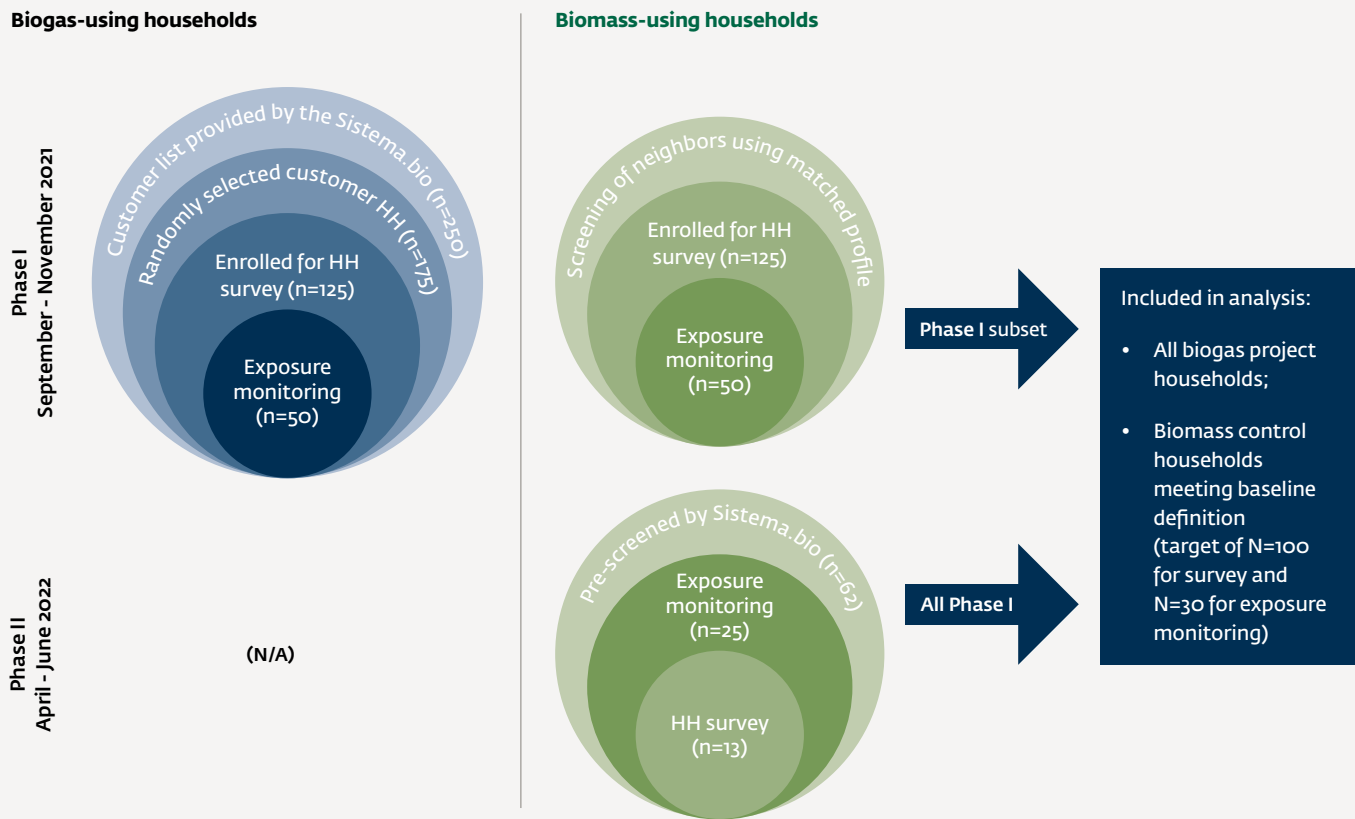
Two main types of data were collected for this assessment.

First, a household survey was conducted with all participants to gather data on the primary metric for measuring the gender outcome – **Quality Time**. As previously noted, this is time spent on income generation, producing goods that otherwise would be bought, education, rest, and/or leisure. The survey also collected demographic information, assessed typical stove and fuel use, and explored time spent on cooking-

related tasks (including fuel acquisition, fuel preparation, biodigester maintenance, food preparation, cooking, and cleanup).

Second, a subset of both groups in the assessment was randomly selected to estimate the health outcome by measuring cooks’ **personal exposure to fine particulate matter (PM_{2.5})**. Personal exposure measurement was conducted using a gravimetric PM_{2.5} sampler, which is a small portable device⁷¹ that participants wore in a custom-designed apron (see Figure 5).⁷² For details on the health measurement methodology, see the Health section under Metrics and Standards.

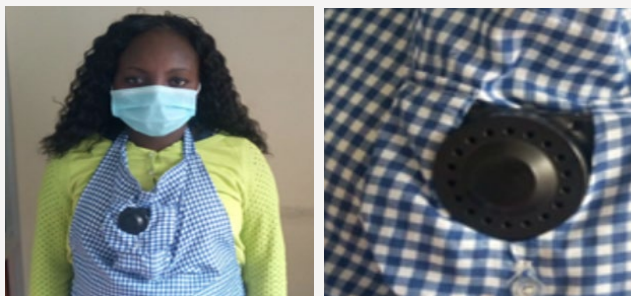
Figure 4: Schematic of Sample Sizes and Data Collection



Customer list provided by Sistema.bio (n=250)

Note: All fieldwork was done under strict COVID-19 protocols.

Figure 5: PM_{2.5} Exposure Monitor



How to measure exposure to PM_{2.5} using gravimetric PM_{2.5} samplers (UPAS)

1. Forty-eight-hour deployment of the ultrasonic personal aerosol sampler (UPAS) personal air pollution monitor (measures PM_{2.5})
2. PM_{2.5} collects on a filter and must be pre- and post-weighted at the same facility.

Stove Use

Survey data on stove use in assessment participants' households showed that 121 of the 126 **biogas-using households** (96 percent) in the project scenario used a biogas stove as their primary stove, but 94 (75 percent) also reported using a biomass stove (wood or charcoal) as a secondary or tertiary stove, and 23 (18 percent) reported using an LPG stove as well. As expected, all of the participants in the **biomass-using households** (115) in the baseline scenario reported using a biomass stove as their primary stove.

B. Metrics and Standards

Health

Gold Standard's methodology for assessing the health improvements from household energy interventions⁷³ relies on field measurements of exposure to fine particulate matter (PM_{2.5}), and the known epidemiologic relationships between PM_{2.5} exposure and a number of negative health outcomes—lung cancer, ischemic heart disease, strokes, chronic obstructive pulmonary disease, and acute lower respiratory infections. The health outcome of a particular intervention (such as a biogas system) is estimated by using the Household Air Pollution Intervention Tool (HAPIT)⁷⁴ (see Figure 6) that applies a combination of measured and default parameters to estimate ill health averted by the intervention, which is quantified as **averted deaths and averted disability-adjusted life years (aDALYs)** (see Box 8).

Box 8: Application of aDALYs

The disability-adjusted life year (DALY) is a metric that combines years of life lost due to premature mortality and years of healthy life lost due to disability/ill health. The averted DALY (aDALY) metric comprises the amount of healthy life saved due to an intervention (including time spent free of illness and avoided premature death). Using aDALYs to quantify the health outcome in the target population is more practical than attempting to measure the actual health outcome. The aDALY metric facilitates easy comparison of the health outcomes across many different types of interventions—for example, comparing the impact of a sanitation program with a clean cooking intervention.

Figure 6: HAPIT

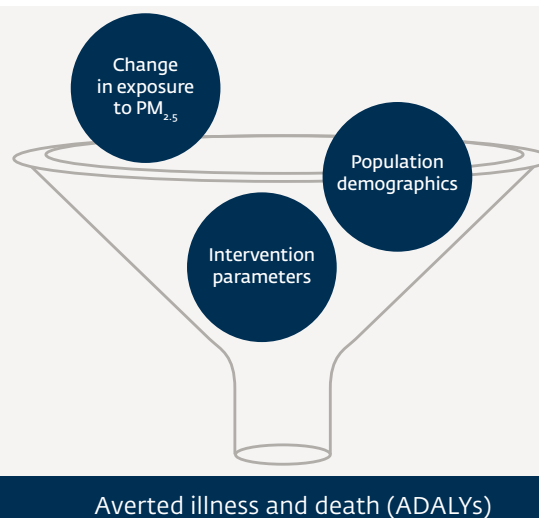
The HAPIT tool estimates ADALYs:

<http://householdenergy.shinyapps.io/hapit3/>

Inputs: PM_{2.5} exposure reductions, lifespan of the intervention, the number of homes targeted, and the percentage of homes using the intervention.

Applies integrated PM_{2.5} exposure-risk curves for: acute lower respiratory infections, chronic obstructive pulmonary disease (COPD), ischemic heart disease, lung cancer, and stroke.

Aggregates impact into averted disability-adjusted life years (DALYs), a metric that combines years of life lost to death, and years of healthy life lost due to illness.



Gender

The **Gold Standard Gender Equality Requirements & Guidelines**⁷⁵ have two components: the Gender-sensitive Requirements (mandated for all Gold Standard-certified projects) and the optional Gender-responsive Guidelines. Sistema.bio met the Gender-sensitive Requirements by documenting female cooks' benefits from using a biogas system and building women's capacity to sell biodigesters in Kenya.⁷⁶ The Gender-responsive Guidelines require program developers to create their own specific gender methodology based on the hypothesized gender outcomes of their project. As of August 2022, only one project (the Lango Safe Water Project in Uganda)⁷⁷ had applied Gold Standard's Gender-responsive Guidelines.⁷⁸

For the CIB, the team developed the gender outcome metric **Quality Time** because there is no standard metric to measure the gender outcome resulting from cookstove adoption. In line with Sistema.bio's observation and Gold Standard gender methodology (Gold Standard Gender-responsive Guidelines), this captured the extent to which biogas use progressed households toward achieving SDG 5. It served as the primary outcome metric for the gender outcome that captured the redeployment of women's saved time on productive and/or valued activities (see Box 7 in the main report for findings from a new study on time use agency to measure women's empowerment and the multidimensional impact of cookstove adoption).

Quality Time is the number of minutes per day that a woman spends on income generation, the production of goods that otherwise would be bought, education, rest, and/or leisure.

C. Outcome Results

This section features more details on the outcome results of health and gender co-benefits under the baseline assessment.

Health

- The personal exposure to PM_{2.5} of female cooks in **biogas-using households** was 68% lower than in **biomass-using households** (averaging **113 µg/m³** in **biomass-using households**, versus **36 µg/m³** in **biogas-using households**)
- The reduction of personal exposure to PM_{2.5} at approximately **77 µg/m³**, was estimated to avert **578 disability-adjusted life years (DALYs) and 16 deaths** per year for every 10,000 homes with a biodigester, or 21 days of healthy life added to each household per year.

Interpretation of the health result

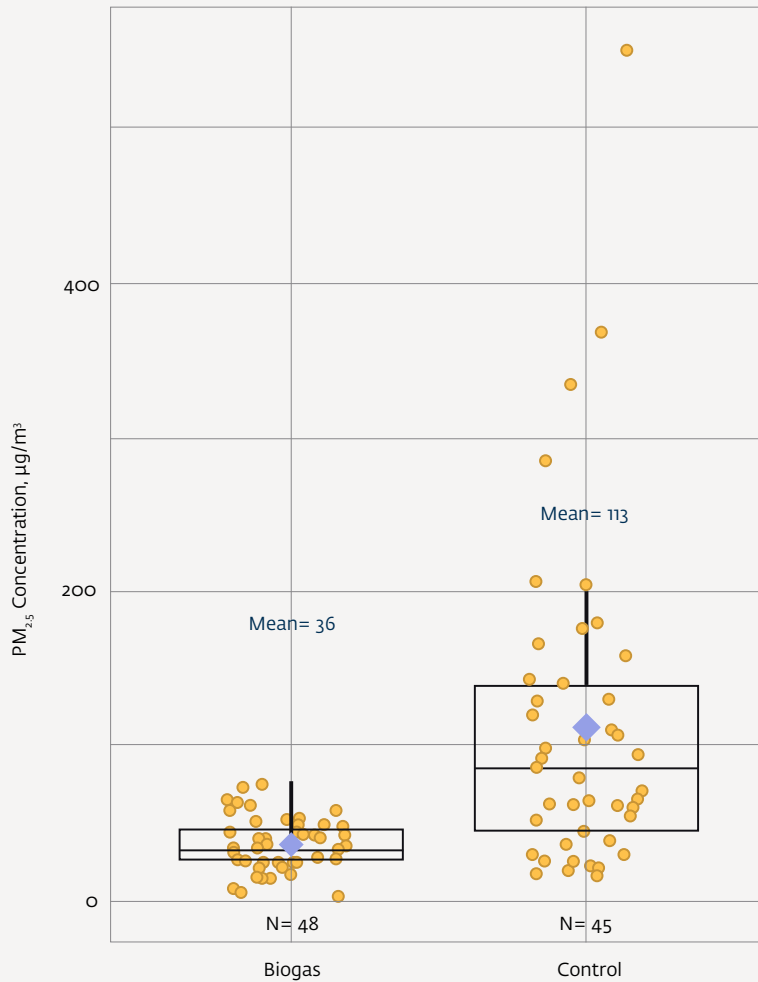
The exposure to PM_{2.5} was lower in female cooks in **biogas-using households** in the project scenario than in female cooks in **biomass-using households** in the baseline scenario. On average, PM_{2.5} exposure was **113 micrograms per cubic meter (µg/m³)** in the **biomass-using households** in the baseline scenario, and **36 µg/m³** in the **biogas-using households** in the project scenario, accounting for a difference of **77 µg/m³**, or a **68 percent** reduction in exposure between the two groups (see Figure 7). When this difference in average PM_{2.5} exposure was translated into estimates of averted ill health (see Figure 8) using the Household Air Pollution Intervention Tool (HAPIT)⁷⁹ (see Figure 6), this assessment found that, per year, for every 10,000 homes using a biogas system, **16 deaths (4 for children + 12 for adults) would be averted**, and the total for **averted disability-adjusted life years would be 578 (309 for children + 269 for adults)**. This is equivalent to **0.016 averted deaths**, and **0.058 aDALYs per household, per year, respectively**. Also, overall, more than half of the ill health averted would accrue to children under age 5, because they would have fewer acute lower respiratory infections.



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^c The Gold Standard aDALY methodology stipulates that the 90 percent confidence interval's margin of error of the sample should be less than 30 percent of the mean. (It does not require statistical significance.) All values are less than 30 percent, meeting this guideline.

Figure 7: PM_{2.5} Exposure

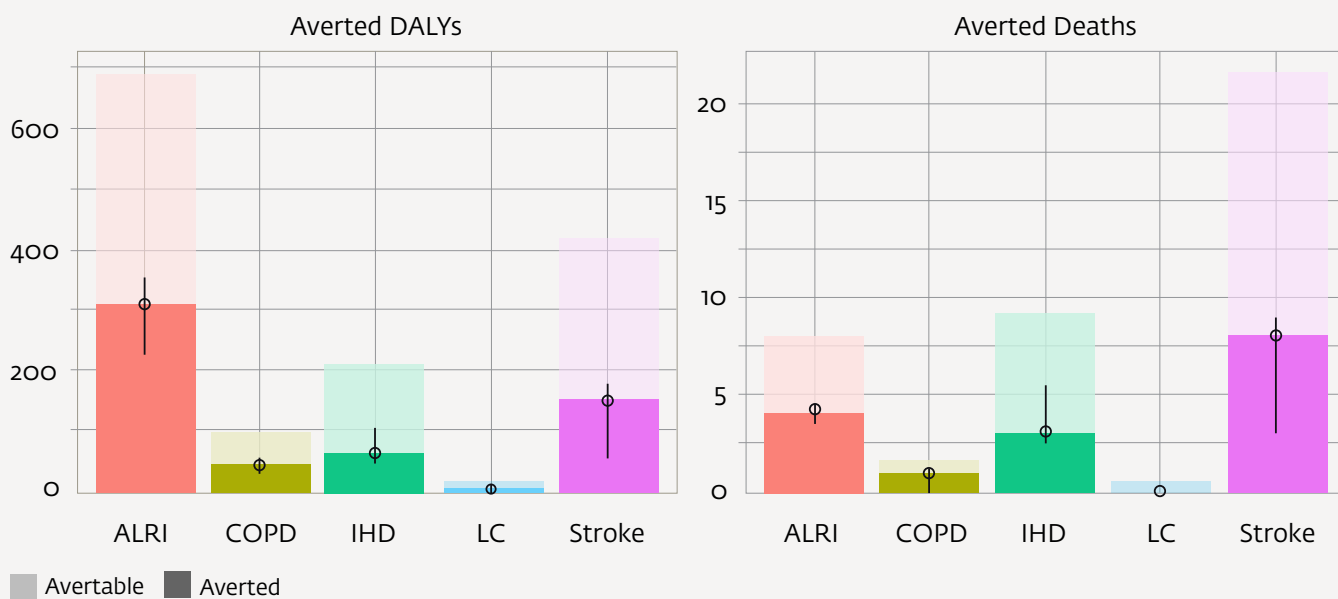


	Biogas	Control
Number of observations	48	45
PM_{2.5} concentration, µg/m³		
Mean (Standard Deviation - SD)	36 (17)	113 (105)
Median	33	86
Range	5 - 77	18 - 551
90% Confidence Interval margin of error	± 4	± 26
90% precision*	11%	23%
Difference in means as compared to the biogas group, µg/m³ (%)	NA	77 (68%)



* The Gold Standard aDALY methodology stipulates that the 90 percent confidence interval's margin of error of the sample should be less than 30 percent of the mean. (It does not require statistical significance.) All values are less than 30 percent, meeting this guideline.

Figure 8: Disease-specific Contributions to Averted Deaths and DALYs (outputs from HAPIT)



Averted ill-health due to the proposed intervention. Each panel represents a specific health measure. Lightly shaded bars are the total avertable ill-health by an intervention that has perfect usage and reduces exposures to the counterfactual. Estimates of ill-health assume that each year of exposure reduction provides five years of benefit.

Measure	Age	Mean Averted	Minimum Averted	Max Averted
Averted DALYs	Child	309	224	356
Averted Deaths	Child	4	3	4
Averted DALYs	Adult	269	133	350
Averted Deaths	Adult	12	5	15

Panels represent different measures of averted ill health. Darkly shaded areas are the mean amount of averted ill health by disease type, and the lightly shaded areas are what could be avertable by a “perfect” intervention. ALRI is acute lower respiratory infection, COPD is chronic obstructive pulmonary disease, IHD is ischemic heart disease, and LC is lung cancer.

Based on available literature, we initially expected to see slightly higher personal exposure to PM_{2.5} in this assessment. For example, PM_{2.5} exposures for women using traditional stoves in Rwanda were reported at 223 µg/m³,⁸⁰ and a systematic review by Pope et al. (2017) of household air pollution found most studies reported traditional biomass user groups had means above 200 µg/m³.⁸¹

36 µg/m³ for the **biogas-using household group**, and 113 µg/m³ for the **biomass-using household group**. These findings are very encouraging from a health standpoint. However, the lower exposure level in the baseline scenario for the **biomass-using household group** means that the transition from cooking with traditional biomass methods to cooking with biogas had a smaller impact on health than expected.

The assessment found that air quality was much cleaner than originally anticipated. For example, the results show

^A “perfect” intervention is defined by HAPIT as one that reduces exposures to the counterfactual of 7 µg/m³, and is used for 100 percent of cooking (7 µg/m³ was selected based on the 2010 Global Burden of Disease counterfactual estimate; in 2021, the World Health Organization (WHO) guideline for ambient air pollution exposure was revised downward to 5 µg/m³).

Gender

- Female cooks in **biogas-using households** in the project scenario spent less time on cooking and fuel-related activities than was the case for female cooks in the **biomass-using households** in the baseline scenario; **on average, this accounted for a total of 99 fewer minutes per day across the assessed activities.**
- Compared to the female cooks in the **biomass-using households** in the baseline scenario, the female cooks in the **biogas-using households** in the project scenario spent an average of **47 more minutes of Quality Time** per day (285 hours, or about 12 days, per year).

Interpretation of the gender result

This assessment found that in comparison to the **biomass-using households'** cooks in the baseline scenario⁸², cooks in **biogas-using households** in the project scenario reported spending less time on cooking and all fuel related tasks, and more time on Quality Time activities. For example, cooks in the **biogas-using households** in the project scenario saved, on average, 77 minutes per day on cooking, and 22 minutes per day on fuel-related tasks – a total of 99 minutes. This assessment also found that, on average, **biogas-using households** in the project scenario spent an average of 47 more minutes per day on Quality Time activities, which suggests that approximately half of the time saved when cooking with biogas is redeployed to Quality Time activities (see Table 6 for detailed results for Time Use).

Table 6: Time Use (via survey of female primary cooks)

	Biogas-using households	Biomass-using households	Difference in means (as compared to biomass group)
N = Observations	126	102	
Cooking time (all tasks, min.^d /day)			
Mean (SD)	146.1 (71.8)	222.9 (140.5)	-76.8
90% precision^e	7%	10%	
P-value for the difference between biogas- and biomass-using households			<0.001 ^f
All-fuel related tasks⁸³ (all tasks, min./day)			
Mean (SD)	36.6 (56.6)	58.4 (73.6)	-21.8
90% precision	23%	21%	
P-value for the difference			0.02^g
Quality Time⁸⁴ (min./day)			
Mean (SD)	412 (266.7)	365.4 (239.2)	+46.6
90% precision	9%	11%	
P-value for the difference			0.17 ^h

^d Min. stands for minutes.

^e The Gold Standard aDALY methodology stipulates that the 90 percent confidence interval's margin of error of the sample should be less than 30 percent of the mean. The Gold Standard methodology does not require statistical significance. All values presented above are less than 30 percent, meeting this guideline.

^f This difference is statistically significant.

^g This difference is statistically significant.

^h Although this difference is not statistically significant, the 90/30 precision guideline was met for each of these groups.



Setting up a biodigester

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Endnotes

- ¹ ESMAP (Energy Sector Management Assistance Program). 2020. *The State of Access to Modern Energy Cooking Services* (English). Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/93741600195758792/The-State-of-Access-to-Modern-Energy-Cooking-Services>.
- ² IEA (International Energy Agency), IRENA (International Renewable Energy Agency), UNSD (United Nations Statistics Division), World Bank, and WHO (World Health Organization). 2022. *Tracking SDG 7: The Energy Progress Report*. June 1, 2022. Washington, DC: World Bank. https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf.
- ³ Puthumana, J.S., L.M. Ngaage, M.R. Borrelli, E.M. Rada, J. Caffrey, and Y. Rasko. 2021. "Risk factors for cooking-related burn injuries in children, WHO Global Burn Registry." *Bulletin of the World Health Organization* 99 (6): 439–445. <https://doi.org/10.2471%2FBLT.20.279786>.
- ⁴ Per the Clean Cooking Alliance, clean cooking solutions refer to a suite of fuel-stove combinations with emissions performance that meets the World Health Organization's guidelines for indoor air quality. They include high-efficiency charcoal and biomass pellet stoves, liquefied petroleum gas (LPG), biogas, ethanol, and electric stoves and pressure cookers.
- ⁵ United Nations. 2021. *Theme Report on Energy Access Towards the Achievement of SDG 7 and Net-Zero Emissions*. https://www.un.org/ohrls/sites/www.un.org.ohrls/files/technical_working_group_1_energy_access_report_2021.pdf.
- ⁶ The term "base of the economic pyramid" is used to describe men and women who are low-income and/or who lack access to basic goods and services. The low-income segment is commonly considered to include people earning up to \$8 per day in terms of their purchasing power parity (PPP). Setting the maximum in PPP terms adjusts the real figure to equate the PPPs of different countries. G20 Development Working Group. 2015. "G20 Inclusive Business Framework." <http://g20.org.tr/wp-content/uploads/2015/11/G20-Inclusive-Business-Framework.pdf>.
- ⁷ Quality Time is defined as the sum of time spent on income generating activities, producing goods that would otherwise be bought, education, rest and leisure.
- ⁸ IEA (International Energy Agency), IRENA (International Renewable Energy Agency), UNSD (United Nations Statistics Division), World Bank, and WHO (World Health Organization). 2022. *Tracking SDG 7: The Energy Progress Report*. June 1, 2022. Washington, DC: World Bank. https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf.
- ⁹ Puthumana, J.S., L.M. Ngaage, M.R. Borrelli, E.M. Rada, J. Caffrey, and Y. Rasko. 2021. "Risk factors for cooking-related burn injuries in children, WHO Global Burn Registry." *Bulletin of the World Health Organization* 99 (6): 439–445. <https://doi.org/10.2471%2FBLT.20.279786>.
- ¹⁰ ESMAP (Energy Sector Management Assistance Program). 2020. *The State of Access to Modern Energy Cooking Services* (English). Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/93741600195758792/The-State-of-Access-to-Modern-Energy-Cooking-Services>.
- ¹¹ Any positive outcomes or impacts, other than direct GHG emissions' mitigation, resulting from carbon offset projects.
- ¹² ESMAP (Energy Sector Management Assistance Program). 2022. "Opening Opportunities, Closing Gaps: Advancing Gender-Equal Benefits in Clean Cooking Operations." Washington, DC: World Bank. <https://cleancooking.org/reports-and-tools/opening-opportunities-closing-gaps-advancing-gender-equal-benefits-in-clean-cooking-operations/>.
- ¹³ Because cooking with a traditional stove takes more time, cooks spend more than 1.3 hours per day on cooking.
- ¹⁴ OECD (The Organization for Economic Cooperation and Development), Issues Paper: Unpaid Care Work: The missing link in the analysis of gender gaps in labour outcomes, 2014 https://www.oecd.org/dev/development-gender/Unpaid_care_work.pdf.
- ¹⁵ WHO (World Health Organization). 2016. *Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children*. https://apps.who.int/iris/bitstream/handle/10665/204717/9789241565233_eng.pdf?sequence=1&isAllowed=y.
- ¹⁶ Clean Cooking Alliance. "Clean Cooking Sector Strategy: Systemic challenges and opportunities." <https://cleancooking.org/clean-cooking-systems-strategy>.
- ¹⁷ They cannot meet the criteria (substantial collateral and/or high interest rates) to access debt from local banks, and they are not eligible for international investments because the amounts they borrow are much smaller than the ticket size offered by international investors. There are local currency risks as well.
- ¹⁸ Dalberg. Clean Cooking Sector Strategy: Emerging Insights from User Research.
- ¹⁹ United Nations. 2021. *Theme Report on Energy Access Towards the Achievement of SDG 7 and Net-Zero Emissions*. https://www.un.org/ohrls/sites/www.un.org.ohrls/files/technical_working_group_1_energy_access_report_2021.pdf.
- ²⁰ SEforALL (Sustainable Energy for All). 2021. "Energizing Finance: Understanding the Landscape 2021." Vienna: Sustainable Energy for All (SEforAll). <https://www.seforall.org/system/files/2021-10/EF-2021-UL-SEforALL.pdf>.
- ²¹ Accenture and Global Alliance for Clean Cookstoves. 2018. *Financing Growth in the Clean Cookstoves and Fuels Market: An Analysis and Recommendations*. Chicago: Accenture. <https://cleancooking.org/reports-and-tools/financing-growth-in-the-clean-cookstoves-and-fuels-market-an-analysis-and-recommendations/>.

- ²² The Brookings Institution's analysis shows that an impact bond is the best instrument to use, when paying for outcomes is more likely to deliver outcomes than paying for inputs. Also, simply convening parties and letting them get on with it is unlikely to go well. The main success factor in impact bonds turns out to be their management. Gustafsson-Wright, Emily. 2020. "What is the size and scope of the impact bonds market? Measuring the Success of Impact Bonds." Global Economy and Development at Brookings. Washington, DC: Brookings Institution. https://www.brookings.edu/wp-content/uploads/2020/09/Impact_Bonds-Brief_1-FINAL-1.pdf.
- ²³ Brookings Institution. 2022. Impact bonds fund services through contracts where private investors provide upfront flexible funding to service providers, and outcome funders repay these investors based on the outcomes achieved by the people receiving the services. Since 2010, 239 impact bonds have been launched across 39 countries. <https://www.brookings.edu/research/social-and-development-impact-bonds-by-the-numbers>.
- ²⁴ King, Matt. 2021. "Results-Based Climate Finance is a powerful tool to build back better, but only if it is within easy reach." World Bank Blogs, March 24, 2021. <https://blogs.worldbank.org/climatechange/results-based-climate-finance-powerful-tool-build-back-better-only-if-it-within-easy>.
- ²⁵ ESMAP (Energy Sector Management Assistance Program). "Clean Cooking Fund." <https://www.esmap.org/clean-cooking-fund>.
- ²⁶ Roots of Impact. 2019. *Social Impact Incentives (SIINC)*. <https://www.roots-of-impact.org/wp-content/uploads/2019/01/Social-Impact-Incentives-SIINC-White-Paper-2016.pdf>.
- ²⁷ Any RBF scheme requires: 1) measurable outcomes that would allow attribution of results to the funding inputs, 2) adoption of widely agreed-upon methodologies for quantifying results from an intervention, 3) a reasonable evidence base for those interventions, 4) credible, independent, third-party verification of results, and 5) demand for verified results targeted to close access gaps from donors and/or the private sector.
- ²⁸ Blaufelder, Christopher, Cindy Levy, Peter Mannion, and Dickon Pinner. 2021. "A blueprint for scaling voluntary carbon markets to meet the climate challenge." McKinsey.com. <https://www.mckinsey.com/capabilities/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge>.
- ²⁹ Philips, Sue, and Jeanette Gurung. 2021. "Bringing a stronger focus on SDG 5: Gender Equality in the voluntary carbon market. TSVC Phase2: Public Consultation Open Letter." June 20, 2021. GenderTech Enterprises, WOCAN, and W+. San Francisco: WOCAN. <https://www.wplus.org/wp-content/uploads/2021/06/TSVCM-Phase-2-Open-Letter-Gender-Equality.pdf>. This has also been reflected in a big jump in the volume for carbon offsets, which achieved dual certification under carbon credits and other standards that certify positive social impacts (these offsets increased 113 percent, from 2.3 metric tons of CO₂ equivalent (MtCO₂e) in 2016 to 4.9 MtCO₂e in 2018, and the market value topped \$24.8 million). Ecosystem Marketplace. 2019. *Financing Emissions Reductions for the Future State of the Voluntary Carbon Markets* 2019. <https://icap.sustainability.illinois.edu/files/project/378/2019-Carbon%20Offsets-MarketOverview.pdf>
- ³⁰ IFC's market sounding consultation with 35 leading market players in the carbon space and 10 development finance institutions/multilateral development banks/impact investors. The WOCAN survey mentioned above found that 65 percent of respondents believe the demand for carbon credits with women's empowerment will grow once buyers are aware of the opportunity to purchase offsets with a "co-benefit" of women's empowerment/gender equality.
- ³¹ Brookings Institution Global Impact Bond Database, accessed, March 1, 2023. <https://www.brookings.edu/research/social-and-development-impact-bonds-by-the-numbers>.
- ³² SEforAll's *Energizing Finance* report shows a significant funding gap for clean cooking access (\$133 committed in 2019 versus the \$4.5 billion required). SEforAll. 2021. *Energizing Finance: Understanding the Landscape* 2021. Vienna: Sustainable Energy for All (SEforAll). <https://www.seforall.org/system/files/2021-10/EF-2021-UL-ES-SEforALL.pdf>.
- ³³ IFC (International Finance Corporation). 2018. "IFC, BIX Capital Partner to Finance Climate-smart Appliances for Low-income African Households." IFC press release, June 4, 2018. <https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=18344>.
- ³⁴ King, Matt. 2021. "Results-Based Climate Finance is a powerful tool to build back better, but only if it is within easy reach." World Bank Blogs, March 24, 2021. <https://blogs.worldbank.org/climatechange/results-based-climate-finance-powerful-tool-build-back-better-only-if-it-within-easy>.
- ³⁵ Gold Standard. 2016. "Methodology to Estimate and Verify Averted Disability Adjusted Life Years (ADALYs) from Cleaner Cooking and Cleaner Household Air: Public Consultation." Geneva: Gold Standard. <https://www.goldstandard.org/our-work/innovations-consultations/methodology-estimate-and-verify-averted-disability-adjusted-life>.
- ³⁶ Gold Standard for the Global Goals. 2017. "Gold Standard Gender Equality Guidelines & Requirements." Draft for public consultation. Geneva: Gold Standard. https://www.goldstandard.org/sites/default/files/documents/gs_gender_equality_guidelines_consultation.pdf.
- ³⁷ Price of aDALY used per capita gross domestic product in Kenya (as of 2019) as a benchmark (\$1,816 to \$1,970) and followed WHO-CHOICE methodology. <https://resource-allocation.biomedcentral.com/articles/10.1186/1478-7547-1-8>.
- ³⁸ Price per Quality Hour (for gender) was based on three available references: 1) W+ units issued using the W+ standard by WOCAN (using the Nepal transaction \$0.60 per hour), 2) gross domestic product (GDP) per capita in Kenya as of 2019, and 3) the living wage for rural Kenya in 2016. These references yielded a price range of: \$0.60 to \$1.02 per added Quality Hour (QH) and worked with the high-end price of \$1 per QH.

³⁹ Gold Standard for the Global Goals. "Certify a Project to Gold Standard." Gold Standard website accessed November 30, 2022. <https://www.goldstandard.org/take-action/certify-project>.

⁴⁰ Gold Standard for the Global Goals. "Certify a Project to Gold Standard." Gold Standard website accessed November 30, 2022. <https://www.goldstandard.org/take-action/certify-project>.

⁴¹ World Bank. Building Evidence to Unlock Impact Finance: A Field Assessment of Clean Cooking Co-benefits for Climate, Health, and Gender (English). Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/099051123130561434/P17423201c1bc105doaa4da0803634916bbo>.

⁴² The assessment found that air quality was much cleaner than originally anticipated. For example, the results show 36 µg/m³ for the biogas-using households group, and 113 µg/m³ for the biomass-using control group. These findings are very encouraging from a health standpoint, because exposure in the project scenario for the biogas-using households group was close to the World Health Organization's first interim guideline of 35 µg/m³. However, the lower exposure level in the baseline scenario for the biomass-using control group means that the transition from cooking with traditional biomass methods to cooking with biogas had a smaller impact on health than expected.

⁴³ Note that this is **the interim guideline** according to the World Health Organization. The World Health Organization global air quality guidelines for PM_{2.5} exposure were revised downward in 2021 to 15 µg/m³ (24-hour average) and 5 µg/m³ (annual average).

⁴⁴ The W+ domains created by Women Organizing for Change in Agriculture and Natural Resource Management (WOCAN) show various methodologies to measure and quantify projects' outcomes on women's lives. For example, one of the W+ Time methods for time savings enables project developers to document the increase in women's discretionary time, by measuring shifts in the use of time away from lower-value activities toward higher-value activities. WOCAN (Women Organizing for Change in Agriculture and Natural Resource Management). <https://www.wplus.org/w-domains/>.

⁴⁵ For example, a meta-analysis of multi-tier framework (MTF) data on time use across six countries estimated that the time savings of users of improved cookstoves was 23 minutes per day in rural areas, and 41 minutes per day in urban areas. This was across all cooking and fuel-preparation tasks. Krishnapriya, P.P., Maya Chandrasekaran, Marc Jeuland, and Subhrendu K. Pattanayak. 2021. "Do Improved Cookstoves Save Time and Improve Gender Outcomes? Evidence from Six Developing Countries." *Energy Economics* 102, October: 105456. <https://doi.org/10.1016/j.eneco.2021.105456>. Notably, the study combined "improved" biomass stove users with users of biogas and other clean-fuel stoves. When the data were disaggregated by gender, the savings for women were reduced in this study to 11 minutes per day in rural areas (range: 8 to 21 minutes). Studies focused on biogas technologies have occasionally reported larger time savings: for example, 110 minutes per day for women using biogas stoves in South India (Anderman, Tal Lee, Ruth S. DeFries, Stephen A. Wood, Roseline Remans, Richie Ahuja, and Shujayath E. Ulla. 2015. "Biogas Cook Stoves for Healthy and Sustainable Diets? A Case Study in Southern India." *Frontiers in Nutrition* 2, September. <https://doi.org/10.3389/fnut.2015.00028>); and 136 minutes per day for women using biogas in Nepal (Gurung, Barun, and Shreya Thakali. 2014. "Monitoring Report: Women's Time Savings from Biogas in Nepal." Kailua Kona: WOCAN. https://mer.markit.com/br-reg/public/project.jsp?project_id=10400000015320). However, other studies have reported lower time savings—about 14 minutes per day (Krishnapriya et al. 2021).

⁴⁶ It is well known that reducing the time that women spend on unpaid labor and drudgerous tasks is important for closing the gap between women and men with regard to women's additional labor burden and time poverty. ESMAP (Energy Sector Management Assistance Program). 2020. *Quantifying and Measuring Climate, Health, and Gender Co-Benefits from Clean Cooking Interventions: Methodologies Review*. Washington, DC: World Bank. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/436301593546281643/quantifying-and-measuring-climate-health-and-gender-co-benefits-from-clean-cooking-interventions-methodologies-review>; Krishnapriya, P.P., Maya Chandrasekaran, Marc Jeuland, and Subhrendu K. Pattanayak. 2021. "Do Improved Cookstoves Save Time and Improve Gender Outcomes? Evidence from Six Developing Countries." *Energy Economics* 102 (October): 105456. <https://doi.org/10.1016/j.eneco.2021.105456>; Jagoe, Kirstie, Madeleine Rossanese, Dana Charron, Jonathan Rouse, Francis Waweru, MaryAnne Waruguru, Samantha Delapena, Ricardo Piedrahita, Kavanaugh Livingston, and Julie Ipe. 2020. "Sharing the Burden: Shifts in Family Time Use, Agency and Gender Dynamics after Introduction of New Cookstoves in Rural Kenya." *Energy Research & Social Science* 64 (June): 101413. <https://doi.org/10.1016/j.erss.2019.101413>.

⁴⁷ ESMAP (Energy Sector Management Assistance Program). 2020. *Quantifying and Measuring Climate, Health, and Gender Co-Benefits from Clean Cooking Interventions: Methodologies Review*. Washington, DC: World Bank. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/436301593546281643/quantifying-and-measuring-climate-health-and-gender-co-benefits-from-clean-cooking-interventions-methodologies-review>.

⁴⁸ A randomized trial in Ghana found that LPG users spent about 50 minutes more per day on income generation than did controls (rest and leisure time was not assessed). Prah, Rebecca Kyerewaa Dwommoh, Daniel Carrion, Felix Boakye Oppong, Theresa Tawiah, Mohammed Nuhu Mujtaba, Stephaney Gyaase, and Adolphine Kwarteng. 2020. "Time Use Implication of Clean Cookstoves in Rural Settings in Ghana: A Time Use Study." *International Journal of Environmental Research and Public Health* 18 (1): 166. <https://doi.org/10.3390/ijerph18010166>. Conversely, biogas adopters in South India spent about 60 minutes per day less on paid labor than controls, but 12 minutes more on relaxation.⁴¹ Anderman, Tal Lee, Ruth S. DeFries, Stephen A. Wood, Roseline Remans, Richie Ahuja, and Shujayath E. Ulla. 2015. "Biogas Cook Stoves for Healthy and Sustainable Diets? A Case Study in Southern India." *Frontiers in Nutrition* 2 (September). <https://doi.org/10.3389/fnut.2015.00028>. Finally, a study in Nepal reported that biogas users spent 66 more minutes per day engaged in non-cooking-related productive activities, and eight more minutes per day on rest or leisure than was the case with non-adopters. Gurung, Barun, and Shreya Thakali. 2014. *Monitoring Report: Women's Time Savings from Biogas in Nepal*. Kailua Kona: WOCAN. https://mer.markit.com/br-reg/public/project.jsp?project_id=10400000015320.

⁴⁹ According to the most recent World Bank study in 2023, the time use surveys did not yield significant differences between primary cooks in the biogas and control households in terms of time spent on Quality Time, or an association between biogas use and increased time spent on income-generating activities for women. However, the team has confirmed that the slightly different results observed in the World Bank and IFC studies for health and gender are within the range of what might be expected when conducting sequential studies using similar methods (i.e., they are within the range of natural sampling variability, especially because the two studies were conducted in slightly different locations). Nonetheless, there were a few key differences in how the participant groups were defined, and how the methods were applied, which may play a role in the observed differences. These specific differences would be available upon request. These are the first two studies to assess Quality Time in order to measure the impact on women; more studies need to be conducted to test the robustness of the indicator to measure the gender benefits of using biogas.

- ⁵⁰ The amount of money generated per stove installation based on the CIB.
- ⁵¹ The result was generated by multiplying 0.058 aDALYs per household by 365 days.
- ⁵² The result was generated by multiplying 0.058 aDALYs per household by the price \$1,816 per aDALY set by the CIB.
- ⁵³ The result was generated by multiplying 0.78 hours of Quality Time per day per household by 365 days.
- ⁵⁴ The result was generated by multiplying 285 hours by the price of \$1 per QH set by CIB.
- ⁵⁵ Gold Standard. 2016. "Methodology to Estimate and Verify Averted Disability Adjusted Life Years (ADALYs) from Cleaner Cooking and Cleaner Household Air: Public Consultation." Geneva: Gold Standard. <https://www.goldstandard.org/our-work/innovations-consultations/methodology-estimate-and-verify-averted-disability-adjusted-life>.
- ⁵⁶ For these Gold Standard project documents, see <https://registry.goldstandard.org/projects/details/2198>.
- ⁵⁷ Clemens, Harry, Rob Bailis, Anne Nyambane, and Victoria Ndung'u. 2018. "Africa Biogas Partnership Program: A Review of Clean Cooking Implementation through Market Development in East Africa." *Energy for Sustainable Development* 46 (June): 23–31. <https://doi.org/10.1016/j.esd.2018.05.012>.
- ⁵⁸ Eaton, Alex. 2022. Communication written to the Berkeley Air Monitoring Group. August 2022.
- ⁵⁹ Companies that are already bankable can attract working capital from banks/local mainstream investors. If a company is too small, its operations are not sufficiently organized to meet due diligence requirements from the impact investors and standards including Gold Standard.
- ⁶⁰ World Bank. Building Evidence to Unlock Impact Finance: A Field Assessment of Clean Cooking Co-benefits for Climate, Health, and Gender (English). Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/099051123130561434/P17423201c1bc105do4dao803634916bbo>.
- ⁶¹ Because the negative health impacts of damaging environmental exposure can take years to develop, using aDALYs to quantify the health impact in the target population is more practical than attempting to measure the actual health impact. This methodology has been implemented at least twice previously – once for a cookstove program in the Lao People's Democratic Republic (Hill, Lawson, Ajay Pillariseti, Kirk R. Smith, Samantha Delapena, Charity Garland, Kirstie Jagoe, David Pennise, Mette Rohr Boatman, Philipp Koetting, and Aurelie Pelletreau. 2015. *Air Pollution and Impact Analysis of a Pilot Stove Intervention: Report to the Ministry of Health and Inter-Ministerial Clean Stove Initiative of the Lao People's Democratic Republic*. Berkeley: University of California, Berkeley, and Berkeley Air Monitoring Group); and once for a public health intervention in Rwanda.
- ⁶² The World Bank's 2023 study finding suggests that time use agency, in addition to time use, is an effective way to measure women's empowerment and the multidimensional impact of cookstove adoption.
- ⁶³ The W+ Standard, created by WOCAN, is the first women-specific standard that measures women's empowerment in a transparent and quantifiable manner, gives a monetary value to results, and creates a new channel to direct financial resources to women. <https://www.wplus.org/about-the-w-standard/>.
- ⁶⁴ United Nations Climate Change. 2021. "The W+ Standard: Nepal." UN Global Climate Action Awards. Women for Results. United Nations Climate Change website, accessed November 30, 2022. <https://unfccc.int/climate-action/momentum-for-change/women-for-results/the-w-standard>.
- ⁶⁵ Gurung, Barun, and Shreya Thakali. 2014. *Monitoring Report: Women's Time Savings from Biogas in Nepal*. Kailua Kona: WOCAN. https://mer.markit.com/br-reg/public/project.jsp?project_id=10400000015320.
- ⁶⁶ World Bank. Building Evidence to Unlock Impact Finance: A Field Assessment of Clean Cooking Co-benefits for Climate, Health, and Gender (English). Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/099051123130561434/P17423201c1bc105do4dao803634916bbo>.
- ⁶⁷ This means that cooking enterprises need to understand, based on the terms and conditions at the time of sale, that they have waived their rights to the GHG reduction, health, and/or gender outcomes. Also, at the time of sale, the additional revenue from the sale of these outcomes should be worked into the offering to the enterprise.
- ⁶⁸ The study required two data collection phases in order to meet the minimum sample size required by Gold Standard. This was necessary because the study collected an over-representation of control households that use LPG at least seven times per week, and an unreported number of households with chimneys that could affect household air quality.
- ⁶⁹ "Meru County–Agribiz." Accessed August 10, 2022. <https://agribiz.kenyacic.org/meru-county/>.
- ⁷⁰ LSM was calculated using a procedure developed by the Marketing & Social Research Association-Kenya (MSRA-Kenya). The measure borrowed heavily from ESOMAR South Africa (<http://www.eighty20.co.za/lsm-calculator/>), but it was customized for Kenyan households. For the definition of social classes, see https://en.wikipedia.org/wiki/NRS_social_grade.
- ⁷¹ Access Sensor Technologies. <https://www.accsensors.com/>.

⁷² The monitoring device was worn continuously by subjects for 48 hours, except when bathing or sleeping. The device collected PM_{2.5} on a filter that measured the concentration of PM_{2.5} before and after the participant began wearing the device.

⁷³ Gold Standard. 2016. "Methodology to Estimate and Verify Averted Disability Adjusted Life Years (ADALYs) from Cleaner Cooking and Cleaner Household Air: Public Consultation." Geneva: Gold Standard. <https://www.goldstandard.org/our-work/innovations-consultations/methodology-estimate-and-verify-averted-disability-adjusted-life>.

⁷⁴ Pillarisetti, A., S. Mehta, and K. R. Smith. 2016. "HAPIT, the Household Air Pollution Intervention Tool, to Evaluate the Health Benefits and Cost-Effectiveness of Clean Cooking Interventions." In *Broken Pumps and Promises – Incentivizing Impact in Environmental Health*, edited by Evan A. Thomas. Switzerland: Springer, 2016, 147–169. Note that as of January 2023, HAPIT is still available but no longer updated or supported. ABODE is the successor model to HAPIT and incorporates the most updated and internally consistent evidence linking exposure to health impacts. Therefore, it has been recommended that Gold Standard update its aDALY methodology to use ABODE rather than HAPIT as the modeling tool going forward (as of January 2023).

⁷⁵ Gold Standard for the Global Goals. 2017. "Gold Standard Gender Equality Guidelines & Requirements." Draft for public consultation. Geneva: Gold Standard. https://www.goldstandard.org/sites/default/files/documents/gender_equality_guidelines_consultation.pdf.

⁷⁶ Project Information and Project Design Document (PDD). <https://platform.sustain-cert.com/public-project/1874>.

⁷⁷ Gold Standard. "Access to Clean Water for Communities in Uganda." Gold Standard website, accessed November 30, 2022. <https://www.goldstandard.org/projects/access-clean-water-communities-uganda>.

⁷⁸ For a summary of field studies that have attempted to measure the gender impacts of development projects, see ESMAP (Energy Sector Management Assistance Program). 2020. *Quantifying and Measuring Climate, Health, and Gender Co-Benefits from Clean Cooking Interventions: Methodologies Review*. Washington, DC: World Bank. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/436301593546281643/quantifying-and-measuring-climate-health-and-gender-co-benefits-from-clean-cooking-interventions-methodologies-review>.

⁷⁹ Pillarisetti, A., S. Mehta, and K. R. Smith. 2016. "HAPIT, the Household Air Pollution Intervention Tool, to Evaluate the Health Benefits and Cost-Effectiveness of Clean Cooking Interventions." In *Broken Pumps and Promises – Incentivizing Impact in Environmental Health*, edited by Evan A. Thomas. Switzerland: Springer, 2016, 147–169. Note that as of January 2023, HAPIT is still available but no longer updated or supported. ABODE is the successor model to HAPIT and incorporates the most updated and internally consistent evidence linking exposure to health impacts. Therefore, it has been recommended that Gold Standard update its aDALY methodology to use ABODE rather than HAPIT as the modeling tool going forward (as of January 2023).

⁸⁰ Kirby, M., C. Nagel, G. Rosa, L. Zambrano, S. Musafiri, J. Ngirabega, E. Thomas, and T. Clasen. 2019. "Effects of a large-scale distribution of water filters and natural draft rocket-style cookstoves on diarrhea and acute respiratory infection: A cluster-randomized controlled trial in Western Province, Rwanda." *PLOS Medicine* 16 (6). <https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1002812>.

⁸¹ Pope, D., N. Bruce, M. Dherani, K. Jagoe, and E. Rehfuess. 2017. "Real-life effectiveness of 'improved' stoves and clean fuels in reducing PM_{2.5} and CO: Systematic review and meta-analysis." *Environment International* 101: 7–18. <https://doi.org/10.1016/j.envint.2017.01.012>.

⁸² In total, 115 biomass-using households were enrolled in this study. In Phase 1, all of these households took part in the household survey, whereas in Phase 2, only a subset of biomass users were surveyed because the focus was assessing personal exposure to PM_{2.5}. Thus, although demographic information was collected from all 115 of the biomass-using households, the household survey collected time-use data from only 102 biomass-using participants.

⁸³ Fuel-related tasks were defined as the sum of time spent on wood fuel collection, wood fuel purchase, charcoal purchase, LPG purchase, wood fuel preparation, water collection, and (for biogas) 50 percent of the time spent collecting manure, adding water, and maintaining the biodigester.

⁸⁴ Quality Time is defined as the sum of time spent on income generating activities, producing goods that would otherwise be bought, education, rest and leisure. Production of goods that would otherwise be bought was defined as: growing food that you eat, producing milk that you drink, making baskets used in the house woven from your own grasses, and (for biogas-using households) production of organic fertilizer, including 50 percent of the time spent collecting manure, adding water, and maintaining the biodigester and 100 percent of the time spent agitating the slurry.



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