Beyond Irrigation: Turning sunlight into supper for Kenya's women and farmers

A pilot of secondary use of solar irrigation power for clean cooking

IISD REPORT

IISD
International Institute for Sustainable Development

Sunil Mani
Tara Laan
Franziska Keller
Cliff Anami
Michaël Aklin

February 2026

Published by the International Institute for Sustainable Development

International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) is an award-winning, independent think tank working to accelerate solutions for a stable climate, sustainable resource management, and fair economies. Our work inspires better decisions and sparks meaningful action to help people and the planet thrive. We shine a light on what can be achieved when governments, businesses, non-profits, and communities come together. IISD's staff of more than 200 people come from across the globe and from many disciplines. With offices in Winnipeg, Geneva, Ottawa, and Toronto, our work affects lives in more than 100 countries.

IISD is a registered charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Province of Manitoba and project funding from governments inside and outside Canada, United Nations agencies, foundations, the private sector, and individuals.

Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: iisd.org
𝕏: @IISD_news

Beyond Irrigation: Turning sunlight into supper for Kenya's women and farmers
A pilot of secondary use of solar irrigation power for clean cooking

February 2026

Written by Sunil Mani, Tara Laan, Franziska Keller, Cliff Anami, and Michaël Aklin

Photo: iStock

Acknowledgements

We would like to thank the International Development Research Centre (IDRC) Canada and the Government of Denmark for their generous support for this publication. We express our appreciation to Bhim Adhikari (IDRC) for his guidance and assistance. This working paper is part of a series by the International Institute for Sustainable Development (IISD) and partners under the Unlocking Inclusive Policy Making for Clean Energy Transition project.

The authors would like to express their gratitude to the individuals and institutions who contributed to this project at different stages. This includes colleagues involved in project design (particularly Anas Rahman, Senior Policy Advisor at IISD), analysis, and outreach and experts from various organizations who provided their peer review inputs for the report.

The authors especially thank the following peer reviewers for their expert insights: Murefu Barasa (EED Advisory Limited, Kenya), Divya Gaur (Council on Energy Environment and Water, India), and Anas Rahman, IISD.

The views expressed in this working paper do not necessarily reflect those of funders or reviewers.

Executive Summary

Globally, about 2.1 billion people are cooking with wood, charcoal, or other polluting fuels, such as kerosene, causing severe public health issues that disproportionately affect women and girls as the predominant household cooks. The transition to cleaner cooking fuels and technologies, such as liquefied petroleum gas (LPG) or electric cooking, has made progress in some regions, particularly Asia, but in sub-Saharan Africa, the number of people without access to clean cooking is increasing. In Kenya, only 30% of the population had access to clean cooking solutions in 2022.

This project examines the prospects of electric pressure cookers powered by solar technology, primarily used for irrigation. SunCulture, a Kenyan company, supplies solar-powered irrigation pumps and batteries, the surplus electricity from which may be used for secondary purposes. SunCulture primarily operates in sub-Saharan Africa and provides pay-as-you-go services to smallholders that include combinations of solar photovoltaic (PV) panels, batteries, drip irrigation systems, lighting, televisions, and charging.

The International Institute for Sustainable Development and SunCulture partnered to assess whether electric pressure cookers powered by these batteries could replace polluting cooking technologies while increasing the secondary use of the solar-powered pump systems and improving the lives of smallholders, particularly women and children. To the best of our knowledge, this study is the first to pilot the secondary use of solar irrigation power for a clean cooking device.

The research project followed a randomized control trial (RCT) design in which 242 SunCulture customers were divided into two groups. One set of customers received a free electric pressure cooker (treatment group) that could be powered by the solar pump battery, whereas another set of customers did not (control group). Baseline and endline surveys were fielded in October 2024 and June 2025, respectively, to collect data on customers' socio-demographic profiles and energy use. The customers were smallholders, both women and men, who already had a SunCulture irrigation system and battery, which was used for secondary purposes, including lighting, television, and charging. Respondents were split about evenly between farmers, salaried employees, and self-employed individuals. The average age of the respondent was 46 years old. The median level of monthly expenditures was between KES 10,000 and KES 20,000 (USD 77 to USD 155), lower than the average rural income in Kenya. Almost all respondents had completed mandatory education, and several had completed some further program (e.g., technical education).

The pilot demonstrated that secondary use of solar irrigation power for cooking is feasible—households used the devices and liked them—but technology design and behavioural changes would be needed to increase uptake and reduce reliance on other sources of cooking energy.

The intervention helped increase the use of electric cookers among the treated households. The probability of usage increased by 49 percentage points in the treatment group compared to the control group. The effect is statistically significant. Around half of the recipients using the devices is a positive outcome. Households might choose not to use a free product due

to unfamiliarity, concern about energy usage, or unsuitability for cooking needs, which are behavioural and contextual barriers and critical to explore for such interventions.

Satisfaction levels with the cookers were generally high. Other fuels, however, tend to be even more popular. Electric pressure cookers reduced reliance on woodfuel, charcoal, and diesel (-4.8 pp), but these statistical estimates have wide confidence intervals, indicating ambiguity in the impact of the intervention in fuel switching. However, when focusing on a subset of households—only the 49% of households who reported using the pressure cookers—one sees larger effects (since the households that did not use the cookers are ignored), with a decline of about 10 percentage points for firewood and 12 percentage points for any type of dirty fuel. Effects on time spent collecting fuels are ambiguous. Battery use increased as well (an approximate increase of 12%–17%), though the effect is not statistically significant.

Qualitative interviews and the endline survey reveal that gendered decision making and competing secondary uses affect the usage of batteries for electric pressure cookers. Consumers use SunCulture's battery for various purposes, including television. As a result, there is competition over different appliances that can be powered with it. Decision making over the battery is often made by men, whereas decisions over cooking are made by women, further reducing the overall use of electric pressure cookers.

In addition, the clients and those tested in this study are those who can afford the solar pump, battery, and television. They are therefore more likely to have access to LPG (<10% of the rural population in Kenya) than those who cannot afford the SunCulture system, providing them with alternative clean cooking options. This may help explain why around half of the households did not use the cookers, and others continued to use other energy sources. It also makes it harder to detect any effect of the cookers.

From a business perspective, there is demand for cooking as a secondary use of solar pumps. However, social barriers (like intra-household dynamics) and power limitations (like battery size) can impede it. Behavioural interventions that improve familiarity with the devices and encourage joint decision making could therefore improve uptake. The design of solar pump systems must also be tailored to address the needs of households. For instance, batteries must be powerful enough to enable multiple appliances and reduce the need for households to make choices about energy use. If subsidies are provided for solar cooking, energy allocation settings or "priority ports"—system controllers that reserve or prioritize a portion of battery or PV power for specific uses (e.g., cooking, refrigeration, etc.)—might be necessary to ensure that subsidized technologies are used as intended.

From a public policy perspective, the success of cooking as a secondary use depends on the existing market options. Competition from LPG and other fuels can be fierce, particularly where such energy sources are subsidized. This suggests that appliances such as electric pressure cookers are most competitive in markets where natural competitors such as LPG are too expensive or unavailable.

Globally, over USD 33 billion is spent on LPG subsidies, far more than the USD 8 billion needed to achieve universal clean cooking (Sustainable Development Goal 7). And yet many poor households (particularly in remote locations) remain reliant on biomass, even in countries such as India and Indonesia that provide both LPG and electricity subsidies.

Redirecting some of these funds, particularly from higher-income consumers to solar-based solutions in geographically remote regions, could help bridge this gap while also providing access to electricity for other purposes like lighting and phone charging. In addition, where solar-powered cooking can make use of surplus power, it could reduce the LPG costs for both households and governments (where LPG is subsidized).

The pilot findings suggest that e-cooking powered by secondary use of solar irrigation systems warrants further investigation. In Kenya, there are 35,500 solar water pumps in operation, suggesting that there is a major opportunity to expand clean cooking in these households with solar-powered devices. It is most likely to be useful in situations where

- solar pumps sit idle for a large part of the year (the median respondent uses their 2–3 times per week), resulting in surplus power (in our study, the cookers were in competition with pumping, as well as television);
- larger solar PV or battery capacity to increase the power available for e-cooking;
- dietary and cultural preferences include foods that are slow cooked, such as grains, pulses or rice;
- households do not have competing electricity demands like television;
- households do not have a battery and do not use irrigation every day, creating surplus power during solar hours for cooking (e.g., for lunch or dinner preparation); and
- LPG and grid electricity are not preferable cooking alternatives, either due to unavailability or high cost.

Policy Recommendations

- Integrate secondary use into solar irrigation programs, based on research on consumer circumstances and preferences.
    - Mandate that solar irrigation subsidies and programs account for surplus PV and build in mechanisms to channel it toward socially beneficial end uses like cooking, lighting, or productive loads.
    - Integrate structured consumer feedback, prioritizing women's voices as primary cooks, so that system and appliance design reflect actual cooking habits and household decision making.
- Design mechanisms to steer secondary use toward intended outcomes of subsidy policies, where applicable.
    - Develop energy allocation settings or "priority ports"—system controllers that reserve or prioritize a portion of battery/PV power for specific uses (e.g., cooking, refrigeration, etc.)—to ensure that subsidized technologies are used as intended.
    - Use monitoring and incentives: Explore low-cost Internet of Things tools to monitor the end-uses that solar photovoltaic-powered irrigation pump batteries are serving and incentivize intended use through monetary benefits (e.g., reduced monthly instalments or discounts on service fees) to households that demonstrate consistent use of solar e-cooking or other priority end-uses.

- Incentivize secondary-use devices through subsidies, finance, and payment installment mechanisms.
    - Price interventions should align with households' willingness to pay by using rebates, results-based financing, or a pay-as-you-go model.
    - Redirect a portion of LPG subsidies toward supporting e-cooking adoption (particularly in LPG-scarce, off-grid regions).
- Support research and development (R&D) and pilots for efficient secondary-use devices.
    - Incentivize R&D to develop higher-efficiency, user-friendly electric pressure cookers and secondary-use controllers.
    - Launch pilot variations (battery-heavy vs. battery-light systems) in multiple geographies to identify optimal configurations, most suited to consumer behaviour.
- Build a learning agenda.
    - Scale up structured pilots across diverse contexts (peri-urban vs. remote, LPG-available vs. LPG-scarce, with/without batteries) to identify the strongest use cases.
    - Governments can work with businesses, consumers, and other stakeholders to better understand how to scale secondary use in different contexts and markets and to identify innovative technologies and financing models.
    - Track fuel displacement, gender impacts, and secondary-use efficiency via periodic surveys.
    - Map the use cases for secondary use to understand the different technology options and under which circumstances each might be most feasible and beneficial.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Solar irrigation power represents a major untapped source of power because it often sits idle for part of the day or even the majority of the year, in the same regions that suffer energy poverty (Rahman & Jain, 2021c). As a result, there has been growing interest in promoting the secondary, non-water-pumping use of solar power (e.g., for lighting, phone charging, etc.). Promoting secondary use strengthens demand for these technologies and reduces wasted electricity.

In addition, the direct beneficiaries of solar irrigation subsidies are generally landowners: male farmers who can access grant schemes or loan products. Targeted policies and technologies that facilitate the use of secondary power by a broader group from the community would have a double benefit: maximizing the benefit of subsidies and reducing energy poverty for women and marginalized groups.

This report presents the results of a project conducted by the International Institute for Sustainable Development (IISD) and SunCulture, a Kenyan firm that provides solar water pumps. The novelty of the project consists of evaluating the impact of the distribution of electric pressure cookers powered from the secondary use of solar irrigation systems via a randomized control trial (RCT). A subset of SunCulture's customers randomly received an electric pressure cooker for free. These cookers are powered by batteries that are included in the solar photovoltaic-powered irrigation pumps (SIPs) provided by SunCulture. The objectives of this research were to

1. identify whether SIPs can support secondary uses to increase value for a more diverse range of beneficiaries while creating an incentive to use water sustainably;
2. establish and road-test methods to pilot secondary usage in ways that maximize benefits for low-income households, women, and youth;
3. reduce demand for traditional fuels (benefiting women and girls as primary cooks);
4. provide a solar-powered service that focuses primarily on the needs of women; and
5. increase the value of secondary use for SunCulture's solar irrigation system.

In doing so, the project's working hypothesis was that providing a secondary use of solar power may lower the barrier to adoption of a cleaner cooking technology. Solar pump users are already familiar with the solar panel, pump, and battery, making the addition of pressure cookers easier.

The project was part of the 2-year study, Unlocking Inclusive Policy Making for the Clean Energy Transition, funded by the International Development Research Centre Canada and led by the International Institute for Sustainable Development in collaboration with numerous partners from the Global South and academic research institutions. The objective was to create knowledge that would change the design of energy policy to achieve more inclusive and sustainable outcomes.

2.0 Background and Literature Review

The following sections provide context for the main research areas: the transition to clean cooking technologies, solar irrigation pumps and secondary use, and an overview of energy and cooking in Kenya.

2.1 Clean Cooking Technologies

About 2.1 billion people globally rely on traditional fuels such as firewood, charcoal, and dung for cooking (International Energy Agency [IEA], 2023; IEA et al., 2025). This represents about 26% of the world's population. The problem is acute in sub-Saharan Africa, where the number of people lacking clean cooking solutions now affects about 80% of households—roughly 1 billion people (IEA, 2025, p. 11). In Kenya, 70% of the total population uses traditional fuels for cooking, mostly affecting the rural population (World Bank, n.d.-a).

These fuels are inefficient and create severe health issues, primarily via indoor air pollution (Ezzati et al., 2004; Lim et al., 2012; World Health Organization, 2014) that increases the risk of respiratory and other diseases (Murray et al., 2020; World Health Organization, 2025). They also result in environmental damage, including deforestation (Chafe et al., 2014; Hosonuma et al., 2012).

Some of these impacts tend to be gendered. Since cooking is often primarily done by women and girls, they tend to be more exposed to its negative consequences (Bonjour et al., 2013; Lim et al., 2012). Likewise, women tend to spend more time collecting wood fuel (Jagoe et al., 2020). The way households use energy is often gendered as well, with some appliances being more popular among men and others among women (Rosenberg et al., 2020).

The disadvantages of these cooking technologies have triggered a global push for cleaner and safer options (Anenberg et al., 2013; Foell et al., 2011; Grieshop et al., 2011; IEA, 2023). These options include the use of alternative fuels or carriers (liquefied petroleum gas [LPG], electricity, and ethanol), different cookstoves (improved cookstoves, etc.), and new kitchen designs (e.g., ventilation). A recent meta-analysis reviewing the ambient air and health impacts of these technologies highlights the benefits of cooking with LPG and with electricity, in particular (Pope et al., 2021).

Policy-makers have expressed a strong interest in promoting clean cooking. Indeed, many states are explicitly including clean cooking technologies as part of their climate plans under their nationally determined contributions.[1] However, the impact of clean cooking technologies has been uneven, despite large subsidies in many countries. Since 2010, nearly 1.5 billion people in Asia and Latin America have transitioned to cleaner cooking technologies, cutting the number of people without access in half over 15 years (IEA, 2025, p. 11). This progress was largely driven by government-led programs, with most households adopting LPG, followed by electricity and other clean options. In contrast, in sub-Saharan Africa, the number of people lacking access is increasing (IEA, 2025).

[1] See countries' nationally determined contributions at the UN Framework Convention for Climate Change's NDC Registry: https://unfccc.int/NDCREG

Part of the problem is that electricity and LPG—even when subsidized—is often more expensive and difficult to access for the poor in remote areas or urban slums. Biomass, when collected by the household, is considered free. Another shortfall in policy-making is a failure to understand consumer needs, leading to limited demand from households for innovative solutions (Chalise et al., 2018; Jeuland & Pattanayak, 2012; Lewis & Pattanayak, 2012; Mobarak et al., 2012; Tornel-Vázquez et al., 2024).[2] Clean cooking technologies are often designed with little input from potential consumers (Mobarak et al., 2012). They therefore fail to meet people's needs and remain underused. Adopting these technologies, while beneficial from health and environmental perspectives, may disrupt cooking habits. Low awareness of the health damage caused by traditional cooking fuel further raises the bar for substitution toward cleaner solutions (Zahno et al., 2020).

However, LPG is also problematic. Governments spent approximately USD 33 billion globally on LPG subsidies for cooking in 2022 (IEA, 2023), far above the estimated USD 8 billion per year needed to achieve universal clean cooking (Sustainable Development Goal 7). Much of this public support is poorly targeted, often benefiting wealthier households rather than the energy poor, particularly because LPG is less available in rural areas. Public expenditures on LPG and electricity subsidies are a major fiscal burden, while clearly being an insufficient strategy to provide universal clean cooking, given persistent reliance on biomass by the poor, even in countries with large electricity and LPG subsidies, such as India and Indonesia.

Despite decades of efforts and billions spent on fossil fuel and electricity subsidies, progress in the transition to clean cooking technologies has been slow (Aklin et al., 2018; IEA, 2023). The literature has identified several bottlenecks. First, cost can impede fuel switching. LPG, for instance, is often more expensive (even when heavily subsidized) than seemingly free firewood that can be collected at no expense (setting aside the opportunity cost of the time spent collecting it) (Gould & Urpelainen, 2018).

Second, as discussed above, new cooking technologies often poorly fit people's needs and preferences. Cooking connects to cultural traditions and norms, as well as daily habits (Akintan et al., 2018; Hooper et al., 2018; Mobarak et al., 2012; Pattanayak et al., 2019). Cooking devices must be adapted to the staples commonly consumed (such as ugali or beans). Different cooking durations, cooking capacity, and ease of use can also affect users' willingness to switch. New cooking technologies that necessitate profound changes in how households cook are unlikely to be welcomed. These problems can be compounded by ex ante uncertainty and ex post technical failures, both of which can discourage potential customers (Chalise et al., 2018; Dendup & Arimura, 2019; Hanna et al., 2016).

Third, observers have raised the potential issues caused by intra-household disagreements (Alem et al., 2023; Rosenberg et al., 2020). In many societies, decisions over important expenses are often made by men. Yet cooking is mostly done by women. Thus, there is potential for a mismatch: the benefits of clean cooking technologies are not accrued by the primary decision-maker of the household. Such intra-household dynamics could, in turn, slow down the adoption of newer cooking technologies (Miller & Mobarak 2013).

[2] "Clean" is here defined at the point of usage. For instance, an electric stove does not generate emissions when being used (and thus qualifies as "clean"), but electricity generated to power it could be polluting.

2.2 Solar Irrigation and Secondary Use

The list of barriers to clean cooking technologies raises a natural question: Are there new cooking technologies that can seamlessly be integrated into people's cooking habits based on the design of the technology and the familiarity of potential users?

This project investigates the potential of electric pressure cookers powered by batteries attached to solar irrigation pumps. The underlying assumption is that households already have these technologies, and any surplus power could be used to run the new cooking device with minimal inconvenience to households. As such, this project also connects to the opportunity of solar irrigation and its secondary use.

SIPs have received considerable interest from farmers, policy-makers, and scientists (Food and Agriculture Organization of the United Nations [FAO], 2018; International Renewable Energy Agency [IRENA], 2016; Kelley et al., 2010; Meah et al., 2008; Smith & Allison, 1978). The idea to use solar photovoltaic (PV) for water pumping and farming goes back to the 1970s (Smith & Allison, 1978). In recent years, several countries have witnessed a rapid increase in the number of SIPs. The low cost of solar PV panels further reinforced the belief that solar water pumps may be an effective solution to water access, both for irrigation and for drinking (EED Advisory, 2018). In India, for instance, it is estimated that more than 900,000 off-grid solar pumps have been deployed (Rahman & Jain, 2021b).[3] In Kenya, a 2021 study estimates that there are 35,500 solar water pumps in operation (EED Advisory & VeraSol, 2021), suggesting that there is a major opportunity to expand clean cooking in these households with solar-powered devices. For instance, the Kenyan government funded a community-level solar-powered water pump in several counties across the country (Njagi, 2019).

In its simplest version, a SIP system uses solar PV panels to power a water pump. The pump can extract water from a well or from a surface-level source, such as a river. It can then be operated by a hose to help irrigate crops. SIPs may additionally include a battery to increase the flexibility of the pump's usage or to enable other services that necessitate electricity outside of solar hours.

Initially found in industrialized countries, solar irrigation has increasingly become more popular in emerging markets (Wazed et al., 2018). SIPs have facilitated smallholder farmers' access to managed irrigation in several regions, including South Asia (India) and East Africa (Kenya) (FAO & IRENA, 2021; Global Off-Grid Lighting Association, 2021; Rahman et al., 2021). The benefits are particularly high for small-scale farmers who do not have access to other irrigation sources (diesel or grid-connected pumps) and face an inconsistent water supply. This characterizes regions such as parts of sub-Saharan Africa, South Asia, and the Middle East and North Africa (Closas & Rap, 2017). Given the importance of the agricultural sector in these regions, a more reliable water supply may improve output and therefore stabilize farmers' income. Furthermore, in places where irrigation pumps are powered by diesel, solar irrigation may also offer environmental benefits.

[3] Data from the PM-KUSUM dashboard, available at https://pmkusum.mnre.gov.in/#/landing.

SIPs raise three issues. The first is that SIPs stand idle for long periods of time. The need for irrigation varies within and across seasons. Irrigation demand in a typical year is about 150 days (Working Group for Agricultural Consumption, 2020), and the energy generation potential is wasted in the remaining days. In Chhattisgarh (India), for instance, farmers only use 27% of the electricity generated by water pumps (Rahman & Jain, 2021b). For businesses in the solar irrigation sector and for energy-poor communities, this represents a missed opportunity. As a result, developing a secondary use for SIPs represents a business opportunity and a means for maximizing any subsidies for SIPs, especially for those that include batteries. Secondary uses may include lighting, phone charging, televisions, and so forth. Our study focuses on electric pressure cookers as a promising source of secondary use.

Second, lowering the cost of irrigation may encourage the overuse of groundwater (Closas & Rap 2017; FAO, 2018). The near-zero operating cost also leads to inefficient irrigation practices depleting groundwater (Beaton et al., 2019). Solutions such as drip irrigation and creating a market for water could mitigate this problem (Raymond & Jain, 2018).

Third, subsidies for irrigation are inequitably distributed. Government subsidy support has predominantly promoted a model of individual pump ownership, but that has many inherent flaws. The subsidy support is typically only available to landowning farmers and excludes landless farmers. Further, the huge upfront investment required, despite the government subsidy, makes it unaffordable for small and marginal farmers. This social inequity also produces gender inequity in asset ownership. In India, women comprise 48% of self-employed farmers (Oxfam India, 2018), but they own only 13.96% of agricultural land holdings (Ministry of Agriculture, 2020). This share further decreases with the land-size group: while 14.7% of marginal land holdings belong to women, the share is only 8% for landholdings (Government of India, 2019). Some studies have shown that the direct impact of these factors is very low for solar pump ownership among women (Rahman & Jain, 2021a). The situation of women's land ownership is similar in other parts of South Asia, Southeast Asia, and sub-Saharan Africa (Doss et al., 2015; Hill, 2011).

Using surplus energy for other productive purposes will likely generate more returns from investments in solar pumps and improve financing prospects, while also likely incentivizing efficient use of groundwater. The secondary activity could be post-harvest management, food-processing, cold storage, or other microenterprises. Energy access for post-harvest management can reduce drudgery and increase productivity, with particularly large improvements in well-being for women (Chayal & Dhaka, 2010). In India, microenterprises are another sector that typically faces a severe lack of access to reliable energy (Waray et al., 2018). Microenterprises also have a high representation of women, with more than 20% of microenterprises run by women (Ministry of Micro, Small and Medium Enterprises, 2024, p. 132). Sectors like textiles and agro-processing have a much higher share of women in the labour force (Patnaik et al., 2021). These are also among the sectors with market-ready products optimized for distributed renewable energy (Waray et al., 2018).

In the establishment of a guidebook on the sustainable implementation of solar irrigation in India, IISD identified a significant knowledge gap around the implementation of policy frameworks to promote the secondary usage of solar pumps, based on interviews with numerous stakeholders across the sector (Goel et al., 2021). Challenges include the need for

charge controllers that can be used to divert energy from pumps to other electric equipment, unbalanced loads when such devices are used, the need for additional power evacuation infrastructure, and potential regulatory barriers, such as when the use of a solar system for non-irrigation purposes is defined as a breach of warranty.

A pilot of secondary usage was identified in West Bengal (Shirsath et al., 2020), but this focused on technical and financial feasibility, with broader consideration of the needs and perceptions of disadvantaged stakeholder groups who could serve as primary beneficiaries. Similar conclusions were reflected in a collaboration between IRENA and the FAO in a review of renewable energy for agri-food systems with respect to Sustainable Development Goals 2 and 7 on zero hunger and affordable and clean energy, respectively. Among its recommendations, the review highlighted the need for innovation so that agri-food business appliances are compatible with renewable energy supply systems, including piloting technological solutions to test the operational viability of appliances, establish supply chains, and identify needs for operations and maintenance services (FAO & IRENA, 2021). The same review also emphasized an increasing need to "place inclusivity at the heart of transforming the food and energy systems," including work to ensure equal access to benefits among women, youth, and marginalized communities (FAO & IRENA, 2021).

2.3 Energy Access and Cooking in Kenya

Classified by the World Bank as a lower-middle-income country, Kenya has been experiencing rapid changes in energy access over the last decade (World Bank Group, n.d.-b). Household electricity access has grown from 16% in 2003 to 76% (68% in rural areas) in 2023 (World Bank Group, 2023). This progress coincides with ambitious plans by the Kenyan government to achieve universal electricity access. The 2015 *Last Mile Connectivity Program* was launched to help expand access, including among the poorest households (Lee et al., 2020).

Access to clean cooking has also steadily improved. In 2010, only 7% of the population had access to clean cooking technology. In 2022, this number had reached 30%. Rural areas have also improved, but at a much lower level: over the same period, access to clean cooking technology went from 1.6% to 10%. Data suggests that about 69% of the population (both urban and rural) relies on traditional cooking fuels. In rural areas, biomass was the dominant source of energy (wood in 80% of households and charcoal in 7.7%), with LPG at 8.8%. In urban areas, LPG is ahead (60%), with charcoal (17%) and woodfuel (9%) second and third, respectively (Kenya National Bureau of Statistics, 2022, Table 2.2).

The cost of cooking can vary, and recent estimates are difficult to localize. Estimates from a study conducted in 2017 suggest that stoves used with woodfuel cost from KSH 0 (three stone fire) to KSH 500 (USD 3.8) (Rahnema et al., 2017). The cost of stoves used with charcoal is in a similar range, though ceramic stoves can cost up to KSH 1,000 (USD 7.7). LPG stoves, in contrast, typically cost between KSH 3,500 and KSH 7,000 (USD 27–54), not including the running cost of the fuel or its transport.

The Kenyan government has also expressed a strong desire to accelerate the transition toward clean cooking fuels. Its goal is to provide universal access to clean cooking by 2028 (Ministry of Energy, 2022). To coordinate efforts, the Ministry of Energy launched the *Kenya National Cooking Transition Strategy* in 2022 (IEA, 2024). Its focus lies particularly on LPG, ethanol, and electricity as keys to deliver universal clean cooking access. Yet electric cooking is rare, and it has been slow to grow (Onsongo et al., 2023), partly because of the high cost of electric stoves and long supply chains.

3.0 Methodology

The SunCulture-IISD project aimed at assessing the potential of one type of electric appliance—pressure cookers—embedded in existing infrastructure: solar irrigation. SunCulture supplies solar irrigation systems, including a battery usable for secondary uses, across Kenya since its launch in 2017. Piloting the secondary use of solar irrigation power for clean cooking is a novel approach that, to our knowledge, is unique in the research field. The details of the study are discussed below.

3.1 Randomized Controlled Trial

The central aim of this study is to assess the prospects of electric cooking as a secondary use of solar irrigation pumps. One way to evaluate these prospects is to measure the impact of electric cookers on potential customers: Do they use these cookers if given the opportunity? Do they displace traditional fuels? And do they affect the overall consumption of electricity? The current scientific literature offers little guidance on these questions, aside from the studies cited above. Answering these questions is difficult. Relying solely on data on households' behaviour can be misleading: maybe these households are fundamentally different in a way that makes extrapolating their situation unreliable. This would make it difficult to use such findings to scale up electric cooking as a solution to the problems of clean cooking and of secondary use of solar pumps.

To avoid this danger, this project implemented an RCT, a tool commonly used across fields in the social sciences and development economics (Angrist & Pischke, 2010; Baldassarri & Abascal, 2017; Duflo, 2020). The underlying idea of an RCT resembles that of clinical trials: units (patients) are randomly allocated to a treatment and a control group. The treatment group is exposed to an intervention (e.g., a new drug), whereas the control group is not. The analyst then measures an outcome of interest (e.g., level of pain) and compares its average value in the treatment and in the control group. Since the assignment to either group is random, there is no reason to expect that the two groups differ, on average, on other factors that could affect the outcome of interest. This implies that any difference between the two can be, in principle, attributed to the treatment. In addition, a dozen interviews were also conducted by SunCulture to contextualize the results and provide qualitative insights.

This project applies the logic of an RCT to the problem of measuring the causal effect of electric pressure cookers. The treatment group consisted of a sample of SunCulture customers, where the "treatment" was the offer of a free electric pressure cooker. The pressure cooker itself had a capacity of 4.16 litres, included a non-stick cooking pot, and offered safety features such as an insulated body and power cord. As in a medical trial, randomization helps increase our trust in our statistical analysis because it reduces concerns that differences in outcomes are caused by other differences, such as households' wealth or size.

As such, RCTs stand in contrast to observational studies, in which the analyst does not control the distribution of the treatment. In such cases, differences in outcomes of interest are difficult to assign to the pressure cooker rather than other factors that could simultaneously be related to the ownership of a pressure cooker and the outcomes of interest. For instance,

in an observational study, one may find that richer households are both more likely to buy an electric pressure cooker and already use LPG, therefore making it difficult to disentangle any effect that the pressure cooker has from the wealth of the household.

In this study, two kinds of assessments are relevant. First, from a policy-maker's perspective, an important quantity is the average difference in key outcomes between the treatment and the control group. When all members of the treatment groups "comply" with their treatment (here, meaning that they use solar pressure cookers when given one), then such a difference is straightforward. However, it may be that members of the treatment group behave as "defiers": households that refuse to use electric pressure cookers. In such a case, the difference in average outcomes is called an intent to treat (ITT). It quantifies the overall effect of the treatment (pressure cookers) regardless of whether they were used or not.[4]

Second, one may want to know if pressure cookers affected outcomes (discussed below) among households in the treatment group that not only received an electric pressure cooker, but also ended up using them. In the technical jargon of RCT, these assessments are called *local average treatment effects* (LATE). They capture the effect of pressure cookers on those who used them. Note that the effects observed on these individuals may not necessarily be extrapolated to other households. Maybe the people who used the cookers are especially open to new technologies or different cooking techniques in a way that does not apply to others. As such, we see the LATE estimates as being suggestive of the impact that electric pressure cookers could have, assuming they were being used.[5]

3.2 Outcomes and Measurement

This project was interested in several outcomes:

- Did usage of electric pressure cookers increase in the treatment group?
- Did electric pressure cookers reduce the use of traditional fuels? Did they increase electricity consumption from the solar battery?
- Did electric pressure cookers reduce the burden of traditional fuels?

To quantify these relations, the project team undertook an RCT among SunCulture customers. A random set of 100 customers was given an electric pressure cooker for free

[4] Formally, the ITT is estimated from the following linear model:

$$\text{Outcome}_{i,t} = \beta \text{Treatment}_{i,t} + \phi_i + \tau_t + \varepsilon_{i,t}$$

where i denotes a household and t is the survey wave (baseline or treatment). Households in the treatment group are coded as 1 in the endline, regardless of whether they use the electric pressure cooker. The models are estimated by least squares, and standard errors are clustered at the household level. The estimated parameter β represents the intent to treat effect of the cookers on the outcomes of interest.

[5] The LATE estimates are obtained from a two-stage least square regression:

$$\text{Using EPC} = \gamma \text{Treatment}_{i,t} + \phi_i + \tau_t + \mu_{i,t}$$

$$\text{Outcome}_{i,t} = \beta \text{Using EPC}_{i,t} + \phi_i + \tau_t + \varepsilon_{i,t}$$

where β is the parameter capturing the LATE. The underlying assumption is that the treatment "works" (that is, increases the use of electric pressure cookers). This is captured by the F statistic on the omitted instrument (Andrews et al., 2019). Here, the F statistic was 167, far above thresholds typically used to be concerned about weak instruments.

with no other obligations. Another random set of 140 customers served as the control group. Customers were selected from SunCulture's database based on their SunCulture system (a battery was needed to power the pressure cooker during non-solar hours). The size of the treatment group was partly determined by resources: how many cookers the project could afford to provide, balanced against the minimal number needed to give a reasonable chance of delivering statistically meaningful results. Given the geographic distribution of households included in the study, the risk of spillover is negligible.

To measure the outcomes of interest, the team conducted two surveys among all selected households. A baseline survey was fielded in October 2024 by 60 Decibels, a professional survey company. This was followed by the distribution of electric pressure cookers among households in the treatment group in early 2025. Finally, an endline survey was fielded in June 2025, also by 60 Decibels. All respondents were asked for consent to participate in both surveys.

Note that these outcomes do not include all the potential benefits associated with electric cooking. For instance, the project did not evaluate the impact it could have on indoor air pollution (Chakraborty et al., 2025). Such impacts are not well captured by surveys and would require a different research strategy.

4.0 Analysis

4.1 Descriptive Statistics

First, we report summary statistics to describe our households in terms of their socio-economic profile and their energy access situation. Table 1 reports the age and gender of the respondents.

Table 1. Age and gender (endline data)

	Number of respondents	Mean	Standard Deviation	Minimum	Maximum
Age of respondent	188	46.18	12.61	22.00	75.00
Women	242	0.31	0.46	0.00	1.00

Source: Authors' analysis of endline survey data.

The average respondent was about 46 years old at the time of the baseline survey, and about 31% of respondents were women. Table 2 shows that the households included in the survey had received considerable formal education, almost all respondents having finished secondary school and a large share having completed tertiary education, which includes different types of schools (agricultural colleges, etc.).

Table 2. Education (endline data)

Education	N	%
1: Primary school	1	0.41
2: Lower secondary school	4	1.65
3: Upper secondary school	74	30.58
4: Tertiary education (university, polytechnic)	162	66.94

Source: Authors' analysis of endline survey data.

Table 3 reports the distribution of income based on monthly expenditures as a proxy. The modal expenditure bracket is KSH 10,000 to KSH 20,000 (USD 77 to USD 155 per month). To benchmark this number, the Kenya Bureau of National Statistics (2022) reports that the average monthly wage in the agricultural sector in 2022 was about KSH 33,000. SunCulture systems are not subsidized; therefore, the clients and those tested in this study are those who can afford the solar pump, battery, and television at market prices. These relatively well-off households were also more likely to have access to LPG (less than 10% of the rural population in Kenya), providing them with alternative clean cooking options.

Table 3. Monthly expenditures (endline data)

Typical monthly expenditure	N	%
1: KES 0–5,000	23	9.70
2: KES 5,001–10,000	74	31.22
3: KES 10,001–20,000	90	37.97
4: KES 20,001–30,000	32	13.50
5: Above KES 30,000	17	7.17
6: Don't know or can't say	1	0.42

Source: Authors' analysis of endline survey data.

Most households used the irrigation pump daily, or at least several times per week (Table 4). For households that use the pump daily, there would be little surplus activity for secondary uses, in contrast to those who only use the pump once a week or only in the dry season (around 17% in total).

Table 4. Usage of solar-powered water pump (baseline data)

Pump Use Frequency	Number of Respondents	%
Multiple times a day	7	2.9%
Every day	122	50.4%
4–6 times per week	12	5%
2–3 times per week	57	23.6%
Once a week	23	9.5%
Only during the dry season	17	7%
Don't know or can't say	2	0.8%
NA	2	0.8%

Source: Authors' analysis of endline survey data.

Next, we examine the energy sources (fuels) used for cooking. Table 5 reports the share of households that used each type of fuel between the baseline and the endline survey. Note that respondents were asked to list all fuels they typically use. Firewood, charcoal, and LPG represent the biggest sources of cooking fuels used by respondents, with shares of 76%, 70%, and 52%, respectively (baseline data). The sample, therefore, includes households at the intersection between reliance on solid fuels (charcoal and woodfuel) and access to modern, cleaner fuels (LPG).

Table 5. Energy sources used for cooking (endline and baseline data)

	Survey round	
Energy source	**Baseline N = 242**	**Endline N = 242**
Firewood	183 (76%)	175 (72%)
LPG	169 (70%)	156 (64%)
Solar	1 (0.4%)	20 (8.3%)
Charcoal	127 (52%)	144 (60%)
Biogas	9 (3.7%)	15 (6.2%)
Electricity	12 (5.0%)	10 (4.1%)
Kerosene	2 (0.8%)	1 (0.4%)
Pellets	0 (NA%)	2 (0.8%)
Other sources	3 (1.2%)	4 (1.7%)

Source: Authors' analysis of baseline and endline survey data.

In Table 6, we report the results of the balance test. If randomizing households into the treatment or the control group was successful, then no socio-demographic variable should predict the treatment status of a given household. And indeed, no variable—neither age, gender, education, income levels, nor the primary cooking fuel used by a household—is predictive of whether a household received the treatment.

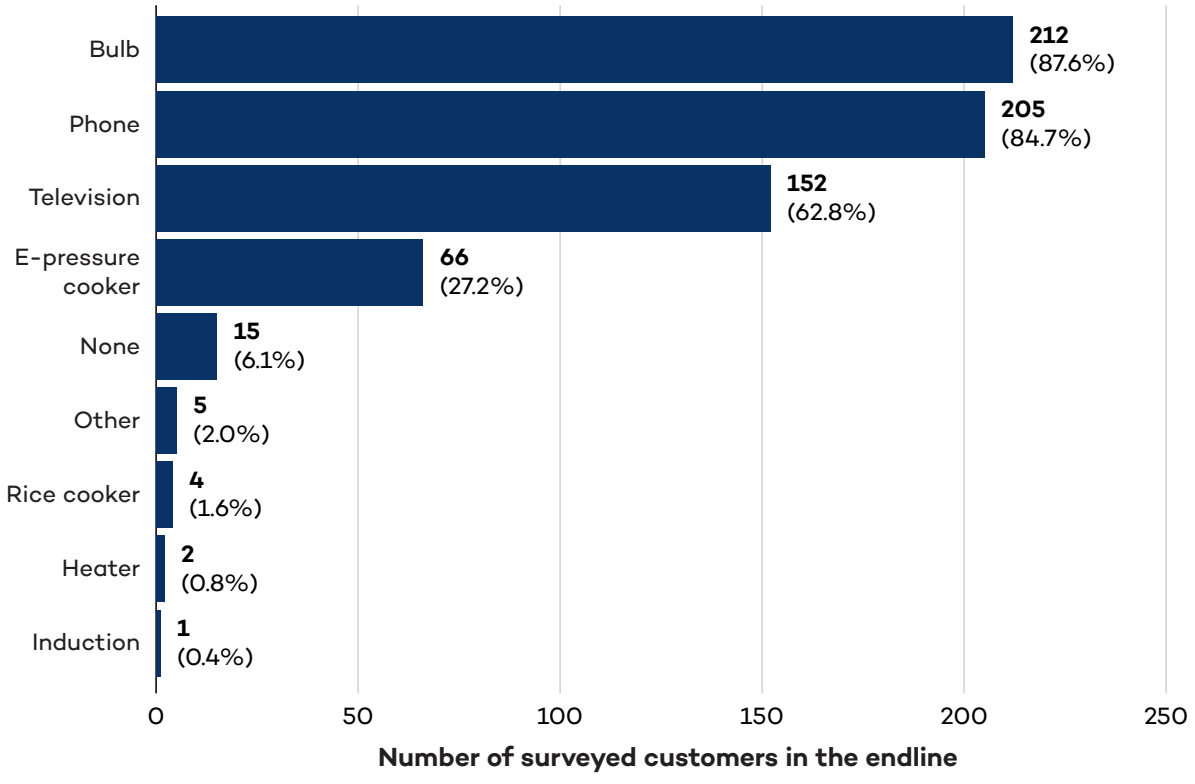
Table 6. Balance of treatment assignment

	Socio-demographics	**Adding county FE**	**Adding energy**
Upper secondary school	-0.168	-0.032	-0.056
	[-0.645, 0.308]	[-0.593, 0.528]	[-0.629, 0.517]
Higher education	-0.241	-0.111	-0.146
	[-0.711, 0.229]	[-0.682, 0.461]	[-0.734, 0.442]
Age	0.001	0.000	0.001
	[-0.004, 0.005]	[-0.005, 0.006]	[-0.004, 0.007]
Female	-0.085	-0.087	-0.088
	[-0.214, 0.045]	[-0.220, 0.045]	[-0.224, 0.047]
Expenditure (5-10k/ month)	0.128	0.206	0.211
	[-0.109, 0.365]	[-0.050, 0.462]	[-0.049, 0.472]

	Socio-demographics	Adding county FE	Adding energy
Charcoal			0.015
			[-0.165, 0.194]
Firewood			-0.057
			[-0.260, 0.145]
LPG			0.017
			[-0.172, 0.205]
Number Observed	188	188	188
R^2	0.065	0.229	0.232
RMSE	0.48	0.43	0.43
Mean (DV)	0.43	0.43	0.43
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)

Notes: The dependent variable equals 1 if the household is in the treatment group and zero otherwise. The second model includes county fixed effects (not reported). The last model includes the most commonly used primary fuels. 90% confidence intervals in brackets.
Note for Tables 6, 8, 10, 11, 12, 13, and 14: R^2 = Coefficient of Determination, RMSE = Root Mean Square Error, Mean (DV) = Mean of Dependent Variable, SE = Standard Error, HH = households.
Source: Authors' analysis of survey data.

Figure 1. Usage of the SunCulture battery (raw count and percentage) (endline data)



Source: Authors' analysis of endline survey data.

An important element of this study is the battery provided by SunCulture. In Figure 1, we report the list of appliances that respondents use with the solar-powered battery. As we can see, virtually all respondents use lighting bulbs and phone charging. Television is also popular. Electric pressure cookers come in fourth.

4.2 Impact of Electric Pressure Cookers

The project aimed to measure the effect of electric pressure cookers at three levels. First, were they used? To examine this, Table 7 reports ownership and usage of pressure cookers between the treatment and control groups.

Table 7. Electric pressure cooker: Share of households that own one and share of households that use one

	Control		Treatment	
	Baseline	**Endline**	**Baseline**	**Endline**
Ownership of electric pressure cooker	9.20%	12%	6.50%	87%
Usage of electric pressure cooker among owners	NA	82.40%	NA	72.60%
Usage of electric pressure cooker overall	NA	9.90%	NA	62.90%

Source: Authors' analysis of baseline and endline survey data.

Table 8 reports the more systematic statistical analysis linking the treatment (a free pressure cooker) to its deployment. We find that the treatment increased ownership of electric pressure cookers by 76 percentage points (with a 90% confidence interval of 66% to 85%). This is not self-evident: giving an item for free (as in this RCT) is not the same as the subject *accepting* it. Studies on clean cooking stoves, for instance, identify low demand and interest as a major barrier to diffusion (Mobarak et al., 2012). Furthermore, if the item ends up being unused, we may even expect respondents to forget about it when being surveyed.

Table 8. Effect of treatment on electric pressure cooker (EPC) ownership and usage

	EPC ownership	**EPC usage**	**EPC usage** (only 83 treated households in the endline)
Treatment	0.759	0.494	
	[0.666, 0.853]	[0.395, 0.594]	
Upper secondary school			0.868
			[0.546, 1.190]
Higher education			0.657
			[0.337, 0.976]
Age			-0.003
			[-0.013, 0.007]
Female			0.032
			[-0.222, 0.286]
Expenditure (5-10k/month)			-0.126
			[-0.514, 0.263]
Expenditure (10-20k/month)			0.015
			[-0.303, 0.334]
Expenditure (20-30k/month)			0.078
			[-0.404, 0.561]
Expenditure (>30k/month)			-0.081
			[-0.597, 0.436]
Num.Obs.	466	445	83
R^2	0.778	0.742	0.403
RMSE	0.21	0.19	0.37
Mean (DV)	0.26	0.17	0.64
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)

Notes: Models in the first and second include household and survey-fixed effects. The model in the third column uses data from treated households in the endline survey to examine whether gender, age, monthly expenditures, and education predict solar cooker usage (county fixed effects included but not reported). 90% confidence intervals in brackets.

Source: Authors' analysis of baseline and endline survey data.

Perhaps more importantly, the treatment also increased the use of these pressure cookers by 49 percentage points (with a confidence interval ranging from 40% to 59%), where "use" is defined as using a cooker at least once a week. When asked how many times they used the electric cooker in a typical week, the median respondent indicated using it twice. Interestingly, we do not see a systematic difference in use (within the treatment group) between female and male respondents, nor between richer and poorer households, nor between people of varying ages. However, we find that respondents with higher levels of formal education were more likely to use the cookers (among households in the treatment group).

In sum, there is strong evidence that the treatment succeeded, in the sense that consumers accepted the offer and, more importantly, are using these cookers.

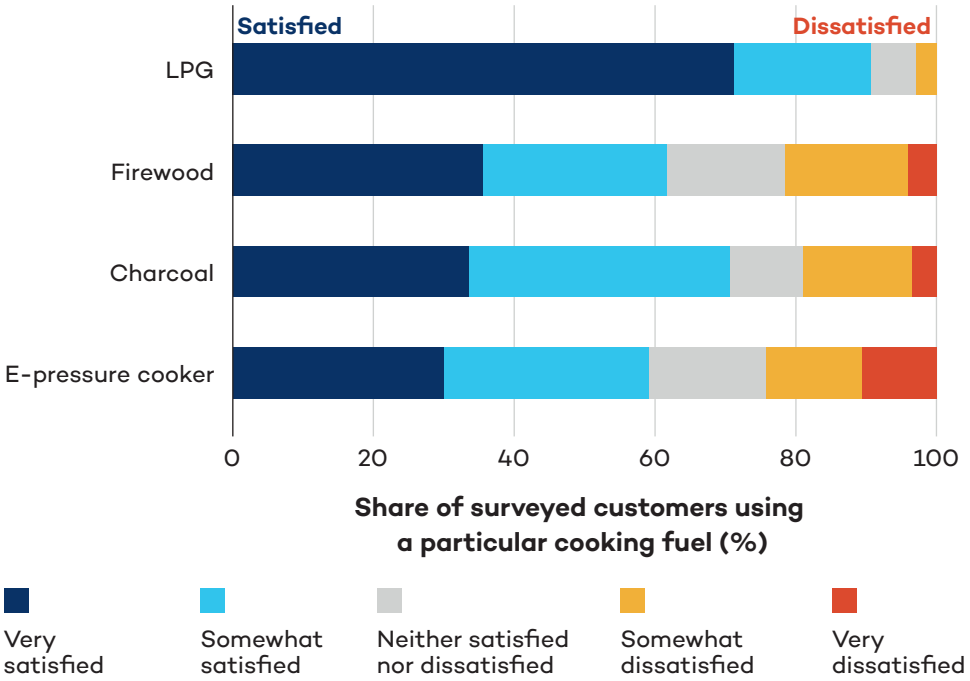
We also examined the level of satisfaction with electric pressure cookers. Note that a handful of households in the control group had an EPC as well. The split is reported in Figure 2 and Table 9. We observe that the overall level of satisfaction is generally positive, with 56% of respondents being somewhat or very satisfied. However, we also see that satisfaction levels are even higher with LPG. This may have important policy and business implications, since LPG could represent a natural alternative to pressure cookers.

Table 9. Satisfaction with the electric pressure cooker by treatment status (endline status)

	Treatment Group	
Satisfaction with pressure cooker	**Control N = 142[1]**	**Treatment N = 100[1]**
1: Very dissatisfied	183 (76%)	175 (72%)
2: Somewhat dissatisfied	169 (70%)	156 (64%)
3: Neither satisfied nor dissat-isfied	1 (0.4%)	20 (8.3%)
4: Somewhat satisfied	127 (52%)	144 (60%)
5: Very satisfied	9 (3.7%)	15 (6.2%)
Unknown	12 (5.0%)	10 (4.1%)
Kerosene	2 (0.8%)	1 (0.4%)
Pellets	0 (NA%)	2 (0.8%)
Other sources	3 (1.2%)	4 (1.7%)

Source: Authors' analysis of endline survey data.

Figure 2. Satisfaction with various cooking technologies (endline data)



Source: Authors' analysis of endline survey data.

Table 10. Effect of e-pressure cookers on usage of firewood, charcoal, LPG, and any traditional dirty fuel (firewood, charcoal, kerosene) as the primary source of cooking

	ITT			
	Firewood	**Charcoal**	**Kerosene**	**Any dirty fuel**
E-pressure cooker	-0.064	-0.037	-0.010	-0.048
	[-0.176, 0.049]	[-0.162, 0.088]	[-0.027, 0.007]	[-0.139, 0.042]
Num.Obs.	484	484	484	484
R^2	0.697	0.662	0.504	0.621
RMSE	0.26	0.29	0.03	0.20
Mean (DV)	0.66	0.42	0	0.88
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)

Note: The estimates are ITT effects. 90% confidence intervals in brackets.
Source: Authors' analysis of baseline and endline survey data.

Second, did the electric pressure cooker affect the use of traditional fuels? Table 10 reports the ITT effect of the electric pressure cooker on the use of firewood (first column), charcoal (second column), LPG (third column), and any dirty fuel as primary sources of cooking. We observe that, on average, all three types of fuels experienced a reduction in use in the

treatment group, with effects ranging from -1 percentage points (kerosene) to -6.4 percentage points (firewood). The use of dirty fuels was reduced by 4.8 percentage points. None of these estimates reaches statistical significance, but they all point toward a potentially beneficial effect of the pressure cooker.

Table 11 reports the equivalent LATE estimates. Recall that these capture the effect of the pressure cookers on households that used them, whereas the ITT compares the treatment and the control group regardless of whether people used the cookers. As expected, we find larger effects (since the households that did not use the cookers are ignored), with a decline of about 10 percentage points for firewood and 12 percentage points for any type of dirty fuel. However, given that these estimates rely on a smaller number of households, they tend to have wider confidence intervals, and therefore none are statistically significant.

Table 11. Effect of e-pressure cookers on usage of firewood, charcoal, LPG, and any traditional fuel as the primary source of cooking

	Local average treatment effect			
	Firewood	**Charcoal**	**Kerosene**	**Any dirty fuel**
Using pressure cooker	-0.104	-0.075	-0.024	-0.122
	[-0.351, 0.143]	[-0.354, 0.204]	[-0.062, 0.015]	[-0.311, 0.067]
Num.Obs.	445	445	445	445
R^2	0.718	0.675	0.505	0.663
RMSE	0.25	0.28	0.03	0.19
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)
F-test (1st stage)	167.3	167.3	167.3	167.3

Note: The estimates are LATE. All models include household and survey-fixed effects. Standard errors are clustered at the household level. 90% confidence intervals in brackets.
Source: Authors' analysis of baseline and endline survey data.

We report the result of a linear regression in Table 12 (where columns 1 and 2 are ITT estimates and columns 3 and 4 are LATE estimates). We find that the free distribution of the cookers increased consumption by about 12% to 18% (ITT estimates). Among households that used pressure cookers (LATE), we find that the effects range from about 20% to 26%. As before, the confidence intervals are wide, and the estimates are not statistically significant.

Table 12. Effect of electric cookstoves on battery electricity consumption

	ITT		LATE	
	Watt-hours (log+1)	**Watt-hours (arc-sinh)**	**Watt-hours (log+1)**	**Watt-hours (arc-sinh)**
Treatment	0.123	0.177		
	[-0.633, 0.879]	[-0.628, 0.981]		
Using pressure cooker			0.197	0.260
			[-1.335, 1.730]	[-1.343, 1.863]
Num.Obs.	164	164	148	148
R^2	0.932	0.933	0.941	0.941
RMSE	131.69	131.36	137.59	137.26
Mean (DV)	66.37	66.37		
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)

Note: The left columns (ITT estimates) use the natural logarithm of consumption (adding 1, given the large number of zeroes in the data). The right columns (LATE estimates) use the inverse hyperbolic transformation (Bellemare & Wichman, 2020).
Source: Authors' analysis.

Finally, we examine whether the electric pressure cookers reduced the need to spend scarce time on collecting other fuels. We provide the results in Table 13 (ITT) and Table 14 (LATE), which split the outcome by gender and by status (parent and children). We find little consistent evidence of a change in time spent on fuel collection. For households that used their pressure cookers (LATE), we find a decline in time spent collecting fuel at the aggregate level and especially for women (though the effect has a wide confidence interval). This is partly compensated for by an increase in time spent by men. Given the widespread use of LPG, these results are not a surprise.

Table 13. Impact of e-pressure cooker on time spent on transporting kerosene (hours/week), LPG, firewood, or charcoal

	ITT				
	Overall	**Women**	**Girls**	**Men**	**Boys**
Treatment	0.692	-0.005	0.011	0.557	0.130
	[-0.527, 1.911]	[-0.609, 0.598]	[-0.238, 0.259]	[-0.067, 1.180]	[-0.160, 0.420]
Num.Obs.	484	484	484	484	484
R^2	0.506	0.528	0.514	0.504	0.500
RMSE	3.16	1.56	0.64	1.64	0.64
Mean (DV)	1.99	0.8	0.21	0.79	0.19
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)

Note: The estimates are ITT effects. All models include household and survey-fixed effects. 90% confidence intervals in brackets.
Source: Authors' analysis of baseline and endline survey data.

Table 14. Impact of e-pressure cooker on time spent on transporting kerosene (hours/week), LPG, firewood, or charcoal

	LATE				
	Overall	**Women**	**Girls**	**Men**	**Boys**
Using pressure cooker	-0.275	-0.774	0.034	0.445	0.021
	[-2.252, 1.703]	[-1.770, 0.222]	[-0.473, 0.540]	[-0.713, 1.602]	[-0.493, 0.536]
Num.Obs.	445	445	445	445	445
R^2	0.604	0.603	0.563	0.548	0.675
RMSE	2.15	1.06	0.55	1.28	0.54
SE	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)	Clustered (HH)
F-test (1st stage)	167.3	167.3	167.3	167.3	167.3

Note: The estimates are LATE. All models include household and survey-fixed effects. Standard errors are clustered at the household level. 90% confidence intervals in brackets.
Source: Authors' analysis of baseline and endline survey data.

4.3 Factors Limiting the Effect of Electric Pressure Cookers

There is tentative evidence, therefore, that electric pressure cookers achieve several desirable effects, but it must be emphasized that most assessments are not statistically significant, though this may be partly due to limited statistical power.

A broader question is what factors explain the noisiness of our estimates. Put another way, the next step of this analysis is to explore the factors that may mitigate the effectiveness of electric pressure cookers.

To start this investigation, we first report estimates of the respondents' willingness to pay (WTP) for electric pressure cookers. Respondents' WTP was elicited via an iterative bidding setup, a commonly used stated preference technique (Boyle & Bishop, 1988; Willis, 2002), including in the study of cooking technologies (Dumga & Goswami, 2025). This analysis was conducted at baseline, at a time when few households knew what electric pressure cookers were. After a brief presentation of these cookers, respondents were asked whether they were willing to buy them. The results should be considered in the context of the income profile of these households: lower than the average agricultural income but higher than that of those who could not afford the SunCulture products with batteries. Three cutoff points were used: KSH 3,000, KSH 6,000, and KSH 9,000 (corresponding to USD 23, USD 46, and USD 69 at the time of writing). Respondents were first asked if they would pay KSH 6,000. If the answer was "no," they were asked if they were willing to pay KSH 3,000. Their response was recorded. Likewise, if they said "yes" to 6,000, they were asked if they were willing to pay KSH 9,000. This allows the construction of a demand curve, which is reported in Table 15. We note that a large majority—79% of respondents—were willing to pay KSH 3,000 (or USD 23). As expected, demand declines as the price point increases, and only 21% indicated being willing to pay KSH 9,000. The implied elasticity price of demand (the percentage change in demand as price increases by 1%) is 1.17.[6] If accurate (recall that this estimate is based on three data points), it suggests that demand is elastic—that is, it responds strongly to a change in price.

Table 15. WTP for an electric pressure cooker (baseline data)

	N	Mean
Used electric pressure Cooker previously (yes=1)	242	0.07
Willing to pay 3000 KSH (yes=1)	242	0.79
Willing to pay 6000 KSH (yes=1)	242	0.43
Willing to pay 9000 KSH (yes=1)	242	0.21
All	242	

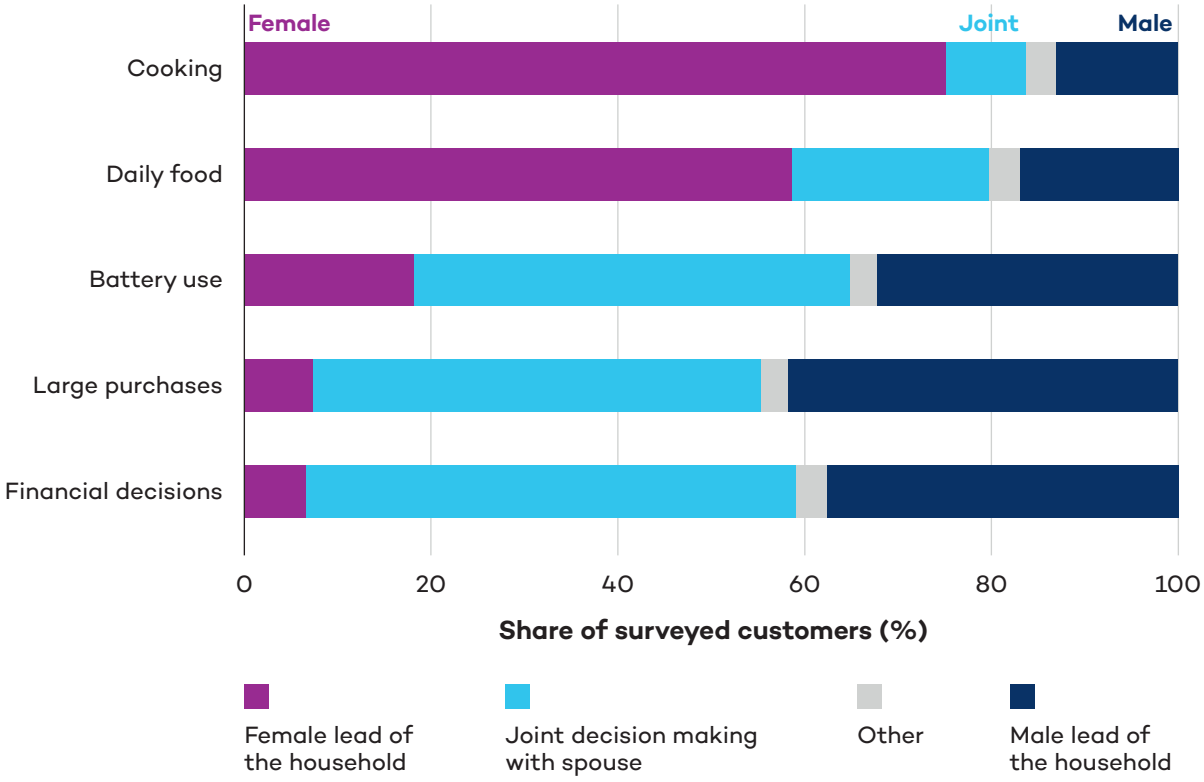
Source: Authors' analysis of baseline survey data.

[6] This estimate is based on a log-log model:

$\log(Q) = \alpha + \beta\log(P)$

where Q is the share of respondents willing to pay at price P. The parameter β captures the elasticity of demand.

Figure 3. Who makes decisions within the households (endline data)?



Source: Authors' analysis of endline survey data.

Yet qualitative interviews point to additional factors that may affect the effectiveness of the pressure cookers. First, since SunCulture's battery must be recharged regularly, any use of one appliance competes with other uses. Since the pressure cooker requires considerable power, using it implies having to reduce consumption for other purposes. Second, households may experience internal tensions regarding different ways in which to use this battery. This is because different individuals are the primary decision-makers in different areas.

Concretely, qualitative interviews and the endline survey revealed that many households preferred using SunCulture's battery for purposes, such as watching television rather than cooking. This highlights the gendered nature of decision making within households. Figure 3 shows that women are generally the primary decision-makers over food (in about 80% of households), whereas only 20% of households report that women make decisions over the use of SunCulture's battery. Thus, the gendered nature of decision making and of appliances (Alem et al., 2023; Rosenberg et al., 2020) creates friction that could reduce the impact of electric pressure cookers.

5.0 Summary and Discussion

5.1 Key Results

This project was designed to evaluate the potential of electric pressure cookers to tackle three problems: the transition to clean cooking technologies, increasing the secondary use of solar irrigation pumps, and identifying technologies and policy approaches that can reduce energy poverty for women and marginalized groups. The main novelty of the project lies in its attempt to bring to the market a cooking technology—electric pressure cookers—that minimizes disruption in cooking habits while building on existing infrastructure (SunCulture's solar irrigation pumps). In doing so, it tried to address some of the key barriers to clean cooking technologies identified in the policy and scientific literature, including the fit between new cooking technologies and existing habits, as well as uncertainty regarding the quality of solar products.

The analysis of the RCT highlights several key findings:

- There is latent demand for devices such as electric pressure cookers. The intervention increased their use by consumers.
- There is tentative evidence that electric pressure cookers can reduce demand for traditional, solid cooking fuels. The econometric estimates point in that direction, though they did not achieve statistical significance.
- There is also tentative evidence that the electric pressure cookers increased the use of SunCulture's battery, thereby increasing solar irrigation's secondary use. Again, the econometric estimates did not reach statistical significance. Evidence for other effects, such as a reduction in time spent collecting fuel, is much less solid.
- Qualitative interviews and the endline survey suggest that intra-household bargaining may be a key impediment to the adoption of electric pressure cookers and other forms of secondary use. Decisions over the use of the battery are primarily made by men, whereas decisions over cooking are made by women. These frictions could plausibly create barriers toward more aggressive secondary use.

These results confirm recent observations regarding the often-overlooked importance of intra-household dynamics. Decisions by households are not made by a single "rational" actor. Instead, they are the product of possibly complex negotiations over competing uses of batteries, such as watching television.

These findings have several implications. First, from a business standpoint, secondary use cannot be solely seen as selling residual unused power. Availability, even at no cost, does not guarantee use. To mobilize demand and increase electricity consumption, batteries must be designed to satisfy the needs of households. If households want to use, for example, televisions, phone charging, and cooking appliances simultaneously, then batteries must be designed accordingly. Likewise, solar irrigation firms need to take gender dynamics into account and avoid the mismatches identified in this project. This may affect marketing strategies (who to target) and tailored demonstration programs (e.g., to reduce risk aversion).

Second, the premise of secondary use of SIP power is that solar-generated energy is lost when pumping is not needed. Devices that can use this power, therefore, have access to "free" electricity. However, the presence of a battery and other secondary-use technologies means that this power is no longer surplus, but precious. Therefore, piloting clean cooking with SIP systems that do not have a battery could yield different results: households might choose to use the pressure cooker during the day to make use of surplus power. But this would depend on (1) household availability and willingness to cook during solar hours, (2) the presence of affordable alternative cooking fuels, and (3) cultural preferences aligning with eating in the middle of the day or pre-cooking meals.

Third, from a policy perspective, this study highlights the importance of holistic strategies to promote solar irrigation. Policy-makers may wish to achieve several goals simultaneously, including increasing agricultural yield, reducing energy poverty, improving gender equality and social inclusion outcomes, and mitigating climate change and air pollution. To achieve such goals, solar technologies must be competitive in several markets. These include the agricultural sector, where solar pumps compete with diesel alternatives. They also include the market for home energy access, where pump batteries compete with solar home systems and off-grid systems. Finally, SIPs must also compete with other cooking technologies, such as LPG.

It is unrealistic to expect SIPs to be competitive in all markets. As a result, policy-makers need to identify SIP systems that can plausibly address the issues that they believe are the most pressing and work with businesses to understand where incentives can be most useful and feasible to accelerate adoption. Likewise, they must identify the right market segment in which SIPs can deliver appealing secondary use. For instance, markets saturated with LPG might not be ideal due to the widespread popularity of this fuel. Remote areas, where LPG infrastructure might not be competitive, could represent a more promising segment. In addition, education programs are needed to promote behavioural change, including on gendered household decision making. Foreseeably, when e-cooking devices are more efficient or battery systems are more powerful, e-cooking powered by SIPs could reduce reliance on LPG, reducing costs for households and potentially governments that subsidize LPG.

Fourth, the results of this pilot demonstrate the feasibility of secondary use of SIP power, but further investigation is needed. Mapping of secondary-use situations and technologies would be helpful to find the most feasible alternatives for different circumstances. This would help SIP providers and governments tailor products and policy interventions.

Finally, the method used to pilot the secondary-use e-cookers was effective. An RCT identified the use of the cookers and changes (or lack thereof) in household behaviours. However, this could have been improved in several ways. First, the project team conducted only limited interviews in addition to the surveys. Qualitative data from more extensive interviews with primary cooks could have drawn out perspectives that might have been hidden by the survey approach, such as gendered choices about battery usage. Secondly, the device was only piloted in households with batteries, which also had televisions and were relatively well off compared to households without a battery. Ideally, the device would have been tested in households without batteries and televisions as well.

With solar PV and battery costs falling, there is a strong opportunity to align clean cooking and solar irrigation programs in the Global South. Pilots across diverse geographies can generate the evidence and user feedback needed to improve efficiency, enhance adaptability, and reduce costs, creating the right conditions for scale-up. By embedding these lessons into broader renewable energy strategies, clean cooking access can be expanded while advancing global decarbonization goals.

5.2 Policy Recommendations

1. Integrate secondary use into solar irrigation programs, based on research on consumer circumstances and preferences.
    - Mandate that solar irrigation subsidies and programs account for surplus PV and build in mechanisms to channel it toward socially beneficial end uses like cooking, lighting, or productive loads.
    - Integrate structured consumer feedback, prioritizing women's voices as primary cooks, so that system and appliance design reflect actual cooking habits and household decision making.
2. Design mechanisms to steer secondary use toward the intended outcomes of subsidy policies.
    - Develop energy allocation settings or "priority ports"—system controllers that reserve or prioritize a portion of battery/PV power for specific uses (e.g., cooking, refrigeration, etc.)—to ensure that subsidized technologies are used as intended.
    - Use monitoring and incentives. Explore low-cost Internet of Things tools to monitor the end uses SIP batteries are serving and incentivize intended use through monetary benefits (e.g., reduced monthly instalments or discounts on service fees) to households that demonstrate consistent use of solar e-cooking or other priority end uses.
3. Incentivize secondary-use devices through subsidies, finance, and payment installment mechanisms.
    - Price interventions should align with households' willingness to pay by using rebates, results-based financing, or a pay-as-you-go model.
    - Redirect a portion of LPG subsidies toward supporting e-cooking adoption (particularly, in LPG-scarce, off-grid regions).
    - Work with solar providers, manufacturers, think tanks, and consumers to inform incentive design and optimal pricing strategy.
4. Support research and development (R&D) and pilots for efficient secondary-use devices.
    - Develop R&D incentives for manufacturers for higher-efficiency, user-friendly electric pressure cookers and secondary-use controllers. This would need to take place in China and other manufacturing hubs. However, incentives for the uptake of such technologies in other jurisdictions would also create economies of scale.

- Pilot variations (battery-heavy vs. battery-light systems) in multiple geographies to identify optimal configurations most suited to consumer behaviour.

5. Build a learning agenda.
    - Scale up structured pilots across diverse contexts (peri-urban vs. remote, LPG-available vs. LPG-scarce, with/without batteries) to identify the strongest use cases.
    - Track fuel displacement, gender(ed) impacts, and secondary-use efficiency via periodic surveys.
    - Map the use cases for secondary use to understand the different technology options and under which circumstances each might be most feasible and beneficial.

References

Akintan, O., Jewitt, S., & Clifford, M. (2018). Culture, tradition, and taboo: Understanding the social shaping of fuel choices and cooking practices in Nigeria. *Energy Research & Social Science*, 40, 14–22. https://doi.org/10.1016/j.erss.2017.11.019

Aklin, M., Bayer, P., Harish, S. P., & Urpelainen, J. (2018). *Escaping the energy poverty trap: When and how governments power the lives of the poor.* MIT Press. https://doi.org/10.7551/mitpress/11479.001.0001

Alem, Y., Hassen, S., & Köhlin, G. (2023). Decision-making within the household: The role of division of labor and differences in preferences. *Journal of Economic Behavior & Organization, 207*, 511–528. https://doi.org/10.1016/j.jebo.2023.01.022

Andrews, I., Stock, J., & Sun, L. (2019). Weak instruments in IV Regression: Theory and practice. *Annual Review of Economics, 11*, 727–753. https://doi.org/10.1146/annurev-economics-080218-025643

Anenberg, S. C., Balakrishnan, K., Jetter, J., Masera, O., Mehta, S., Moss, J., & Ramanathan, V. (2013). Cleaner cooking solutions to achieve health, climate, and economic cobenefits. *Environmental Science & Technology, 47*(9). https://doi.org/10.1021/es304942e

Angrist, J. D, & Pischke. J.-S. (2010). The credibility revolution in empirical economics: How better research design is taking the con out of econometrics. *Journal of Economic Perspectives, 24*(2), 3–30. https://doi.org/10.1257/jep.24.2.3

Baldassarri, D., & Abascal, M. (2017). Field experiments across the social sciences. *Annual Review of Sociology, 43*(1), 41–73. https://doi.org/10.1146/annurev-soc-073014-112445

Beaton, C., Jain, P., Govindan, M., Garg, V., Murali, R., Roy, D., Bassi, A., & Pallaske, G. (2019). *Mapping policy for solar irrigation across the water-energy-food (WEF) nexus in India.* International Institute for Sustainable Development. https://www.iisd.org/publications/solar-irrigation-wef-nexus-india

Bellemare, M. F., & Wichman, C. J. (2020). Elasticities and the inverse hyperbolic sine transformation. *Oxford Bulletin of Economics and Statistics, 82*(1), 50–61. https://doi.org/10.1111/obes.12325

Bonjour, S., Adair-Rohani, H., Wolf, J., Bruce, N. G., Mehta, S., Prüss-Ustün, A., Lahiff, M., Rehfuess, E. A., Mishra, V., & Smith. K. R. (2013). Solid fuel use for household cooking: Country and regional estimates for 1980–2010. *Environmental Health Perspectives, 121*(7), 784–90. https://doi.org/10.1289/ehp.1205987

Boyle, K. J., & Bishop, R. C. (1988). Welfare measurements using contingent valuation: A comparison of techniques. *American Journal of Agricultural Economics, 70*(1), 20–28. https://doi.org/10.2307/1241972

Chafe, Z. A., Brauer, M., Klimont, Z., Van Dingenen, R., Mehta, S., Rao, S., Riahi, K., Dentener, F., & Smith, K. R. (2014). Household cooking with solid fuels contributes to ambient $PM_{2.5}$ air pollution and the burden of disease. *Environmental Health Perspectives 122*(12), 1314–1320. https://doi.org/10.1289/ehp.1206340

Chakraborty, M., Jain, S., Thornton, S., Aklin, M., Giang, A., & Zimmerman, N. (2025). Impact of residential cooking and heating on temporal changes of black carbon in rural India." *Scientific Reports, 15*(1), Article 33549. https://doi.org/10.1038/s41598-025-18384-1

Chalise, N., Kumar, P., Priyadarshini, P., & Yadama, G. N. (2018). Dynamics of sustained use and abandonment of clean cooking systems: Lessons from rural India. *Environmental Research Letters, 13*(3), Article 035010. https://doi.org/10.1088/1748-9326/aab0af

Chayal, K., & Dhaka, B. L. (2010). Analysis of role performance of women in farm activities. *Indian Research Journal of Extension Education, 10*(2), 109–112. https://api.seea.org.in/uploads/pdf/v10224.pdf

Closas, A., & Rap, E. (2017). Solar-based groundwater pumping for irrigation: Sustainability, policies, and limitations. *Energy Policy, 104*, 33–37. https://doi.org/10.1016/j.enpol.2017.01.035

Dendup, N., & Arimura, T. H. (2019). Information leverage: The adoption of clean cooking fuel in Bhutan. *Energy Policy, 125*, 181–195. https://doi.org/10.1016/j.enpol.2018.10.054

Doss, C., Kovarik, C., Peterman, A., Quisumbing, A., & van den Bold, M. (2015). Gender inequalities in ownership and control of land in Africa: Myth and reality. *Agricultural Economics, 46*(3), 403–434. https://doi.org/10.1111/agec.12171

Duflo, E. (2020). Field experiments and the practice of policy. *American Economic Review, 110*(7), 1952–1973. https://doi.org/10.1257/aer.110.7.1952

Dumga, K. T., & Goswami, K. (2025). Willingness to pay for cooking with electricity among rural households: The case of southern Ethiopia. *Heliyon, 11*(1), Article e41343. https://doi.org/10.1016/j.heliyon.2024.e41343

EED Advisory. (2018). *Evaluation of the sustainability of solar powered water supply systems in Kenya.* https://energypedia.info/images/5/51/Evaluation_of_the_Sustainability_of_SPWSS_in_Kenya.pdf

EED Advisory & VeraSol. (2021, November). *Quality in the off-grid solar market: An assessment of the consumer experience in Kenya.* https://verasol.org/publications/quality-in-the-off-grid-solar-market-an-assessment-of-the-consumer-experience-in-kenya/

Ezzati, M., Lopez, A. D., Rodgers, A., & Murray, C. J. L. (Eds.). (2004). *Comparative quantification of health risks: Global and regional burden of disease attributable to selected major risk factors.* World Health Organization. https://www.who.int/publications/i/item/9241580313

Food and Agriculture Organization of the United Nations. (2018). *The benefits and risks of solar-powered irrigation – A global overview.* https://openknowledge.fao.org/server/api/core/bitstreams/e3fae24e-5d85-48e7-94ce-0c115bc8723c/content

Food and Agriculture Organization of the United Nations, & International Renewable Energy Agency. (2021). *Renewable energy for agri-food systems.* https://www.irena.org/publications/2021/Nov/Renewable-Energy-for-Agri-food-Systems

Foell, W., Pachauri, S., Spreng, D., & Zerriffi, H. (2011). Household cooking fuels and technologies in developing economies. *Energy Policy, 39*(12), 7487–7496. https://doi.org/10.1016/j.enpol.2011.08.016

Goel, S., Murali, R., Swain, P., Rahman, A., Viswanathan, B., Agrawal, S., Beaton, C., Govindan, M., Jain, A., & Palit, D. (2021). *Implementing solar irrigation sustainably: A guidebook for state policy-makers on maximizing the social and environmental benefits from solar pump schemes.* International Institute for Sustainable Development. https://www.iisd.org/system/files/2021-12/implementing-solar-irrigation-sustainably.pdf

Global Off-Grid Lighting Association. (2021). *Global off-grid solar market report: Semi-annual sales and impact data.* https://www.gogla.org/wp-content/uploads/2024/11/gogla_sales-and-impact-report-h2-2022.pdf

Gould, C. F., & Urpelainen, J. (2018). LPG as a clean cooking fuel: Adoption, use, and impact in rural India. *Energy Policy, 122*, 395–408. https://doi.org/10.1016/j.enpol.2018.07.042

Government of India. (2019). *All India report on agriculture census 2015–16.* https://hortharyana.gov.in/images/docs/statisticalData/AgriCensus2015-16.pdf

Grieshop, A. P., Marshall, J. D., & Kandlikar, M. (2011). Health and climate benefits of cookstove replacement options. *Energy Policy, 39*(12), 7530–7542. https://doi.org/10.1016/j.enpol.2 011.03.024

Hanna, R., Duflo, E., & Greenstone, M. (2016). Up in smoke: The influence of household behavior on the long-run impact of improved cooking stoves. *American Economic Journal: Economic Policy, 8*(1), 80–114. https://doi.org/10.1257/pol.20140008

Hill, C. (2011). *Enabling rural women's economic empowerment: Institutions, opportunities and participation.* United Nations. https://www.un.org/womenwatch/daw/csw/csw56/egm/Hill-BP-1-EGM-RW-Sep-2011_CH.pdf

Hooper, L. G., Dieye, Y., Ndiaye, A., Diallo, A., Sack, C. S., Fan, V. S., Neuzil, K. M., & Ortiz, J. R. (2018). Traditional cooking practices and preferences for stove features among women in rural Senegal: Informing improved cookstove design and interventions. *PLOS ONE, 13*(11), Article e0206822. https://doi.org/10.1371/journal.pone.0206822

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., Angelsen, A., & Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters, 7*(4), Article 044009. https://doi.org/10.1088/1748-9326/7/4/044009

International Energy Agency. (2023). *A vision for clean cooking access for all.* https://www.iea.org/reports/a-vision-for-clean-cooking-access-for-all

International Energy Agency. (2024). *Kenya 2024: Energy policy review.* https://www.iea.org/reports/kenya-2024

International Energy Agency. (2025). *Universal access to clean cooking in Africa Progress update and roadmap for implementation.* https://www.iea.org/reports/universal-access-to-clean-cooking-in-africa

International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, World Bank, & World Health Organization. (2025). *Tracking SDG 7: The energy progress report 2025*. World Bank. http://hdl.handle.net/10986/43577

International Renewable Energy Agency. (2016). *Solar pumping for irrigation: Improving livelihoods and sustainability.* https://www.irena.org/Publications/2016/Jun/Solar-Pumping-for-Irrigation-Improving-livelihoods-and-sustainability

Jagoe, K., Rossanese, M., Charron, D., Rouse, J., Waweru, F., Waruguru, M., Delapena, S., Piedrahita, R., Livingston, K., & Ipe, J. (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*, Article 101413. https://doi.org/10.1016/j.erss.2019.101413

Jeuland, M. A., & Pattanayak, S. K. (2012). Benefits and costs of improved cookstoves: Assessing the implications of variability in health, forest and climate impacts. *PLOS ONE, 7*(2), Article e30338. https://doi.org/10.1371/journal.pone.0030338

Kelley, L. C., Gilbertson, E., Sheikh, A., Eppinger, S. D., & Dubowsky, S. (2010). On the feasibility of solar-powered irrigation. *Renewable and Sustainable Energy Reviews, 14*(9), 2669–2682. https://doi.org/10.1016/j.rser.2010.07.061

Kenya National Bureau of Statistics. (2022). *2022 Kenya demographic and health survey.* https://www.knbs.or.ke/reports/kdhs-2022/

Kenya Bureau of National Statistics. (n.d.). *Table 3.22 – Consumer price indices Kenya, 2018–2022 [Data]*. https://www.knbs.or.ke/wp-content/uploads/2024/04/2023-Economic-Survey-Kenya-Employment-Earnings-and-Consumer-Price-Indices.xlsx

Lee, K., Miguel, E., & Wolfram, C. (2020). Experimental evidence on the economics of rural electrification. *Journal of Political Economy, 128*(4), 1523–1565. https://doi.org/10.1086/705417

Lewis, J. J., & Pattanayak, S. K. (2012). Who adopts improved fuels and cookstoves? A systematic review. *Environmental Health Perspectives, 120*(5), 637–645. https://doi.org/10.1289/ehp.1104194

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., AlMazroa, M. A., et al. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet, 380*(9859), 2224–2260. https://doi.org/10.1016/S0140-6736(12)61766-8

Meah, K., Ula, S., & Barrett, S. (2008). Solar photovoltaic water pumping—Opportunities and challenges. *Renewable and Sustainable Energy Reviews, 12*(4), 1162–1175. https://doi.org/10.1016/j.rser.2006.10.020

Miller, G., & Mobarak, A. M. (2013). *Gender differences in preferences, intra-household externalities, and low demand for improved cookstoves* (Working paper 18964). National Bureau of Economic Research. https://doi.org/10.3386/w18964

Ministry of Energy. (2022). *Behaviour change and communication strategy for promoting clean cooking in Kenya.* Republic of Kenya. https://energy.go.ke/sites/default/files/KAWI/Other%20Downloads/BCC%20Strategy%20for%20Promoting%20Clean%20Cooking%20%20Kenya(1).pdf

Ministry of Micro, Small and Medium Enterprises. (2024). *MSME annual report 2023–2024.* Government of India. https://msme.gov.in/msme-annual-report-english-2022-23

Mobarak, A. M., Dwivedi, P., Bailis, R., Hildemann, L., & Miller, G. (2012). Low demand for nontraditional cookstove technologies. *Proceedings of the National Academy of Sciences, 109*(27), 10815–10820. https://doi.org/10.1073/pnas.1115571109

Murray, C. J. L., Aravkin, A. Y., Zheng, P., Abbafati, C., Abbas, K. M., Abbasi-Kangevari, M., Abd-Allah, F., Abdelalim, A., Abdollahi, M., Abdollahpour, I., Abegaz, K. H., Abolhassani, H., Aboyans, V., Abreu, L. G., Abrigo, M. R. M., Abualhasan, A., Abu-Raddid, L. J., Abushouk, A. I., Adabi, M. … & Lim, S. (2020). Global burden of 87 risk factors in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet, 396*(10258), 1223–1249. https://doi.org/10.1016/S0140-6736(20)30752-2

Njagi, K. (2019, December 20). *Solar-pumped water slakes rural Kenya's thirst for development.* Reuters. https://www.reuters.com/article/us-kenya-solar-water/solar-pumped-water-slakes-rural-kenyas-thirst-for-development-idUSKCN1OY0DH

Onsongo, E., Nayema, K., Kinuthia, B., Kausya, M., & Okoko, A. (2023). *Kenya national eCooking baseline study [KNeCS] report.* Nuvoni Research. https://mecs.org.uk/publications/kenyan-national-baseline-ecooking-study-knecs-report/

Oxfam India. (2018). *Move over "sons of the soil":Why you need to know the female farmers that are revolutionizing agriculture in India.* http://uatwar.oxfamindia.org/women-empowerment-india-farmers

Patnaik, S., Jha, S., & Jain, T. (2021). *Improving women's productivity and incomes through clean energy in India.* Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/Improving-Womens-Incomes-and-Productivity-through-Clean-Energy-in-India.pdf

Pattanayak, S. K., Jeuland, M., Lewis, J. J., Usmani, F., Brooks, N., Bhojvaid, V., Kar, A., Lipinski, L., Morrison, L., Patange, O., Ramanathan, N., Rehman, I. H., Thadani, R., Vora, M., & Ramanathan, V. (2019). Experimental evidence on promotion of electric and improved biomass cookstoves. *Proceedings of the National Academy of Sciences, 116*(27), 13282–13287. https://doi.org/10.1073/pnas.1808827116

Pope, D., Johnson, M., Fleeman, N., Jagoe, K., Duarte, R., Maden, M., Ludolph, R., Bruce, N., Shupler, M., Adair-Rohani, H., & Lewis, J. (2021). Are cleaner cooking solutions clean enough? A systematic review and meta-analysis of particulate and carbon monoxide concentrations and exposures. *Environmental Research Letters, 16*(8), Article 083002. https://doi.org/10.1088/1748-9326/ac13ec

Rahman, A., Agrawal, S., & Jain, A. (2021). *Powering agriculture in India Strategies to boost Components A and C under PM-KUSUM scheme*. Council on Energy, Environment and Water. https://www.ceew.in/publications/powering-irrigation-system-with-solar-powered-plants-and-grid-pumps-in-india

Rahman, A., & Jain, A. (2021a). *Can Chhattisgarh further equity, prosperity, and sustainability through solar pumps?* Council on Energy, Environment and Water. https://www.ceew.in/publications/saur-sujala-yojana-for-sustainable-solar-pump-programme-in-chhattisgarh

Rahman, A., & Jain, A. (2021b). *How is India using its solar pumps for irrigation?* Council on Energy, Environment and Water. https://www.ceew.in/publications/solar-pumps-underutilization-and-usage-patterns-in-india

Rahman, A., & Jain, A. (2021c). *Making remote monitoring of solar pumps work for states.* Council on Energy, Environment and Water. https://www.ceew.in/publications/making-remote-monitoring-of-solar-pumps-work-for-states

Rahnema, A., Sánchez, F., & Giordano, P. (2017). *Alternative cooking fuels in Kenya: How can household decision making be influenced?* https://www.iese.edu/media/research/pdfs/WP-1177-E.pdf

Raymond, A., & Jain, A. (2018). *Solar for irrigation: A comparative assessment of deployment strategies.* Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/CEEW-Solar-for-Irrigation-Deployment-Report-17Jan18_0.pdf

Rosenberg, M., Armanios, D., Aklin, M., & Jaramillo, P. (2020). Evidence of gender inequality in energy use from a mixed methods study in India. *Nature Sustainability, 3*, 110–118. https://doi.org/10.1038/s41893-019-0447-3

Shirsath, P. B., Saini, S., Durga, N., Senoner, D., Ghose, N., Verma, S., & Sikka, A. K. (2020). *Compendium on solar powered irrigation systems in India.* CGIAR Research Program on Climate Change, Agriculture and Food Security. https://hdl.handle.net/10568/109736

Smith, D. V., & Allison, S. V. (1978). *Micro irrigation with photovoltaics.* https://dspace.mit.edu/handle/1721.1/31298

Tornel-Vázquez, R., Iglesias, E., & Loureiro, M. (2024). Adoption of clean energy cooking technologies in rural households: The role of women. *Environment and Development Economics, 29*(6), 499–517. https://doi.org/10.1017/S1355770X24000226

Waray, S., Patnaik, S., & Jain, A. (2018). *Clean energy innovations to boost rural incomes.* https://www.ceew.in/publications/clean-energy-innovations-boost-rural-incomes

Wazed, S. M., Hughes, B. R., O'Connor, D., & Calautit, J. K. (2018). A review of sustainable solar irrigation systems for sub-Saharan Africa. *Renewable and Sustainable Energy Reviews, 81*, 1206–1225. https://doi.org/10.1016/j.rser.2017.08.039

Willis, K. G. (2002). Research note: Iterative bid design in contingent valuation and the estimation of the revenue maximising price for a cultural good. *Journal of Cultural Economics, 26*(4), 307–324. https://doi.org/10.1023/A:1019903814513

Working Group for Agricultural Consumption Study. (2020). *Final report.* Maharashtra Electricity Regulatory Commission. https://www.mahadiscom.in/wp-content/uploads/2020/07/32_11.03.2020_-Final_Report_AG-Working-Group.pdf

World Bank Group. (n.d.-a). Access to clean fuels and technologies for cooking (% of population) – Kenya [Database]. https://data.worldbank.org/indicator/EG.CFT.ACCS.ZS?locations=KE

World Bank Group. (n.d.-b). Data for Kenya, Lower middle income [Database]. https://data.worldbank.org/?locations=KE-XN

World Bank Group. (2023). Access to electricity (% of population) – Kenya [Database]. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=KE

World Health Organization. (2014). *WHO guidelines for indoor air quality: Household fuel combustion.* https://www.who.int/publications/i/item/9789241548885

World Health Organization. (2025). *World health statistics 2025: Monitoring health for the SDGs, Sustainable Development Goals.* https://www.who.int/publications/i/item/9789240110496

Zahno, M., Michaelowa, K., Dasgupta, P., & Sachdeva, I. (2020). Health awareness and the transition towards clean cooking fuels: Evidence from Rajasthan. *PLOS ONE, 15*(4), Article e0231931. https://doi.org/10.1371/journal.pone.0231931

Published by the International Institute for Sustainable Development

Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
𝕏: @IISD_news

IISD

iisd.org