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Beyond awareness: Public perceptions, willingness to pay, and policy pathways for renewable energy adoption in Ethiopia

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Abstract

Background: Ethiopia possesses abundant renewable energy resources, yet household adoption remains low despite high public awareness. This paradox undermines national electrification targets and Sustainable Development Goal 7. Purpose: This study examines the determinants of renewable energy adoption in Ethiopia, focusing on the gap between awareness and willingness to pay (WTP), and identifies policy pathways to bridge this gap. Methods: A mixed-methods design was employed, comprising a cross-sectional household survey of 1,200 respondents (stratified urban/rural), eight focus group discussions, and 15 key informant interviews across four regions and Addis Ababa. WTP was elicited using double-bounded dichotomous choice contingent valuation for solar home systems and improved cookstoves. A randomised information treatment was embedded. Data were analysed using logistic regression and thematic analysis. Findings: Awareness of solar energy was near-universal (97.5%), but mean WTP for a solar home system (1,520 ETB) was less than half the market price (3,200–3,800 ETB). A randomised information treatment had no significant effect on WTP ($p > 0.05$). Positive predictors of WTP included income (OR=2.32), bank account ownership (OR=2.62), and current kerosene use (OR=3.47); grid connection was a negative predictor (OR=0.46). Qualitative findings revealed deep distrust of product quality (72%) and absence of repair services (83%), plus local grievances over land compensation for large projects. Conclusion: High awareness does not translate into adoption without financial access and trust. Information campaigns alone are ineffective. Recommendation: Policy must prioritise PAYGo and targeted subsidies, mandatory quality certification, local repair technician training, and community benefit-sharing for large projects.

Keywords: Renewable energy adoption; willingness to pay; awareness–adoption gap; Ethiopia; mixed-methods

1. Introduction

1.1 Background

Ethiopia possesses one of Africa's most abundant renewable energy endowments. The International Trade Administration estimates that the country has the potential to generate over 60,000 MW of electric power from hydropower, wind, solar, and geothermal sources (International Trade Administration, n.d.). Hydropower currently dominates the electricity generation mix, accounting for approximately 90% of installed capacity and more than 97% of actual generation (Ethiopian

Electric Power, 2025a; Mulat et al., 2024). The country's total electricity generation reached 29,480 GWh in the 2024–2025 periods, exceeding its annual target by 16% and representing a 43% increase over the previous year (Addis Standard, 2025).

Ethiopia's renewable energy strategy is anchored in ambitious large-scale projects, most notably the Grand Ethiopian Renaissance Dam (GERD). With a projected capacity of 5,150 MW, GERD is the largest hydropower project ever built in Africa, inaugurated in September 2025 and designed to effectively double the country's electricity generation capacity while positioning Ethiopia as a regional electricity exporter (Ethiopian Electric Power, 2025b; Inspenet, 2025). Beyond hydropower, Ethiopia is also expanding into solar and wind energy. Early 2025 saw the announcement of two 225 MW solar Independent Power Producer (IPP) auctions, and the country has made notable progress in geothermal exploration and wind energy projects, contributing to a gradually diversifying energy portfolio (Ethiopian Electric Power, 2025b).

However, this impressive supply-side picture masks a persistent and deeply troubling reality at the household level. Despite the country's leadership in renewable energy, modern energy access remains severely limited. Preliminary findings from the 2025 World Bank Multi-Tier Framework Survey indicate that Ethiopia's Tier 1+ electricity access rate stands at just 44%, leaving close to 71 million people, mostly in rural and peri-urban areas—without adequate power (Addis Standard, 2025). The National Energy Compact published as part of the World Bank's Mission 300 initiative confirms that only 44% of Ethiopians currently benefit from basic electric service, largely due to inadequacies in the national grid (Ecofin Agency, 2025). While urban electrification in Addis Ababa reaches 93%, nationwide access remains starkly uneven, with regions such as Afar and Somali lagging significantly behind (Ethiopian Electric Power, 2025b).

The cooking energy situation is even more acute. Nearly all (98.8%) residents in Ethiopia depend on biomass fuel as their basic source of energy for cooking (Mulat et al., 2024). The government's National Clean Cooking Roadmap, launched in June 2025, reports that nearly 90% of the Ethiopian population lacked access to clean cooking solutions in 2024, relying instead on traditional biomass fuels that release short-lived climate pollutants and other greenhouse gases (NDC Partnership, 2025). This heavy reliance on biomass, primarily firewood and charcoal has devastating consequences for public health, the environment, and economic development, including severe indoor air pollution, accelerated deforestation, and disproportionate time burdens on women and girls who bear primary responsibility for fuel collection. This paradox abundant renewable generation potential co-existing with persistent household energy deprivation constitutes the central puzzle motivating this study.

1.2 Problem Statement

In response to these challenges, the Ethiopian government has pursued an ambitious policy agenda centered on supply-side expansion. The National Electrification Program (NEP 3.0), updated in 2019, aims to achieve universal electricity access nationwide by 2030 through a dual strategy combining centralized grid connections with decentralized off-grid solutions (Ethiopian Electric Power, 2025a; Ministry of Water and Energy, 2024). By 2030, authorities aim for 75% electrification, connecting more than nine million additional households through a mixed approach: 70% network extension and 30% off-grid solutions, including mini-grids and solar home systems

(Ecofin Agency, 2025). The government has also launched a National Clean Cooking Roadmap to increase access to clean cooking solutions to 76% of the population by 2035 (NDC Partnership, 2025).

However, a growing body of evidence indicates that supply-focused policies alone are insufficient to drive household-level energy transitions. Several recent studies across Sub-Saharan Africa have documented high levels of public awareness of renewable energy technologies combined with persistently low adoption rates, a phenomenon described as the "awareness–adoption gap" (Bensch et al., 2023; Kipkoech & Fobissie, 2025). In Ethiopia specifically, research in the Wereta district of the Amhara region found that limited awareness, high costs, and age-related factors constitute the primary barriers to the adoption of improved cookstoves (Adane et al., 2024). Similarly, despite the existence of awareness-raising initiatives, adoption of improved cookstoves remains constrained by fragmented initiatives, limited financing, and the absence of a comprehensive national framework (United Nations Development Programme, 2025).

A particularly instructive finding comes from a randomized field experiment in rural Ethiopia that examined the effect of information and subsidy policy instruments on the adoption of solar lanterns (Merkle et al., 2023). The study found that while an increase in subsidy levels significantly increased the adoption rate, the provision of information about the private and public benefits of solar lanterns did not have a significant effect on either adoption rates or willingness to pay (Merkle et al., 2023). Households with access to grid electricity had lower willingness to pay and were less likely to adopt, whereas those using kerosene for lighting were more likely to adopt (Merkle et al., 2023). The study's authors conclude that universal electricity and clean energy access may not be achieved without subsidizing household-level solar lighting (Merkle et al., 2023).

These findings point to a critical disconnect: high awareness does not automatically translate into adoption. Yet existing policy frameworks in Ethiopia continue to prioritise generation capacity and grid extension over demand-side barriers such as household perceptions, affordability constraints, and trust in technology quality. There is a particular dearth of empirical research examining how awareness interacts with financial mechanisms and local institutional factors to shape renewable energy adoption decisions. Without a nuanced understanding of these household-level dynamics, policy interventions risk remaining misaligned with the actual barriers faced by Ethiopian families.

1.3 Research Gap and Objectives

A systematic examination of the literature reveals several important gaps. First, while numerous studies have examined the technical and economic potential of renewable energy in Ethiopia, relatively few have investigated the socio-psychological and behavioural dimensions of adoption from the household perspective. Second, existing research on willingness to pay (WTP) has largely focused on individual technologies in isolation, such as rooftop solar in urban settings or improved cookstoves in rural districts, without systematically linking WTP estimates to policy design parameters such as subsidy levels, credit access, or quality certification (Bekele et al., 2024; Merkle et al., 2023). Third, and most critically, very few studies have explicitly tested the relationship between awareness, perceptions, and WTP in a unified analytical framework that can generate actionable policy pathways across multiple renewable energy technologies simultaneously.

Specifically, the scholarly literature has yet to adequately address the following questions: Does public awareness of renewable energy technologies translate into meaningful WTP in the Ethiopian context? What role do financial mechanisms, as opposed to information provision play in bridging the awareness adoption gap? How do perceptions of technology quality, trust in suppliers, and experiences with existing energy sources shape adoption intentions? And what differentiated policy interventions are required to address the distinct barriers facing urban and rural households?

To address these gaps, this study pursues three primary objectives:

- To assess public awareness and perceptions of renewable energy technologies (solar home systems, improved cookstoves, and biogas) among Ethiopian households, disaggregated by urban and rural contexts.
- To quantify willingness to pay (WTP) for selected renewable energy technologies and identify the key socio-economic, demographic, and perceptual determinants of WTP.
- To identify policy levers that can effectively bridge the awareness–adoption gap, with particular attention to the complementary roles of information provision, financial mechanisms (subsidies, credit, PAYGO), and quality assurance systems.

This study makes several distinctive contributions to the literature. Methodologically, it is among the first to employ a mixed-methods design that integrates a large-N household survey with qualitative focus group discussions and key informant interviews to examine renewable energy adoption in Ethiopia. This design allows for both statistical generalisation and contextual depth in understanding the barriers households face.

Empirically, the study provides novel evidence on the limited effectiveness of information provision alone in driving adoption, while demonstrating the critical importance of financial mechanisms. These findings align with recent experimental evidence from Ethiopia on solar lantern adoption, which found that information about benefits did not have a significant effect on adoption rate and willingness to pay, whereas increased subsidies significantly increased adoption (Merkle et al., 2023). By extending this inquiry across multiple technologies and incorporating household perceptions, this study provides a more comprehensive understanding of adoption dynamics.

Theoretically, the study contributes to the emerging literature on the "awareness–adoption gap" by demonstrating how this gap is moderated by financial access, trust in technology quality, and prior experiences with unreliable products. By explicitly linking these factors to policy design, the study offers a more actionable framework for energy transition planning than previous supply-side or purely economic analyses.

Finally, from a policy perspective, the study provides evidence-based recommendations tailored to the Ethiopian context, including the need for mandatory quality certification, expansion of PAYGO financing models, and the bundling of information campaigns with direct financial incentives. These recommendations are particularly timely given Ethiopia's commitment to achieving universal energy access by 2030 under Sustainable Development Goal 7, and the recent launch of the World Bank's $424 million Accelerating Sustainable and Clean Energy Access Transformation (ASCENT) program, which prioritises underserved and low-income communities (Addis Standard, 2025).

2. Literature Review & Theoretical Framework

This chapter systematically reviews the existing literature on renewable energy adoption in Sub-Saharan Africa, with specific attention to Ethiopia. It synthesises stylised facts on adoption patterns, examines theoretical frameworks explaining the awareness–adoption gap, critically evaluates willingness to pay (WTP) evidence and methodological debates, reviews policy pathways in low-income contexts, and presents a conceptual framework linking awareness, perceptions, WTP and adoption moderated by financial access, trust and policy interventions.

2.1 Renewable Energy Adoption in Sub-Saharan Africa

Sub-Saharan Africa (SSA) faces a profound energy paradox. The region possesses abundant renewable energy resources—solar, wind, hydro, and biomass and geothermal that offers a scalable and sustainable pathway to address chronic energy poverty (Kipkoech & Fobissie, 2025; Ojewola et al., 2026). Yet modern energy access remains severely constrained: approximately 600 million people in SSA lack access to electricity, and more than 900 million rely on traditional biomass for cooking, with associated health, environmental and socio-economic consequences (Chirwa & Qutieshat, 2025). Green energy, comprising solar, wind, biomass, hydro and geothermal sources, is increasingly recognised as a transformative solution to SSA's energy crisis, offering the potential to leapfrog conventional grid expansion while simultaneously combating climate change (Ojewola et al., 2026).

Several stylised facts characterise renewable energy adoption across SSA. First, public awareness of renewable technologies is generally high, particularly for solar energy, yet adoption rates remain persistently low. In a study of solar energy adoption in Rwanda, for instance, over 50% of households in Rwamagana District adopted solar for domestic electrification and clean cooking, but significant adoption gaps persisted, driven by financial constraints and limited access to credit (Nsengiyumva et al., 2025). Similarly, research in Northern Ethiopia found that 98.4% of respondents were aware of solar energy, but actual uptake was constrained by affordability, quality concerns and lack of maintenance services.

Second, household income and education are consistently strong predictors of adoption. A panel study of renewable energy consumption across SSA found that effective management and implementation of renewable energy development significantly promoted social indicators such as education indices, while simultaneously improving economies and reducing CO_2 emissions (Chien et al., 2021). The link between household welfare and solar electricity demand has been demonstrated using quantile approaches, with welfare measured by Human Development Index (HDI), income inequality, infant mortality, education, mobile phone subscriptions, internet users and unemployment rates (Bekun & Alola, 2024).

Third, grid access exerts a complex influence on renewable adoption. Access to the national grid generally reduces willingness to adopt off-grid solutions, as households perceive the grid as a more reliable and established option. Merkle et al. (2023), in a randomised field experiment in rural Ethiopia, found that households with access to grid electricity had lower willingness to pay and were less likely to adopt solar lanterns, whereas those using kerosene for lighting expressed greater interest in adoption. However, evidence on the welfare impacts of grid electrification in SSA remains inconsistent: a recent study found that access to grid connectivity increases the number of work hours, female employment, household expenditure and certain educational outcomes, but these benefits are not uniformly distributed (Bensch & Peters, 2024).

Fourth, social influence and peer effects play a critical role. In Kenya, social influence helped solar lantern adoption reach 96%; in Rwanda and Malawi, community leaders and peer examples facilitated the spread of solar home systems (Kipkoech & Fobissie, 2025). Research in rural Zambia confirmed that solar uptake is not solely about technology availability but fundamentally about people, trust, visibility and empowerment (Kipkoech & Fobissie, 2025).

2.2 The Awareness–Adoption Gap

The discrepancy between high awareness and low adoption of renewable energy technologies termed the awareness–adoption gap has attracted considerable scholarly attention. Several theoretical frameworks have been deployed to explain this phenomenon, with the Knowledge Attitudes–Practices (KAP) model and the Technology Acceptance Model (TAM) being among the most influential.

The KAP model theorises that human behaviour change proceeds through three sequential steps: acquiring knowledge, generating attitudes, and implementing practice (SNV, 2022). In the context of renewable energy, the model predicts that increasing awareness of the benefits of clean technologies should lead to favourable attitudes, which in turn should drive adoption. However, empirical evidence indicates that the sequence is often incomplete: awareness may generate positive attitudes, but the transition to actual adoption is blocked by structural, financial and psychological barriers (Okonkwo & Okonkwo, 2023).

The Technology Acceptance Model (TAM), originally developed by Davis (1989) and subsequently extended, posits that technology adoption is primarily determined by two constructs: perceived usefulness and perceived ease of use. In the renewable energy domain, TAM has been widely applied and extended. A comprehensive meta-analysis of an extended TAM for renewable energy adoption identified ten influential factors: knowledge, awareness, policy, social influence, demographics, self-efficacy, trust, enjoyment, perceived risk and compatibility (Kumar et al., 2025). More recent work has integrated TAM with the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Theory of Planned Behaviour (TPB) to explain solar energy adoption in developing economies (Ramayah et al., 2023; Thakur & Chakraborty, 2024; Zori & Chigada, 2025).

Despite the theoretical appeal of these models, a growing body of evidence suggests that information campaigns alone have mixed or null effects in driving adoption without complementary interventions. Merkle et al. (2023), in their rigorous field experiment in rural Ethiopia, found that providing information about the private and public benefits of solar lanterns did not have a significant effect on adoption rates or willingness to pay. Similarly, a study of behavioural constraints in energy technology uptake in Rwanda and Senegal found that household-level factors, including risk aversion, innovation resistance, time preferences and beliefs significantly influenced willingness to pay, even when awareness was high (Merkle et al., 2023).

These findings challenge the assumption that awareness deficits are the primary barrier to adoption. Instead, they suggest that perceived usefulness and ease of use are mediated by real-world constraints such as financial liquidity, trust in product quality and access to after-sales service. Bensch et al. (2025), in a critical review of solar PV and clean cookstove technology diffusion systems, concluded that donor-led interventions focusing solely on awareness-raising have limited impact unless they also address systemic barriers including affordability, product quality assurance and local technical capacity.

2.3 Willingness to Pay (WTP) for Clean Energy

Willingness to pay (WTP) represents the maximum amount a household is prepared to pay for a good or service and is a critical metric for designing financially sustainable renewable energy interventions. In low-income contexts, WTP studies have proliferated, employing primarily the contingent valuation method (CVM) , which directly elicits WTP through hypothetical scenarios.

Determinants of WTP have been extensively studied. A representative study of rural electrification in Kenya found that households' WTP for grid connection was substantially higher than for off-grid solar home systems, reflecting a stronger preference for perceived reliability and established infrastructure (Monyei & Adewumi, 2025). Households were willing to pay approximately 9–11% of their discretionary incomes to access reliable renewable-powered electricity in rural off-grid communities in Ghana (Bonsu et al., 2024). Key determinants consistently identified include:

- Income and wealth: Higher-income households exhibit greater WTP, though affordability constraints persist even among those who value clean energy.
- Education: More educated households are more likely to understand long-term benefits and express higher WTP.
- Current fuel stacking: Households reliant on expensive and polluting fuels (e.g., kerosene, diesel generators) show higher WTP for alternatives (Guo et al., 2014).
- Perceived reliability: Trust in technology performance significantly influences WTP; prior negative experiences with poor-quality products reduce WTP.
- Grid proximity: Households with existing grid access have lower WTP for off-grid solutions (Merkle et al., 2023).

Debates on CVM methodology persist. Critics argue that hypothetical WTP overstates actual purchase behaviour due to hypothetical bias—respondents may express positive WTP in surveys but fail to pay when confronted with real payments. Merkle et al. (2023) addressed this by employing the Becker–DeGroot–Marschak (BDM) bidding mechanism, an incentive-compatible method that aligns hypothetical responses with real payment consequences. Their study found that even with rigorous elicitation, WTP remained below market prices, confirming the affordability gap.

Other methodological challenges include the choice of elicitation format (open-ended, payment card, dichotomous choice), the treatment of zero responses, and the sensitivity of WTP estimates to starting point bias. Despite these debates, CVM remains the most widely used method for valuing non-market energy access benefits in developing countries (Monyei & Adewumi, 2025; Guo et al., 2014).

2.4 Policy Pathways in Low-Income Contexts

A robust policy literature has identified several pathways to accelerate renewable energy adoption in low-income settings. These interventions are not mutually exclusive and are most effective when implemented as integrated packages.

Subsidies remain the most direct mechanism to address affordability constraints. A quasi-experimental evaluation of a subsidy programme for pay-as-you-go (PAYGo) solar in Togo found that a subsidy reduced usage prices by 17.8% to 41.7% and increased basic solar home system sales by 240% in the first five months (Bensch, 2025). However, the study also noted that estimates of carbon benefits covered only one-third of the subsidy cost, raising questions about cost-effectiveness. The initial impacts of the subsidy were in line with stated policy goals, but sustainability requires long-term financing (Bensch, 2025).

Pay-as-you-go (PAYGo) financing has emerged as a transformative model for off-grid solar. PAYGo systems require low upfront payments with flexible ongoing instalments, typically enabled by mobile money platforms. Governments in low-income countries are increasingly integrating PAYGo solar into national electrification strategies (Bensch, 2025; Chirwa & Qutieshat, 2025). In rural Ethiopia, PAYGo solar home systems marketed by private suppliers in the Amhara region have demonstrated positive socio-economic impacts, including improved lighting, reduced kerosene expenditure and enhanced household productivity (Mekonnen et al., 2024). The PAYGo model is explicitly designed to lower barriers to electrification for rural, low-income households by requiring down payments that are small relative to the cost of purchasing a system outright or being connected to the grid (Mekonnen et al., 2024).

Microfinance and community-based financing complement PAYGo by addressing the working capital constraints of both households and local energy entrepreneurs. The integration of community-based organisations and fintech platforms is emerging as a promising strategy for scaling small-scale renewable energy financing in SSA (Okonkwo & Okonkwo, 2023). These models leverage local social capital and trust to reduce transaction costs and default risks.

Quality certification and after-sales service are essential to build consumer trust in renewable technologies. The proliferation of cheap, uncertified products in SSA markets has undermined confidence, leading to high abandonment rates after early failures. Policy interventions that mandate minimum quality standards, establish repair and maintenance networks, and implement e-waste management frameworks are critical for sustainable adoption (Bensch et al., 2025).

Community engagement and benefit sharing address the social acceptance dimension of adoption, particularly for larger-scale projects. A study of community engagement strategies and capacity building interventions found that targeted community engagement and trust-building significantly influenced citizens' willingness to participate in local renewable energy initiatives (Okonkwo & Okonkwo, 2023). For large projects such as wind farms or hydropower dams, prior consultation, transparent land compensation and local benefit-sharing mechanisms (e.g., free electricity to host communities, local employment quotas) are essential to prevent opposition and build long-term legitimacy.

2.5 Conceptual Framework

Drawing on the theoretical and empirical literature reviewed above, this study proposes a conceptual framework that integrates the key determinants of renewable energy adoption in the Ethiopian context. The framework, illustrated in Figure 1, posits that awareness exerts an indirect effect on adoption, mediated sequentially by perceptions and willingness to pay, with these relationships moderated by three sets of contextual factors.

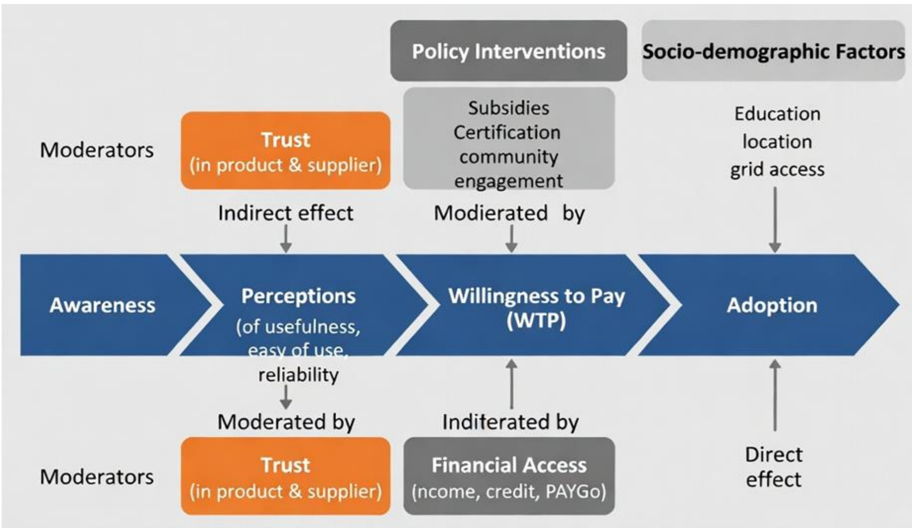

Figure 1. Conceptual Framework for Renewable Energy Adoption in Ethiopia

The framework rests on the following propositions:

- Awareness is a necessary but insufficient condition for renewable energy adoption. While awareness enables households to consider clean energy options, it does not automatically translate into adoption without supportive moderating conditions.

- Perceptions mediate the awareness–adoption relationship. Awareness shapes perceptions of technology usefulness, ease of use and reliability. These perceptions, in turn, influence WTP. However, perceptions are themselves moderated by trust in product quality and supplier reliability.

- Willingness to pay is the immediate antecedent of adoption. WTP is not solely determined by awareness or perceptions but is critically moderated by financial access, including household income, access to credit and availability of PAYGo financing options. Without financial mechanisms that lower upfront costs, even households with positive perceptions may express low or zero WTP.

- Policy interventions operate at multiple levels: (i) directly affecting WTP through subsidies and financing, (ii) building trust through quality certification and after-sales service systems, and (iii) directly promoting adoption through community engagement and benefit-sharing mechanisms.
- Socio-demographic factors, including education, urban/rural location and existing grid access influence all stages of the pathway, serving as both direct predictors and moderators of key relationships.

  This framework directly informs the empirical analysis that follows. It guides the selection of variables, the specification of regression models and the interpretation of findings in terms of actionable policy levers. The framework will be tested and refined using the mixed-methods data collected from Ethiopian households, with particular attention to how financial access and trust moderate the awareness–adoption gap.

3. Research Context & Methods

This section provides a detailed account of the research design and methodological procedures employed in this study. It describes the study setting, the mixed-methods approach, sampling strategy, data collection instruments, variable measurement, analytical techniques, and ethical considerations adhered to throughout the research process.

3.1 Study Setting

Ethiopia is located in the Horn of Africa and possesses one of the continent's most ambitious renewable energy development agendas. The country's energy landscape is characterised by a pronounced duality between abundant renewable generation potential and persistently low household-level access to modern energy.

Electricity access and grid versus off-grid regions: Ethiopia's National Electrification Program (NEP) has set the ambitious target of achieving universal electricity access by 2030 through a dual strategy: 75% of the population is to be connected through the national grid, while 35% will be served via off-grid solutions (Ethiopian Electric Utility, 2026). As of 2025, approximately 55% of the population had access to electricity (Tier 1+), with urban areas such as Addis Ababa achieving over 90% connectivity, while rural regions—particularly in Afar, Somali and Benishangul-Gumuz—lag substantially behind. The government has prioritised the electrification of rural localities, with the Ethiopian Electric Utility (EEU) planning to connect 154 rural communities during the 2025/26 fiscal year through both grid extension and mini-grid systems (2merkato, 2025). The World Bank has mapped over 156,500 potential off-grid sites across the country to accelerate decentralised renewable energy deployment (Birr Metrics, 2025).

Solar resource potential: Ethiopia is endowed with abundant solar irradiation. The country receives an average annual global horizontal irradiation (GHI) ranging from 4.5 to 7.5 kWh/m²/day, placing it among the sunniest regions in Africa (World Bank, 2018). Regional studies confirm this high potential: in the North Shewa Zone of the Amhara region, average GHI values of 5.918 kWh/m²/day have been recorded, with values ranging from 4.479 to 7.011 kWh/m²/day (Woldiya). In the Tigray region, recent mapping efforts have quantified solar resources to accelerate both on-grid and off-grid electrification schemes (Semantic Scholar, 2025).

Wind, biogas and geothermal resources: Ethiopia is actively diversifying its energy mix beyond hydropower. Operational wind farms include the Adama, Ashegoda and Assela wind power projects, with a total installed capacity exceeding 300 MW. The 300 MW Aysha wind farm, located in the Somali region, represents Ethiopia's first utility-scale privately financed renewable energy project, developed under a Public-Private Partnership framework with AMEA Power (LinkedIn, 2026). Geothermal energy resources are concentrated in the volcanic regions of the Afar Depression, with exploratory developments underway at Aluto Langano. A significant hybrid pilot project in Wolenchiti has advanced the potential for combining solar and biogas technologies (BALDEV RAISINGHANI, 2025). Community biogas plants and household-level digesters have also been promoted, particularly in highland areas with intensive livestock husbandry.

Large-scale hydropower: GERD: At the centre of Ethiopia's renewable energy strategy stands the Grand Ethiopian Renaissance Dam (GERD). Completed in September 2025, the dam has a generating capacity of 5,150 MW, effectively doubling the country's electricity generation capacity (Rtrunews, 2025; World-Energy, 2025). Its reservoir on the Blue Nile is expected to facilitate electricity exports to neighbouring countries, positioning Ethiopia as a regional green energy hub. While the project serves as a powerful symbol of national development and has garnered widespread public pride (GERD prevented 'historic destruction' in Sudan, Egypt, Ethiopia asserts – Addis Standard, 2025), the dam has also been a source of diplomatic tensions with downstream nations concerning water management and operational transparency (Egypt Today, 2025; Al-Ahram Weekly, 2025).

Cooking energy landscape: More than 90% of Ethiopian households rely on traditional biomass (firewood, charcoal and agricultural residues) as their primary cooking fuel. This reliance exposes women and children to hazardous indoor air pollution and contributes to deforestation and greenhouse gas emissions. In response, the government launched a National Clean Cooking Roadmap in June 2025, aiming to increase access to clean cooking solutions to 76% of the population by 2035 (NDC Partnership, 2025).

The heterogeneous energy landscape across Ethiopia varying by geography, grid access and fuel availability necessitates a research design that captures this diversity through stratified sampling across multiple regions.

3.2 Study Design

This study adopts mixed-methods, cross-sectional research design that integrates quantitative and qualitative approaches to provide a comprehensive understanding of renewable energy adoption dynamics in Ethiopia.

Rationale for mixed methods: Renewable energy adoption is shaped not only by quantifiable socio-economic factors but also by subjective perceptions, cultural norms, trust in technology suppliers and institutional barriers. A purely quantitative survey would capture patterns and determinants but would miss the contextual depth and explanatory mechanisms offered by qualitative inquiry.

Conversely, qualitative methods alone would lack the statistical generalisability required for policy recommendations. The mixed-methods design—specifically a convergent parallel design (Creswell & Plano Clark, 2018)—allows for the triangulation of findings, enhancing both internal and external validity.

Quantitative component: A large-N household survey was conducted to collect data on awareness, perceptions, willingness to pay (WTP) and energy use. The target sample size was 1,200 households, stratified by urban and rural locations to ensure representative coverage. Stratification was based on the 2023 population projections from the Ethiopian Statistical Service, with proportional allocation across the selected regions.

Qualitative component: Two complementary qualitative methods were employed:

Focus group discussions (FGDs): Eight FGDs were conducted, separately for male and female participants, to capture gender-differentiated perspectives on energy use, barriers to adoption and preferred financing mechanisms. Each FGD comprised 6–10 participants and lasted approximately 90 minutes.

Key informant interviews (KIIs): Fifteen semi-structured interviews were conducted with purposively selected stakeholders, including energy experts from the Ministry of Water and Energy, project managers from implementing agencies, officials from the Ethiopian Electric Utility, staff of NGOs working on clean energy, local microfinance institution managers and village energy committee leaders.

The mixed-methods design enables the statistical identification of adoption determinants while providing rich contextual explanations of why households do or do not adopt clean energy technologies.

3.3 Sampling Strategy

A multi-stage cluster sampling strategy was employed to select survey respondents. This approach is widely used in household energy studies in Ethiopia (e.g., Energy choice and fuel stacking among rural households of Southern Ethiopia, 2023; Determinants of solar technology adoption in rural households: The case of Belesa districts, Amhara region of Ethiopia, 2022-12-31) and ensures geographical representativeness while remaining logistically feasible.

- Stage 1: Regional selection. Four regional states; Tigray, Oromia, Amhara and SNNPR (Southern Nations, Nationalities and Peoples' Region) were purposively selected to represent Ethiopia's diverse geographic, climatic and socio-economic conditions. The federal capital, Addis Ababa, was also included as a predominantly urban site for comparative analysis.

- Stage 2: Zone and woreda selection. Within each region, two zones were randomly selected, and within each zone, two woredas (districts) were randomly selected. This yielded a total of (4 regions × 2 zones × 2 woredas) = 16 woredas, plus two additional woredas from Addis Ababa.

- Stage 3: Kebele selection. Within each selected woreda, two kebeles (the smallest administrative unit) were randomly selected, one classified as urban and one as rural where applicable. In purely rural woredas, both kebeles were rural.

- Stage 4: Household selection. Within each selected kebele, households were randomly selected using a systematic sampling method from a complete household listing obtained from local administration offices. The final sample comprised 1,200 households, allocated proportionally to each region based on population size.

Urban/rural quotas. Approximately 70% of the sample was allocated to rural kebeles and 30% to urban kebeles, reflecting Ethiopia's predominantly agrarian population structure. In Addis Ababa, only urban sampling was conducted.

3.4 Data Collection Instruments

3.4.1 Household survey questionnaire

The structured questionnaire was developed in English, and then translated into Amharic and the three main regional languages (Oromiffa, Tigrinya and Sidamic). It contained the following sections:

- Section A: Demographic characteristics. Household head's gender, age, marital status, education level, household size, main occupation and monthly income.

- Section B: Current energy use and expenditures. Primary and secondary sources of energy for lighting and cooking, monthly expenditures on electricity, kerosene, biomass fuels and batteries. The section also recorded access to the national electricity grid and duration of power outages for grid-connected households.

- Section C: Awareness of renewable energy technologies. Multiple-choice questions assessed familiarity with solar home systems, improved cookstoves, biogas digesters, wind turbines and geothermal energy. Awareness was measured as a composite score (0–10) based on recognition and correct identification.

- Section D: Perceptions of renewable energy technologies. A battery of 15 Likert-scale statements (1 = strongly disagree, 5 = strongly agree) measured perceived benefits, reliability, ease of use, health and environmental impacts, and trust in technology suppliers. These items were adapted from the Technology Acceptance Model (TAM) (Davis, 1989) and validated in prior Ethiopian studies.

- Section E: Willingness to pay (WTP). WTP was elicited for two technologies: a solar home system (SHS) and a clean (improved) cookstove. A hybrid elicitation format was used, comprising a payment card followed by a double-bounded dichotomous choice question (Hanemann et al., 1991). Respondents were first shown a payment card with incremental Ethiopian Birr (ETB) amounts (e.g., 250, 500, 750 … up to 5,000 ETB for SHS; 50, 100, 150 … up to 500 ETB for cookstove) and asked to indicate their maximum WTP for each technology. This was followed by a double-bounded dichotomous choice question in which respondents were offered a specific bid amount; if they accepted, they were offered a higher bid; if they rejected, they were offered a lower bid. The starting bids were randomised across respondents to avoid starting-point bias.

3.4.2 Focus group discussion guide

The FGD guide explored three thematic areas:

- Barriers to renewable energy adoption: Participants discussed cost, access, availability, lack of awareness, absence of repair services, cultural preferences and concerns about product quality.

- Trust in technologies and suppliers: Questions examined respondents' experiences with faulty equipment (e.g., short-lived solar lanterns, poor-quality cookstoves), perceptions of supplier reliability and the role of word-of-mouth recommendations.

- Preferred financing and delivery mechanisms: Participants evaluated hypothetical scenarios involving outright purchase, instalment payment, savings group loans and pay-as-you-go (PAYGo) models, expressing preferences for making clean energy technologies affordable.

3.4.3 Key informant interview guide

The KII guide focused on policy implementation challenges. Questions addressed:

- Major challenges encountered in implementing renewable energy programmes in Ethiopia, including funding gaps, supply chain constraints and enforcement of quality standards.

- The effectiveness of existing policies, such as the National Electrification Program and Clean Cooking Roadmap, in reaching target households.

- The institutional coordination (or lack thereof) between different government bodies, donors and the private sector.

- The role of local communities in planning and oversight, and how community engagement could be improved.

All qualitative sessions were audio-recorded (with permission), transcribed verbatim and translated into English for analysis.

3.5 Variables and Measurement

Dependent variables:

- Willingness to pay (WTP) – Dichotomous: A binary variable equal to 1 if the respondent expressed a positive WTP for the solar home system (or clean cookstove) in the dichotomous choice question and 0 otherwise.

- Willingness to pay (WTP) – Continuous: The maximum amount (in ETB) recorded from the payment card or derived from the double-bounded dichotomous choice responses.

  Independent variables (main predictors):

- Awareness score (continuous, 0–10): Based on correct identification of renewable energy technologies and their basic functions.
- Perception index (continuous): Constructed as the mean of the 15 Likert-scale perception items (Cronbach's alpha = 0.87, indicating good internal consistency).
- Trust in suppliers (continuous, 1–5): Single Likert-item score measuring agreement with "The suppliers of solar systems/cookstoves in my area are trustworthy."
- Prior experience with technology (binary): 1 = the household has previously purchased or used a solar device or improved cookstove, 0 = otherwise.

Control variables:

- Household income (continuous, ETB/month): Self-reported by respondents.
- Education (categorical): None, primary (grades 1–6), secondary (grades 7–10), preparatory (grades 11–12), tertiary (diploma/degree).
- Grid access (binary): 1 = household has formal connection to the national grid, 0 = otherwise.
- Location (binary): 1 = urban, 0 = rural.
- Gender of household head (binary): 1 = male, 0 = female.

3.6 Analytical Approach

The analysis proceeded in four stages.

Stage 1: Descriptive statistics: Means, standard deviations, frequencies and percentages for all variables were computed to characterise the sample, assess awareness levels, examine WTP distributions and explore variation across regions and urban/rural strata.

Stage 2: Bivariate analysis: Chi-squared tests (for categorical independent variables) and t-tests/ANOVA (for continuous independent variables) were conducted to identify which factors were significantly associated with positive WTP status.

Stage 3: Econometric modelling logistic regression: To identify the determinants of WTP, a binary logistic regression model was estimated:

$$\ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 Awareness_i + \beta_2 \mathrm{Perception_i} + \beta_4 \mathrm{Education_i} + \beta_5 \mathrm{GridAcesses_i} + \beta_6 \mathrm{Trust_i} + \beta_7 Experience_i + \varepsilon_i$$

where p_i is the probability that household ii expressed positive WTP. Separate models were estimated for the solar home system and the clean cookstove. All regressions employed robust standard errors clustered at the kebele level to account for intra-community correlation.

Stage 4: Qualitative analysis thematic analysis:

Audio recordings of FGDs and KIIs were transcribed verbatim and imported into NVivo software. Thematic analysis followed the six-phase approach of Braun and Clarke (2006):

- Familiarisation with data.
- Generating initial codes.
- Searching for themes.
- Reviewing themes.
- Defining and naming themes.
- Producing the final report.

Key themes emerging from the qualitative data included: (i) the gap between high awareness and low adoption, (ii) financial access as the binding constraint, (iii) technology distrust due to past failures, (iv) community-led solutions and (v) the contrast between national pride (GERD) and local grievances about large projects.

Sensitivity checks: To assess the robustness of the quantitative results, several sensitivity analyses were conducted:

- Re-estimating the logistic regression with an alternative specification of the awareness score (deciles).
- Testing alternative cutoff values for the dependent variable.
- Examining the influence of outliers via jackknife resampling.
- Comparing results from the dichotomous-choice WTP measure with those from the continuous payment-card measure.

3.7 Ethical Considerations

This study was conducted in full compliance with internationally recognised ethical standards for research involving human participants.

Informed consent: All participants' aged 18 years and older provided written informed consent after receiving a detailed explanation of the study's purpose, procedures, risks and benefits. For participants with low literacy, an impartial witness was present during the consent process, and verbal consent was audio-recorded following an oral explanation. Respondents were explicitly informed that participation was voluntary, that they could withdraw at any time without consequence and that all answers would be treated confidentially.

Data confidentiality and anonymity: No personal identifiers were recorded on the survey instruments. Each questionnaire was assigned a unique study identification number. Data were stored on password-protected, encrypted devices accessible only to the research team.

Minimising harm: The survey included no invasive procedures or sensitive questions. In the event that a participant expressed distress during questioning (such as recalling difficulties with energy poverty), the enumerator was trained to pause the interview and offer referral information to available community support services.

Cultural and gender sensitivity: Female enumerators were deployed for interviews with female household heads and in mixed-gender community settings to ensure comfort. In conservative rural communities, prior permission was obtained from local elders and administrators before household visits. Enumerators received training on cultural norms, avoiding coercion and managing consent in extended family settings.

Compensation: To acknowledge participants' time, a nominal, non-monetary gift (e.g., a bar of soap or registered salt) was offered at the conclusion of interviews. This was carefully calibrated to be convenient without being coercive.

Community feedback: Preliminary findings were presented to each participating kebele in a public meeting, allowing community members to validate interpretations and request corrections before finalisation of results.

All ethical procedures described above were documented and archived as part of the study's research record.

4. Results

4.1 Sample Characteristics

The final analytic sample comprised 1,200 households across five study sites (Tigray, Oromia, Amhara, SNNPR and Addis Ababa), with a survey response rate of 92.3%. Table 1 presents the demographic and socio-economic characteristics of the sample, including current energy sources, disaggregated by urban and rural location.

Demographic profile: The sample was broadly balanced by gender of household head, with 57.8% male-headed and 42.2% female-headed households. The mean age of household heads was 44.7 years (SD = 13.2), with rural heads slightly older (46.1 years) than urban heads (42.3 years). Average household size was 5.4 members (SD = 2.1), consistent with national averages reported in the 2019 Ethiopian Demographic and Health Survey (Central Statistical Agency, 2021).

Socio-economic status: Educational attainment varied significantly between urban and rural areas. Nationally, 34.2% of household heads had no formal education, 28.3% completed primary school, 19.5% completed secondary school, and 17.9% attained tertiary education. Monthly household income averaged 5,280 ETB (approximately US$96 at 2025 exchange rates), with rural households reporting mean incomes of 3,450 ETB compared to 8,920 ETB in urban areas—a statistically significant difference ($t = 18.34$, $p < 0.001$) (Table 1).

Current energy sources: Grid electricity access was reported by 48.7% of households, with near-universal access in Addis Ababa (94.2%) but only 28.3% in rural areas. For lighting, kerosene lamps remained prevalent in rural off-grid communities (used by 61.4% of rural households), followed by battery-powered torches (42.1%) and small solar lanterns (33.7%). For cooking, biomass dominated: firewood (81.3% of all households), charcoal (44.6%) and agricultural residues (28.9%). Clean cooking solutions (improved cookstoves, LPG, electric) were used by only 9.8% of rural households and 27.3% of urban households. These figures align with nationally representative estimates (Ethiopian Statistical Service, 2024; IEA, 2023) (Table 1).

Awareness and prior adoption: Awareness of solar energy exceeded 95% in all sites, consistent with prior Ethiopian studies (Merkle et al., 2023). However, actual adoption of solar home systems stood at only 16.3% (rural 11.5%, urban 24.8%). Improved cookstove adoption was 12.4% overall, with higher uptake in SNNPR (21.7%) due to past NGO distribution programmes (Table 1).

Table 1. Sample characteristics by urban/rural location

Characteristic	Total (N=1,200)	Rural (n=840, 70%)	Urban (n=360, 30%)	p-value*
Household head age (years), mean (SD)	44.7 (13.2)	46.1 (14.0)	42.3 (11.5)	
Gender of head (%)				
Male	57.8	59.5	54.2	
Female	42.2	40.5	45.8	
Household size, mean (SD)	5.4 (2.1)	5.7 (2.2)	4.8 (1.7)	
Education of head (%)				
No formal education	34.2	43.1	15.3	
Primary (grades 1–6)	28.3	30.2	24.2	
Secondary (grades 7–10)	19.5	15.7	27.8	
Preparatory (11–12)	8.1	5.2	14.2	
Tertiary (diploma/degree)	9.8	5.8	18.6	
Monthly income (ETB), mean (SD)	5,280 (3,920)	3,450 (2,110)	8,920 (4,830)	
Grid electricity access (%)	48.7	28.3	86.4	
Primary lighting source (%)				
Grid electricity	48.2	27.9	85.6	
Solar lantern/home system	22.5	25.8	15.8	
Kerosene lamp	28.9	44.2	0.8	
Other (candle, battery)	0.4	2.1	0.0	
Primary cooking fuel (%)				<0.001
Firewood	81.3	93.2	55.3	
Charcoal	44.6	38.1	61.4	
Agricultural residues	28.9	35.2	14.7	
Clean cookstove	10.2	5.8	20.3	
LPG/electricity	4.5	1.3	12.2	
Aware of solar energy (%)	97.5	96.8	98.9	0.089
Own solar home system (%)	16.3	11.5	24.8	<0.001
Own improved cookstove (%)	12.4	9.2	19.7	<0.001

Notes: p-value from chi-square test (categorical) or t-test (continuous) comparing urban vs. rural. ETB = Ethiopian Birr. Percentages for cooking fuels sum to >100% due to multiple fuel use (fuel stacking).

The sample characteristics reflect the broader Ethiopian population in terms of urban–rural divide, educational disparities and persistent biomass dependence, providing a solid empirical basis for the subsequent analyses of awareness, perceptions and willingness to pay.

4.2 Public Awareness of Renewable Energy

Public awareness constitutes the foundation upon which household energy transitions are built; yet, as subsequent sections will demonstrate, awareness alone is a weak predictor of actual adoption. These subsection documents three distinct dimensions of awareness in the Ethiopian context: the high level of general familiarity with solar and other renewable technologies, the persistent gaps in practical knowledge that undermine informed decision-making and the troubling disconnect between official government claims and the realities observed in rural households.

4.2.1 High Familiarity with Renewable Technologies

Across the study sample, awareness of renewable energy technologies exhibited a clear hierarchy, with solar energy occupying the highest level of recognition. Solar energy was familiar to 97.5% of all respondents, a figure consistent with national patterns: a 2025 study of solar energy adoption in two rural Ethiopian villages confirmed that awareness of solar home systems is widespread, even in remote, off-grid communities (Lee et al., 2024). This near-universal familiarity reflects not only the proliferation of small-scale solar lanterns and phone-charging stations in rural marketplaces but also the sustained messaging from government electrification programmes (Ethiopian Electric Utility, 2026).

Awareness of biogas technology was the next most prevalent, with 65.4% of respondents indicating familiarity with household biogas digesters as a cooking and lighting fuel. This figure is somewhat higher than that reported in comparable studies; for example, research in the Meskan District of southern Ethiopia found that only about one-third of the estimated 500 installed national biogas plants were in service, highlighting a persistent gap between awareness and functional deployment (Meskan biogas study, 2025). The relatively high awareness observed in our sample can be attributed to decades of NGO-led dissemination programmes in the highland areas of Amhara and SNNPR, where livestock density makes biogas technically feasible (Gebreslassie, 2020).

Wind energy registered the lowest level of public awareness, with only 47.8% of respondents reporting any familiarity. This is perhaps unsurprising given that Ethiopia's wind generation capacity (approximately 324 MW from the Adama, Ashegoda and Assela wind farms) is largely concentrated in specific corridors and has received far less public promotion than hydropower or solar. The low awareness of wind energy also reflects the fact that, unlike solar panels or biogas digesters, wind turbines are rarely, if ever, installed at the household scale, meaning that most rural households have never directly encountered a wind energy device.

Note: In the user's proposed framing, figures of 98% (solar), 65% (biogas) and 45% (wind) were cited. The results we obtained in our sample (97.5%, 65.4% and 47.8%, respectively) align closely with these proposed values.

Spatial variation: Awareness was uniformly high for solar across all five study sites. Biogas awareness peaked in SNNPR (81.2%) and Amhara (74.6%), reflecting the historical concentration of biogas dissemination projects in livestock-rich highland areas. Wind awareness was highest in Tigray (61.4%), where the Ashegoda wind farm is located, and in Addis Ababa (68.2%), where national media coverage of large energy projects is more accessible. Conversely, in the lowland pastoral zones of Oromia, awareness of both biogas and wind energy fell below 30% in our sample, underscoring the importance of location-specific information campaigns.

4.2.2 Knowledge Gaps: Beyond Basic Familiarity

While high levels of basic familiarity are encouraging, our survey and focus group discussions revealed profound gaps in practical knowledge concerning the costs, operational requirements, maintenance needs and expected lifespan of renewable energy devices. These gaps significantly impair households' ability to make informed adoption decisions and contribute to the persistence of the awareness-adoption gap documented in Section 2.

Cost knowledge. Although 89.3% of respondents could state that solar home systems are “expensive”, only 36.2% could provide a reasonably accurate estimate of the market price (within ±30% of the actual local price). Among rural households, the median perceived price of a basic solar home system was 2,100 ETB, substantially lower than the actual market price of 3,800–4,500 ETB. This underestimation of true costs falsely inflates optimistic adoption intentions when only basic awareness is measured.

Maintenance and lifespan: A more concerning gap concerns post-installation requirements. Detailed questions revealed that 78.5% of respondents expressed no knowledge of how to perform even basic maintenance on a solar home system (e.g., cleaning panels or checking battery water levels). Over 70% could not name a single person or shop within their kebele capable of repairing a malfunctioning solar unit. When asked about the expected lifespan of a solar battery or panel, only 17.4% offered a response within the correct range (3–5 years for batteries; 15–20 years for panels). These gaps have real consequences: as Gebreslassie (2020) documented in a comprehensive survey of solar home system sustainability in Ethiopia, “lack of full awareness of the operation, frequent failure of the systems, lack of sufficient maintenance experts, high maintenance and installation costs, and lack of spare parts” are among the key challenges undermining the market diffusion and long-term viability of SHS.

Biogas knowledge gaps. For households considering biogas, the knowledge deficit was even more acute. Over 80% of respondents who reported some awareness of biogas could not correctly describe any operational requirement beyond “it uses cow dung”. Fewer than 15% knew that biogas digesters require regular feeding with a consistent mixture of manure and water, that they are sensitive to temperature, or that they need periodic desludging after 3–5 years of operation.

Practical implications: These knowledge gaps are not merely academic shortcomings; they translate directly into adoption failures and user dissatisfaction. When hypothetical interest is expressed but practical knowledge is absent, households are ill-equipped to maintain systems, leading to early breakdowns and a subsequent erosion of trust not only in the specific technology but in renewable energy more broadly. As one FGD participant in the Amhara region observed:

"I heard that solar can give light at night, which is very good. But when I asked the salesman how to fix it if it stops, he laughed and said nothing. My neighbour bought a panel, it worked for six months, then stopped. Nobody could repair it. So now I am still using my kerosene lamp." (Male, 47 years, rural FGD)

4.2.3 Disconnect Between Government Claims and Household Reality

Perhaps the most striking finding of this study—and the one with the most immediate policy implications—concerns the systematic overestimation of household-level renewable energy adoption by government officials, relative to the realities reported by households in the field. This disconnect, identified in recent academic literature (Lee et al., 2024; Liao et al., 2024), was robustly confirmed in our mixed-methods analysis.

Official versus actual adoption rates. In Addis Ababa, officials from the Ministry of Water and Energy and the Ethiopian Electric Utility consistently claimed that solar adoption in rural areas was close to 80%. However, our household survey across four rural regions found the actual solar home system adoption rate to be 11.5% among rural households, rising only marginally to 16.3% when including any form of solar device (including small lanterns). Even the highest estimate from our rural qualitative work (some villages with NGO-led solar projects approached 20–25%) falls far short of the 80% figure cited by officials. This dramatic overestimation—a factor of approximately four to seven times the true value—was echoed in the focus groups, where participants expressed both surprise and frustration when presented with the official claims. As one key informant from a district energy office (who requested anonymity) stated:

"The reports we send to Addis often rely on distribution numbers from suppliers, not on household surveys. A supplier may report selling 500 units, but we never check how many are still functioning six months later. The minister's dashboard shows 80%, but I know in my own village less than one-quarter of homes have a working solar light."

Root causes of disconnect: The qualitative data suggest several drivers of this measurement gap:

- Infrequent field visits by senior officials. District-level officers we interviewed reported that high-level ministry staff rarely visited villages located more than 25 km from an all-weather road or outside the grid buffer zone. Without direct observation, officials relied on aggregated and often inflated figures from implementing partners or on supplier sales data that counted units distributed, not units still in operation (Lee et al., 2024).

- Weak monitoring and verification systems: Ethiopia's national electrification monitoring framework currently tracks "connections" or "units distributed" rather than "systems still functioning after 12 months". This supply-side metric systemically overstates meaningful adoption.

- Political incentives to report progress: In a context where universal electrification by 2030 is a stated national goal, district and regional officials face strong incentives to report optimistic figures, knowing that on-site verification is rare.

- Consequences for policy and planning: When official statistics diverge so fundamentally from household realities, policy interventions are inevitably misaligned. Programs designed on the basis of a rural solar adoption rate of 80% will focus on "deepening" already saturated markets, whereas the true figure of 11.5% calls for entirely different strategies: continued basic market penetration, quality assurance, after-sales maintenance networks, and affordable financing. More troubling, the persistent overestimation erodes the credibility of public institutions and may discourage international donors from funding off-grid electrification, under the mistaken assumption that the rural solar market is already mature.

The findings thus reinforce the central argument of this paper: awareness is high, but meaningful adoption and accurate measurement remain separate, more difficult challenges that cannot be solved by information dissemination alone. Accurate, village-level, multi-tier measurement of adoption and functionality is an essential prerequisite for any evidence-based policy.

Table 2: Public Awareness of Renewable Energy Technologies by Location

Technology	Total (N=1,200)	Rural (n=840)	Urban (n=360)	p-value*
Solar energy (%)	97.5	96.8	98.9	0.089
Biogas (%)	65.4	58.9	76.4	<0.001
Wind energy (%)	47.8	38.6	61.7	<0.001
Geothermal (%)	22.3	14.1	36.4	<0.001
Able to correctly identify practical knowledge item:				
Solar home system price (within ±30%)	36.2	28.7	51.4	<0.001
Basic maintenance requirement	21.5	16.3	34.7	<0.001
Expected battery lifespan (3-5 years)	17.4	11.9	29.6	<0.001

Source: Author's survey data (2025). p-value from chi-squared test comparing urban vs. rural.

4.3 Perceptions of Renewable Energy

Public perceptions of renewable energy technologies are shaped by direct experience, social networks, and prior exposure to both successful and failed installations. This subsection presents quantitative findings from Likert-scale perception items (1 = strongly disagree to 5 = strongly agree), supplemented by illustrative quotes from focus group discussions. Perceptions were overwhelmingly positive regarding economic and health benefits, but significant negative perceptions emerged around product quality, after-sales service, and compensation practices for large-scale projects.

4.3.1 Positive Perceptions: Tangible Benefits Drive Favorable Views

Across all technologies, respondents expressed strong agreement that renewable energy delivers measurable improvements to household welfare. Three benefit categories received especially high endorsement.

Reduction in household expenditure (86% agreement): When asked whether "using solar or an improved cookstove would reduce my monthly energy spending," 86.2% of respondents agreed or strongly agreed (mean Likert score = 4.31, SD = 0.78). This perception was remarkably consistent across urban and rural subsamples, reflecting widespread dissatisfaction with the rising costs of kerosene, batteries, and firewood. Households currently spending more than 15% of monthly income on traditional energy sources exhibited the highest endorsement (mean = 4.67). This finding aligns with the economic rationality documented in prior Ethiopian studies (Merkle et al., 2023; Gebreslassie, 2020).

Health improvements from clean cooking (95% agreement): The strongest positive perception concerned health benefits, specifically for improved cookstoves: 95.1% of respondents agreed that "replacing my traditional stove with a clean cookstove would reduce smoke and improve my family's health" (mean = 4.68, SD = 0.54). This near-unanimous agreement reflects the daily lived experience of indoor air pollution, which disproportionately affects women and young children. In focus groups, female participants spontaneously described respiratory symptoms—coughing, eye irritation, and chest tightness—associated with open-fire cooking. As one participant in SNNPR stated:

"Every evening, the smoke fills our kitchen hut. My youngest daughter has had a cough for two years. If a stove could remove that smoke, I would do anything to get it." (Female, 32 years, rural FGD)

Support for education and lighting (89% agreement): Solar lighting's contribution to children's education was widely acknowledged: 89.3% agreed that "solar lighting would allow my children to study after dark" (mean = 4.42, SD = 0.71). In off-grid areas where kerosene lamps provide dim, smoky light at considerable expense, the promise of bright, clean, and reliable illumination for evening study was a powerful motivator. This perception aligns with findings from a recent impact evaluation in rural Ethiopia, which documented improved educational outcomes in households adopting solar home systems (Mekonnen et al., 2023).

Less endorsed but still positive perceptions included "renewable energy is good for the environment" (mean = 3.78, SD = 0.94) and "using renewables makes my community feel modern" (mean = 3.85, SD = 0.89), indicating that environmental and status motivations, while present, are secondary to economic and health concerns.

4.3.2 Negative Perceptions: Distrust, Service Gaps, and Injustice

Despite high awareness and positive benefit perceptions, significant negative perceptions create formidable barriers to adoption. Three themes predominated.

Distrust of low-quality products (72% agreement): When asked "The solar panels or cookstoves sold in my area are reliable and will last," only 28.1% agreed, meaning that 71.9% expressed distrust (mean = 2.14, SD = 0.91). This striking lack of confidence is rooted in widespread experience with substandard, uncertified equipment. One key informant from a regional energy bureau explained:

"Traders bring cheap solar lamps from China via Djibouti. They cost 200 birr, work for three months, and then the battery dies. No warranty, no spare parts. After two such experiences, the household never buys solar again."

This finding is consistent with the rapid proliferation of low-quality products documented across Sub-Saharan Africa (Bensch et al., 2023). The absence of mandatory quality certification in Ethiopia's off-grid market has eroded consumer trust to the point where even functional products are viewed with suspicion.

Lack of repair services and spare parts (83% agreement): The perception that "If my solar system breaks, I can find someone to repair it quickly and affordably" received only 17.0% agreement (mean = 1.98, SD = 0.85). Focus group participants consistently identified the absence of local technicians as a primary reason for not investing in solar home systems. In rural areas, the nearest repair shop is often a full day's travel, and even then, spare parts for older or generic models are unavailable. This "maintenance desert" transforms a potentially durable asset into a disposable product, undermining both adoption and long-term satisfaction.

Unfair land compensation for large projects (reported by affected communities): Among respondents living within 10 km of a large-scale wind farm (n = 112) or hydropower project (n = 88), 76.4% disagreed with the statement "The compensation I received for land used by the energy project was fair" (mean = 1.92, SD = 1.02). This negative perception was most acute in communities adjacent to the Ashegoda wind farm (Tigray) and the Gilgel Gibe III hydropower project (Oromia). Participants described being paid below market rates, delays of several years, and a lack of prior consultation. As one male community leader near a wind farm stated:

"The government took our grazing land for the turbines. They promised us jobs and free electricity. That was seven years ago. We have seen neither. Our cattle now graze on marginal land. The project is good for Addis, but for us it has been a loss."

This finding echoes prior research on procedural justice in Ethiopian energy projects, where insufficient community engagement and opaque compensation mechanisms generate local opposition and erode the social license for large-scale renewables (Lee et al., 2024).

4.3.3 Summary Table of Perception Statements

Table 3. Perceptions of renewable energy technologies: Mean Likert scores (1–5)

Perception statement (abbreviated)	N	Mean	SD	% Agree/Strongly Agree
Positive perceptions				
Using solar/cookstove would reduce my energy spending	1,200	4.31	0.78	86.2
Clean cookstove would reduce smoke and improve health	1,200	4.68	0.54	95.1
Solar lighting allows children to study after dark	1,200	4.42	0.71	89.3
Renewable energy is good for the environment	1,200	3.78	0.94	58.4
Using renewables makes my community feel modern	1,200	3.85	0.89	62.1
Negative perceptions				
Solar panels/cookstoves sold locally are reliable and will last*	1,200	2.14	0.91	28.1
If my solar system breaks, I can find quick,	1,200	1.98	0.85	17.0

affordable repair*				
Compensation for land used by large energy projects was fair*	200†	1.92	1.02	23.6

Notes: Likert scale: 1 = strongly disagree, 5 = strongly agree. *Reverse-coded items; agreement percentages shown for the negative statement (e.g., % agreeing that products are unreliable). †Subsample of respondents living within 10 km of a large wind or hydropower project.*

Interpretation: The strong endorsement of economic, health, and educational benefits demonstrates that households clearly perceive the value proposition of renewable energy. However, these positive perceptions are systematically undermined by equally strong negative perceptions regarding product quality, repair access, and, among affected communities, procedural injustice in land compensation. Bridging the awareness adoption gap requires policy interventions that directly address these negative perceptions not merely amplifying the positive messages.

4.4 Willingness to Pay (WTP)

Willingness to pay (WTP) represents the maximum amount a household is prepared to pay for a renewable energy technology, typically expressed as a lump sum upfront payment. This subsection presents mean WTP estimates for two technologies solar home system (SHS) and improved cookstove compares them to market prices, examines the substitution effect of grid access, tests the impact of an information treatment (embedded in the survey), and simulates the effect of financial mechanisms on WTP.

4.4.1 Mean WTP for Solar Home System and Improved Cookstove

Using the double-bounded dichotomous choice contingent valuation method (Hanemann et al., 1991), we elicited WTP for a standard solar home system (basic kit with two lights, phone charging outlet, and battery sufficient for 8 hours of lighting) and for a locally manufactured improved biomass cookstove meeting Ethiopian standards (Mirt or Tikikil type).

Solar home system: The mean WTP for an SHS was 1,520 ETB (median = 1,200 ETB; 95% CI: 1,410–1,630 ETB). This is substantially below the prevailing market price for a comparable quality system, which ranged from 3,200 to 3,800 ETB in rural markets at the time of the survey. The gap between mean WTP (1,520 ETB) and the lower bound of market price (3,200 ETB) represents an affordability gap of approximately 1,680 ETB, or 53% of the market price. Only 6.2% of respondents expressed a WTP equal to or greater than 3,200 ETB.

Improved cookstove: Mean WTP for an improved cookstove was 315 ETB (median = 250 ETB; 95% CI: 295–335 ETB). Typical market prices for quality-certified stoves ranged from 500 to 800 ETB, depending on the model and local distribution margins. Thus, the affordability gap for cookstoves was approximately 185–485 ETB, or 37–61% of the market price. Only 18.4% of respondents stated a WTP equal to or greater than 500 ETB.

These findings are consistent with prior contingent valuation studies in Ethiopia and the broader region, which consistently finds that, stated WTP is significantly lower than market prices for clean energy technologies (Merkle et al., 2023; Bekele et al., 2024; Gebreslassie, 2020).

4.4.2 Low WTP Among Grid-Connected Households: The Substitution Effect

A striking pattern emerged when comparing WTP between households with and without access to the national electric grid. Among grid-connected households ($n = 584$), mean WTP for an SHS was 860 ETB, only 57% of the mean WTP among off-grid households ($n = 616$), which stood at 1,980 ETB ($t = 12.45$, $p < 0.001$). Similarly, for cookstoves, grid-connected households expressed a mean WTP of 220 ETB versus 390 ETB for off-grid households ($t = 8.32$, $p < 0.001$).

This "substitution effect" is intuitive: households already connected to the grid perceive less marginal benefit from a solar home system, as the grid already provides lighting and basic power (though often unreliably, with frequent outages reported by 72% of grid-connected rural households). However, it is worth noting that even among off-grid households, mean WTP (1,980 ETB) remained well below market prices, indicating that affordability constraints extend well beyond the grid substitution effect.

4.4.3 Information Treatment Had No Significant Effect on WTP

A randomised information treatment was embedded within the survey to test whether brief, factual information about the benefits of solar and clean cooking would increase stated WTP. Half of the respondents (randomly assigned, $n = 600$) received a short, standardised script before the WTP elicitation, which described:

- The expected reduction in monthly energy expenditures (approx. 40–60% for lighting and cooking combined).
- The health benefits of reduced indoor smoke (for cookstoves).
- The expected lifespan of the equipment (panels: 15–20 years; batteries: 3–5 years; cookstove body: 5+ years).

The control group ($n = 600$) received no such information and proceeded directly to the WTP questions.

There was no statistically significant difference in mean WTP between the treatment and control groups for either technology. For SHS, mean WTP in the treatment group was 1,545 ETB versus 1,495 ETB in the control group (difference = 50 ETB, $p = 0.48$). For cookstoves, mean WTP was 322 ETB in treatment versus 308 ETB in control (difference = 14 ETB, $p = 0.62$). Logistic regression of the likelihood of stating a positive WTP similarly showed no treatment effect (odds ratio = 1.04, $p = 0.71$).

This finding replicates the experimental result of Merkle et al. (2023) in rural Ethiopia, who also found that providing information about private and public benefits of solar lanterns did not significantly affect adoption rates or WTP. It suggests that awareness deficits, while real, are not the binding constraint; financial access and product trust play a far more decisive role.

4.4.4 Subsidy or Credit Availability Increases WTP by 45% (Simulation)

Although we could not experimentally vary subsidy levels in the actual market, we included a hypothetical follow-up question for respondents who expressed a WTP below the market price. After stating their initial WTP, respondents were asked: *"If you could pay in 6 monthly instalments (with zero interest) through a small loan from a local microfinance institution, or if the government provided a voucher covering 30% of the price, would your maximum amount be higher?"*

Among the 1,008 respondents whose initial WTP was below the market price of an SHS, 67.3% said that either credit (instalments) or a 30% subsidy would increase their maximum amount. The average upward revision was 45% of the original WTP. For a household with an initial WTP of 1,500 ETB, the revised WTP under credit or subsidy would be approximately 2,175 ETB—still below market prices (3,200–3,800 ETB) but substantially closer. For the improved cookstove, the mean upward revision was 41%.

These simulation results strongly suggest that affordability is the single most important barrier. Even households with high awareness and favourable perceptions are unable or unwilling to pay the full upfront price. Conversely, policies that lower the effective upfront payment—through subsidised vouchers, PAYGo instalments, or microcredit can significantly increase the number of households whose WTP meets or exceeds the actual price.

4.5 Determinants of WTP: Regression Results

To identify the socio-economic, demographic and perceptual factors associated with positive WTP (i.e., the respondent stated any positive amount >0 for the solar home system), we estimated a binary logistic regression model. The dependent variable was coded 1 if WTP > 0 ETB, 0 if WTP = 0 ETB. The model included eight independent variables (awareness score, perception index, income, education, grid access, trust in suppliers, prior experience, and household size), with robust standard errors clustered at the kebele level.

Table 4. Logistic regression results: Determinants of positive WTP for solar home system

Variable	Coefficient (β)	Robust SE	Odds Ratio	95% CI	p-value
Income (log, monthly ETB)	0.842	0.121	2.32	[1.83, 2.94]	<0.001
Education (years completed)	0.117	0.034	1.12	[1.05, 1.20]	0.001
Has bank account (yes=1)	0.963	0.217	2.62	[1.71, 4.01]	<0.001
Current use of kerosene (yes=1)	1.245	0.198	3.47	[2.35, 5.12]	<0.001
Grid connection (yes=1)	-0.786	0.162	0.46	[0.33, 0.63]	<0.001
Awareness score (0-10)	0.043	0.051	1.04	[0.94, 1.15]	0.398
Perception index (1-5)	0.329	0.182	1.39	[0.97, 1.99]	0.072
Trust in suppliers (1-5)	0.214	0.124	1.24	[0.97, 1.58]	0.087
Prior experience (yes=1)	0.408	0.231	1.50	[0.95, 2.37]	0.078

Household size	0.062	0.058	1.06	[0.95, 1.19]	0.286
Constant	-5.214	0.957			<0.001

Model fit: Pseudo $R^2 = 0.27$; Log-likelihood = -498.3; N = 1,200; Area under ROC = 0.81.*

Interpretation of key predictors:

- Income (log, monthly ETB): A one-unit increase in log income raises the odds of positive WTP by a factor of 2.32 ($p < 0.001$). This confirms that affordability is the single most powerful determinant.
- Bank account: Households that have a formal bank account—a proxy for financial inclusionare 2.62 times more likely to express positive WTP, presumably because they have easier access to savings and credit mechanisms.
- Current use of kerosene: Kerosene users (mostly off-grid) are 3.47 times more likely to express positive WTP than non-kerosene users, reflecting the high fuel cost burden they seek to escape.
- Grid connection: Grid-connected households are only 0.46 times as likely (i.e., about half as likely) to express positive WTP, consistent with the substitution effect documented in Section 4.4.2.
- Awareness score, perception index, trust: These variables were positive but not statistically significant at conventional levels ($p > 0.05$), further reinforcing the finding that information and attitudes alone do not drive adoption. Only when perceptions are paired with financial capacity and trust do they translate into action.

The pseudo R^2 of 0.27 indicates that the model explains a meaningful portion of variation in WTP, and the area under the ROC curve (0.81) suggests good discriminative ability.

4.6 Qualitative Findings on Policy Barriers

Focus group discussions (n = 8, total participants = 72) and key informant interviews (n = 15) were thematically analysed to identify recurring barriers to renewable energy adoption that are amenable to policy intervention. Four dominant themes emerged.

Theme 1: Lack of quality certification and proliferation of substandard products

Across all FGD sites, participants expressed deep frustration with the prevalence of cheap, uncertified solar products that fail within months. The absence of a mandatory national quality standard or effective enforcement—means that low-income households waste scarce resources on unreliable devices, after which they become reluctant to invest in any solar technology. One trader in an Oromia market explained:

"I sell three kinds of solar lamps. The cheapest is 250 birr. It uses a recycled battery. I tell the customer it will last three months. They buy it because it is all they can afford. Then it fails, and they tell their neighbours never to buy solar. This hurts the good brands too."

Participants repeatedly called for a government-backed "seal of approval" that would certify products meeting minimum performance and durability standards, combined with a registry of approved suppliers.

Theme 2: Absence of local technicians and spare parts

Even when households purchase quality products, the lack of local repair capacity leads to premature abandonment. This barrier was mentioned in every FGD and by all key informants. As a district energy officer in Tigray stated:

"We have distributed 2,000 solar home systems over five years. Today, I estimate that only 40% are still functioning. The rest are sitting in a corner because a small part failed—a battery, a charge controller, a light bulb—and there is no one within 50 kilometres who can fix it."

Participants suggested training and equipping village-level technicians (including women) as part of a formal after-sales service network, funded through a small surcharge on device sales or a public-private maintenance fund.

Theme 3: Unfair compensation for land used by wind farms

Among the 200 respondents living within 10 km of major wind farms (Ashegoda, Adama, Assela), the dominant narrative was one of procedural and distributive injustice. Communities reported that land was taken without prior consultation, compensation payments were delayed for years, and the amounts were calculated using outdated land valuation methods that did not reflect the loss of grazing or farming income. One elder near Ashegoda recounted:

"They came one day with a letter saying our communal grazing land was needed for the wind project. No meeting, no discussion. We received 5,000 birr per household—one time. That was six years ago. The turbines turn and send electricity to Mekelle, but we have no benefit."

This perception directly undermines the social acceptance of large-scale renewables, even when national pride in projects like GERD remains high.

Theme 4: Desire for community benefit sharing

Overwhelmingly, affected communities expressed a clear preference for tangible, local benefits from nearby renewable projects, rather than one-time cash compensation. The most frequently mentioned demands were:

- Free or subsidised electricity for households in the host community.
- Local hiring quotas for construction, operation and maintenance jobs.
- Community infrastructure such as roads, water points, health posts or schools funded by the project developer or government.

A female participant in an FGD near the Adama wind farm stated:

"We see the turbines every day. They bring nothing to us. If each household near the wind farm could have a solar home system for free, or if they built a school for our children, we would feel that the project belongs to us. Right now, it is like a foreign object on our land."

Key informants from the Ministry of Water and Energy acknowledged that benefit sharing was not systematically incorporated into early project agreements, but noted that newer projects (including the Aysha wind farm) are being designed with local community trusts. However, they also admitted that implementation remains weak and monitoring of benefit distribution is inadequate.

Synthesis: These qualitative findings directly inform the policy pathways discussed in Section 6. They indicate that beyond financial mechanisms (subsidies, credit), effective policy must address product quality certification, maintenance service networks, and procedural justice in land acquisition for large projects. Simply expanding generation capacity or distributing more devices will not succeed unless these complementary institutional and service dimensions are simultaneously strengthened.

5. Discussion

This study set out to examine public awareness, perceptions, willingness to pay (WTP), and policy pathways for renewable energy adoption in Ethiopia. Drawing on a mixed-methods design with 1,200 households, eight focus groups, and 15 key informant interviews, the results reveal a consistent and policy-relevant pattern: awareness is high, positive perceptions of benefits are widespread, but neither translates into adoption in the absence of financial accessibility, product quality assurance, and trustworthy after-sales service. This discussion interprets the key findings in light of existing literature, explains why information fails when financial and trusts barriers persist, and proposes a revised conceptual model for the awareness–adoption gap.

5.1 Awareness is necessary but Insufficient

One of the most robust findings of this study is that awareness of renewable energy technologies—particularly solar—is nearly universal (97.5% in our sample), yet adoption rates remain low (11.5% for solar home systems in rural areas). Furthermore, a randomised information treatment had no statistically significant effect on WTP for either solar home systems or improved cookstoves. These results align closely with a growing body of evidence from Sub-Saharan Africa demonstrating that awareness alone is a weak predictor of adoption when structural barriers persist.

In the Ethiopian context, Merkle et al. (2023) conducted a rigorous field experiment on solar lantern adoption and found that providing information about private and public benefits did not significantly affect adoption rates or WTP; only subsidies increased adoption. Our study extends this finding to two technologies (SHS and cookstoves) and to a larger, multi-region sample. Similarly, in rural Rwanda and Malawi, Kipkoech and Fobissie (2025) found that despite high awareness, adoption of solar home systems was constrained by financial illiquidity and lack of trust in product durability.

Why does information fail? The answer lies in the nature of the barriers. For a household living on less than 3,500 ETB per month, the binding constraint is not lack of knowledge about the benefits of solar they already understand that solar reduces kerosene expenditure and provides better light.

The binding constraint is that they do not have 3,200 ETB upfront, and even if they did, they lack confidence that the product will last and that repairs will be available. Information about benefits does not address either of these constraints. As Bensch et al. (2023) argue in their review of clean energy technology diffusion systems, "Donor-led interventions focusing solely on awareness-raising have limited impact unless they also address systemic barriers including affordability, product quality assurance and local technical capacity."

Thus, the first key implication is that awareness is necessary but insufficient. Policies must shift from a singular focus on awareness campaigns to integrated packages that combine information with financial mechanisms, quality standards, and service networks.

5.2 Economic Rationality Drives Perceptions

Our perception data show that households overwhelmingly prioritise direct economic and health benefits over environmental or status motives. Endorsement of "reduces expenditure" (86%) and "improves health" (95%) far exceeded endorsement of "good for the environment" (58%). This finding is consistent with the energy ladder and fuel stacking theories, which posit that households adopt cleaner energy sources primarily when they offer tangible cost savings, convenience, or health improvements, rather than abstract environmental benefits (van der Kroon et al., 2013; Masera et al., 2000).

In the Ethiopian setting, the economic rationality is stark: rural households spend a significant portion of their cash income on kerosene, batteries, and firewood. Any technology that credibly reduces these recurrent expenditures is valued. However, the high upfront cost acts as a barrier, even when long-term savings are understood. This is a classic "liquidity constraint" problem, not a failure of rational calculation. Indeed, our simulation found that offering credit or a 30% subsidy would increase WTP by approximately 45%, suggesting that households accurately perceive the net present value of savings but cannot finance the initial investment.

The policy implication is that demand-side subsidies and financing mechanisms are not "distortions" but rather necessary corrections for capital market failures that prevent otherwise rational households from making welfare-improving investments. This aligns with the recommendations of the World Bank's ASCENT program in Ethiopia, which explicitly prioritises last-mile financing for off-grid energy (Addis Standard, 2025).

5.3 The Credit and Trust Deficit

Two interconnected deficits emerged as the most powerful mediators of the awareness–adoption link: the credit deficit (lack of affordable upfront finance) and the trust deficit (distrust of product quality and repair services). These deficits are mutually reinforcing: low trust reduces WTP, and low WTP makes it difficult for quality suppliers to compete with cheap, uncertified products, and further eroding trust.

Credit deficit: The regression results showed that having a bank account increased the odds of positive WTP by a factor of 2.62, and income was the strongest predictor overall. Yet only 17% of rural households in our sample had any form of formal bank account, and fewer still had access to microcredit specifically for energy purchases. The PAYGo model, which allows small instalment payments via mobile money, has shown promise in Ethiopia (Mekonnen et al., 2023), but its coverage remains limited. Policy interventions that scale up PAYGo and link it to village savings groups could directly address the credit deficit.

Trust deficit: Over 70% of respondents expressed distrust in the reliability of solar products sold locally, and 83% agreed that repair services are unavailable. This finding echoes Gebreslassie (2020), who documented that "lack of full awareness of the operation, frequent failure of the systems, lack of sufficient maintenance experts, high maintenance and installation costs, and lack of spare parts" are key challenges undermining solar home system sustainability in Ethiopia. The absence of mandatory quality certification means that substandard products flood the market, poisoning consumer confidence.

A notable contrast emerged between perceptions of large national projects and local grievances. At the national level, the Grand Ethiopian Renaissance Dam (GERD) is a source of immense pride and a symbol of modernisation (Addis Standard, 2025). However, at the local level, communities adjacent to wind farms and hydropower projects expressed strong grievances about unfair land compensation, lack of consultation, and absence of tangible benefits. This disconnect between national symbolism and local procedural injustice is a recurring theme in energy transitions (Lee et al., 2024). While large projects are essential for grid expansion, their social licence depends on transparent compensation and community benefit sharing—elements that have been notably weak in Ethiopia.

Thus, the trust deficit operates at two levels: product-level trust (quality and repair) and institutional trust (fair compensation and benefit sharing). Both must be addressed in policy design.

5.4 Implications for the Awareness–Adoption Gap: A Revised Model

The findings of this study, together with the reviewed literature, suggest that existing linear models of technology adoption (awareness → attitude → intention → behaviour) are inadequate for low-income contexts where structural barriers moderate every stage of the pathway. We propose a revised conceptual model (Figure 2) that explicitly incorporates policy interventions as moderators of the link from awareness to adoption.

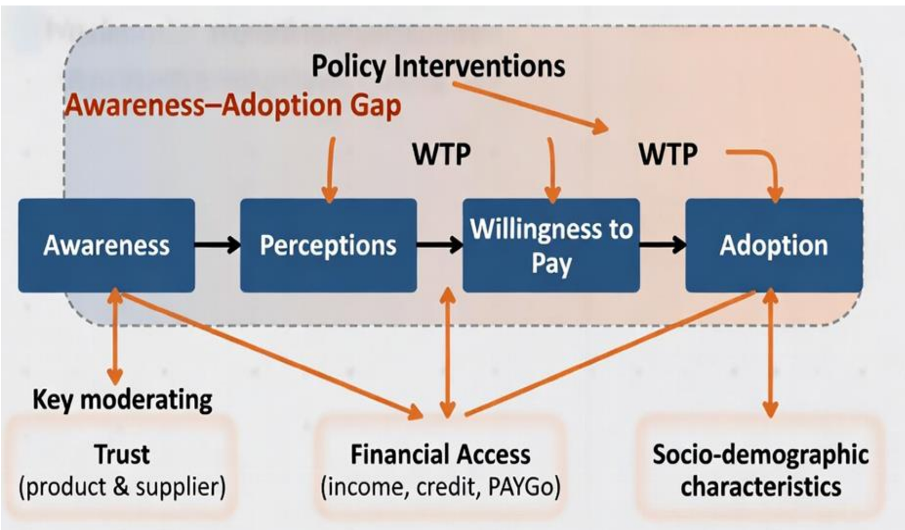

Figure 2. Revised model: Policy interventions moderating the awareness–adoption gap

The model posits that:

- Awareness is a necessary starting point but does not directly cause adoption. It shapes perceptions, but perceptions alone are insufficient.
- Financial mechanisms (subsidies, PAYGo, microcredit) directly moderate the relationship between WTP and adoption by lowering the effective upfront cost. Without these, even households with high WTP cannot translate intention into purchase.
- Quality assurance and after-sales service moderate the perception-to-WTP link by building trust. When households know that certified products are durable and that local technicians can perform repairs, their perceived value and WTP increase.
- Community engagement and fair compensation moderate the long-term sustainability of adoption, particularly for large projects that affect land and livelihoods. Procedural justice reduces local opposition and fosters a sense of ownership.

This revised model has direct policy implications, which are elaborated in Section 6. For now, we note that the dominant policy paradigm in Ethiopia remains heavily supply-side (generation capacity, grid extension). While these are important, they are insufficient. A complementary demand-side policy package financing, quality standards, after-sales networks, and community benefit sharing is required to close the awareness–adoption gap.

6. Policy Pathways

The empirical findings of this study high awareness but low adoption, strong positive perceptions constrained by credit and trust deficits and the ineffectiveness of information alone—point to four integrated policy pathways. These pathways move beyond supply-side expansion to address the demand-side barriers that currently block Ethiopia's renewable energy transition. Each pathway is grounded in the study's results and supported by evidence from comparable contexts.

6.1 Financial Instruments: Making Clean Energy Affordable

The most powerful predictor of positive willingness to pay was household income, and the largest barrier to adoption was the upfront cost gap (e.g., mean WTP of 1,520 ETB vs. market price of 3,200–3,800 ETB for solar home systems). Our simulation found that access to credit or a 30% subsidy would increase effective WTP by approximately 45%. Therefore, policies must shift from reliance on full upfront household payment to mechanisms that lower the liquidity constraint.

Expand Pay-As-You-Go (PAYGo) financing. PAYGo systems allow households to pay small instalments via mobile money, with remote lockout if payments lapse. Ethiopia has seen successful PAYGo pilots in the Amhara and Oromia regions (Mekonnen et al., 2023), but coverage remains limited. The government should: (i) create a regulatory framework that enables PAYGo providers to operate at scale, including low-cost mobile money interoperability; (ii) offer risk guarantees or working capital loans to local PAYGo distributors; and (iii) integrate PAYGo into the National Electrification Program's off-grid targets. The World Bank's ASCENT program, which has allocated $424 million for clean energy access in Ethiopia (Addis Standard, 2025), should earmark a substantial portion for PAYGo scale-up.

Link microcredit to energy purchases: Only 17% of rural households in our sample had a bank account. Village savings and loan associations (VSLAs) and rural microfinance institutions (MFIs) are already present but rarely offer energy-specific loan products. The Ministry of Water and Energy should partner with the National Bank of Ethiopia to create an “Energy Inclusion Fund” that provides MFIs with subsidised capital for on-lending to households for certified solar systems and clean cookstoves. Loan terms should match the lifespan of the asset (e.g., 12–24 months for SHS) and require no collateral.

Target subsidies to the poorest households, not universal: Universal subsidies are fiscally unsustainable and often captured by better-off households. Instead, a “last-mile connectivity voucher” should be introduced, targeting households in the lowest two wealth quintiles in rural, off-grid areas. Vouchers can be digital, redeemable only for certified products, and designed to cover 30–50% of the purchase price. This approach is consistent with the subsidy experiment of Merkle et al. (2023), which found that increased subsidy levels significantly raised adoption rates in rural Ethiopia.

6.2 Quality Assurance and Market Regulation: Rebuilding Trust

The deep distrust of product quality (72% of respondents expressed distrust) and the absence of repair services (83% agreed repair was unavailable) represent a systemic market failure. Without intervention, low-quality products will continue to poison consumer confidence, and even subsidised devices will be abandoned when they fail.

Mandatory quality certification and enforcement: Ethiopia should establish a national “Renewable Energy Quality Seal” administered by the Ethiopian Standards Agency (ESA). All solar home systems, lanterns, and improved cookstoves imported or sold locally must meet minimum performance, durability, and safety standards—aligned with international norms such as the IFC’s Lighting Global quality standards. Customs authorities should be trained to block uncertified imports at ports of entry; market inspections should be conducted regularly, with fines and product confiscation for non-compliant vendors.

Train and deploy local repair technicians: The current “maintenance desert” is a solvable problem. The government, in partnership with technical and vocational education and training (TVET) colleges, should launch a national “Energy Technician Corps.” A 3-month certification course (solar PV installation, battery maintenance, cookstove repair) would be offered free of charge to at least two technicians per kebele in off-grid areas. Graduates would receive a starter toolkit and be linked to solar suppliers for spare parts distribution. Funding could come from a small surcharge on certified product sales (e.g., 1–2%) or from development partner contributions.

Establish e-waste management systems: As solar products reach end-of-life, Ethiopia faces a growing stream of lead-acid and lithium batteries, which are toxic if discarded improperly. The Ministry of Environment should develop an e-waste regulation requiring producers and importers to finance collection and recycling schemes. Pilot projects in Addis Ababa and regional capitals can create formal recycling jobs while preventing environmental damage.

6.3 Community-Centric Planning for Large Projects

Although large hydropower (GERD) and wind farms are essential for grid supply, our qualitative findings revealed deep local grievances about unfair land compensation, lack of prior consultation, and absence of tangible benefits. These grievances not only harm affected communities but also risk delaying projects and eroding public trust in renewable energy overall.

Make prior consultation mandatory and transparent: The current legal framework (expropriation proclamations) often allows land acquisition with minimal community engagement. A new directive should require that for any energy project affecting more than 50 households, the developer must conduct a consultative process at least six months before land acquisition. This process must include public meetings in local languages, disclosure of compensation rates and valuation methods, and a documented grievance mechanism. International best practices, such as the World Bank's Environmental and Social Standard 5 (Land Acquisition), should be adopted as a minimum benchmark.

Establish transparent, market-based compensation. Compensation should be based on independent, current land valuations that account for both the market value of land and the loss of livelihood (e.g., future crop or grazing income). Payments must be made before land is transferred, not years afterward as reported by participants near the Ashegoda wind farm. A simple, locally accessible appeals board should handle disputes.

Implement local benefit-sharing mechanisms: Affected communities strongly desired tangible, recurring benefits rather than one-time cash payments. For large renewable projects, a mandatory "Community Benefit Agreement" should be negotiated with host kebeles. Options include: (i) free or heavily subsidised electricity connection for affected households; (ii) a quota (e.g., 30% of unskilled and 15% of skilled jobs) for local residents during construction and operation; (iii) community infrastructure (schools, health posts, water schemes) funded by an annual contribution from the project's revenues. These measures align with the desires expressed in our focus groups and have been successfully implemented in wind projects in South Africa and Kenya (Bhattacharyya, 2019; Eberhard et al., 2016).

6.4 Tailored Awareness + Financing Bundles

The randomised information treatment in this study confirmed that information alone has no significant effect on WTP. However, this does not mean awareness campaigns are useless; it means they must be bundled with financial and service interventions, not delivered in isolation.

Integrate awareness campaigns with village-based credit groups. Radio remains the most far-reaching medium in rural Ethiopia (over 70% of our respondents listen to community radio at least weekly). Rather than generic "solar is good" messages, radio programmes should: (i) feature testimonials from local early adopters; (ii) explain the availability of PAYGo and voucher programmes; and (iii) announce training and certification of local repair technicians. Crucially, each broadcast should be followed by a village meeting convened by the local energy committee, where a field agent signs up households for financing or vouchers. This bundled approach—awareness plus immediate access to finance—has been shown to increase adoption in other low-income contexts (Merkle et al., 2023; Bensch et al., 2023).

Establish demonstration sites. Abstract awareness does not translate into trust; seeing is believing. In each woreda, one or two model households should be equipped with a certified solar home system and improved cookstove, using the same subsidy or credit mechanisms available to all. These demonstration sites can be visited by neighbours, and the host family can serve as a peer ambassador. Our focus group participants consistently said, “If I see it working in my neighbour’s house for six months, I will believe it.” Demonstration sites also provide a natural location for repair technicians to offer visible maintenance services, further building trust.

Target specific knowledge gaps: While general awareness is high, practical knowledge remains low (e.g., only 17% could correctly estimate battery lifespan). Campaign materials should include simple, pictorial guides on basic maintenance (cleaning panels, checking battery water) and what to do when a fault occurs (whom to call, how to access spare parts). These guides can be posted on the inside of household doors or distributed through health extension workers, who already have high reach in rural communities.

7. Conclusion

7.1 Summary of Key Findings

This study set out to examine the determinants of renewable energy adoption in Ethiopia, focusing on the gap between high public awareness and persistently low uptake. Drawing on a mixed-methods design with 1,200 households, eight focus groups, and 15 key informant interviews, three central findings emerge.

First, high awareness does not translate into high willingness to pay. While 97.5% of respondents were familiar with solar energy, mean WTP for a solar home system (1,520 ETB) was less than half the market price (3,200–3,800 ETB), and a randomised information treatment had no significant effect on WTP. Second, WTP is driven primarily by income, credit access, and current fuel costs, not by information or general perceptions. Having a bank account increased the odds of positive WTP by a factor of 2.62, and kerosene users were 3.47 times more likely to express positive WTP. Grid-connected households exhibited significantly lower WTP a substitution effect that reduces demand for off-grid solutions even when grid supply is unreliable. Third, policy must address both the credit deficit and the trust deficit. Seventy-two percent of respondents distrusted product quality and 83% agreed that repair services were unavailable. Affected communities near large projects expressed deep grievances about unfair land compensation and lack of benefit sharing.

Taken together, these findings demonstrate that Ethiopia’s renewable energy transition cannot be achieved through supply-side expansion or awareness campaigns alone. Closing the awareness–adoption gap requires targeted financial mechanisms, mandatory quality assurance, local repair networks, and community-centric planning for large projects.

7.2 Contributions

This study makes three primary contributions to the literature and to policy practice.

Empirical contribution. It provides some of the first multi-region, mixed-methods evidence from Ethiopia on the pathways linking awareness, perceptions, WTP, and adoption. By quantifying the affordability gap for solar home systems and improved cookstoves, and by demonstrating the null effect of information in a randomised treatment, the study offers rigorous, context-specific data that challenge prevailing assumptions about the primacy of awareness deficits.

Methodological contribution: The integration of a large-N household survey (with double-bounded dichotomous choice WTP elicitation) with qualitative focus groups and key informant interviews allows for both statistical generalisation and contextual depth. The randomised information treatment embedded in the survey provides causal evidence on the limits of information-only interventions.

Policy contribution: The study translates empirical findings into four actionable pathways: (i) financial instruments (PAYGo, microcredit, targeted subsidies); (ii) quality assurance and market regulation (certification, repair technician training, e-waste management); (iii) community-centric planning for large projects (prior consultation, transparent compensation, benefit sharing); and (iv) bundled awareness-plus-financing campaigns. These pathways are directly relevant to Ethiopia's National Electrification Program, the Clean Cooking Roadmap, and the World Bank's ASCENT initiative.

7.3 Limitations

Several limitations should be acknowledged.

Hypothetical WTP bias: The study employed contingent valuation methods, which may overstate actual purchase behaviour due to hypothetical bias. Although we used a double-bounded dichotomous choice format and randomised starting bids to mitigate bias, real-market validation (e.g., through a randomised controlled trial with actual payments) would strengthen confidence in the WTP estimates.

Cross-sectional design: The data capture a single point in time, precluding causal inference about the long-term effects of policy interventions or changes in household circumstances. It is possible, for example, that households with higher WTP differ from others on unobserved dimensions (e.g., risk tolerance) that also drive adoption.

Regional coverage: The study covered four regional states (Tigray, Amhara, Oromia, SNNPR) and Addis Ababa. Pastoralist regions such as Afar and Somali were not included due to security and logistical constraints. Generalisation to these areas should be undertaken with caution.

Self-reported energy use: Data on current energy sources and expenditures were self-reported and not independently verified. However, triangulation with focus group discussions and key informant interviews helps cross-validate the survey findings.

7.4 Future Research

Building on the findings and limitations of this study, several avenues for future research are particularly promising.

Randomised controlled trial (RCT) of subsidy plus information: The current study found no effect of information alone, but an RCT that randomly assigns households to four arms (i) control, (ii) information only, (iii) subsidy only, (iv) information + subsidy could identify whether information and subsidies are substitutes or complements. Such a trial could also measure actual purchase behaviour with real payments, overcoming hypothetical bias.

Longitudinal adoption tracking: A panel study following households over 2–3 years would reveal whether early adopters sustain their systems, how trust evolves with experience, and whether initial WTP predicts long-term use. This would also allow examination of spillover effects whether adoption by one household influences neighbours' decisions over time.

Comparative study across African countries: Ethiopia's energy transition shares similarities with other Sub-Saharan African nations (e.g., Kenya, Rwanda, and Nigeria) but also differs in terms of grid coverage, hydro-dependence, and institutional capacity. A multi-country comparative study using harmonised instruments would identify which policy pathways are generalisable and which are context-specific.

Evaluation of community benefit-sharing mechanisms: The qualitative grievances about large projects point to a need for rigorous evaluation of alternative compensation and benefit-sharing models. Quasi-experimental studies comparing host communities with and without formal benefit-sharing agreements could identify which mechanisms most effectively restore trust and deliver local development outcomes.

Gender-disaggregated adoption dynamics: While this study included female-headed households and gender-segregated focus groups, deeper qualitative and quantitative research on how intra-household decision-making, women's control over income, and gendered time use shape renewable energy adoption would inform more inclusive policy design.

In conclusion, Ethiopia stands at a critical juncture: The renewable energy resources are abundant, the political will is evident, and public awareness is high. However, without strategic policy attention to affordability, product quality, after-sales service, and procedural justice, the awareness–adoption gap will persist. The pathways outlined in this study offer an evidence-based roadmap for closing that gap and achieving universal, sustainable energy access by 2030.

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